Voice And Telephony over ATM: Status

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March 1998
Overview

- VTOA: Protocol Stack and Services
- AAL: AAL1, AAL5, New AAL2
- Interworking Function
  - Signaling
  - Addressing
  - Timing and Synchronization
Voice over ATM: Issues

- Connection Setup
- Coding/decoding of voice into bits
- Packing of digital bit stream into cells (AAL1 or AAL5)
- End-to-end transmission of cells (Trunking)
Why VOA?

- Single physical connection for voice, video, data
- Integrated management, maintenance, signaling
  ⇒ Reduced cost
AAL1 or AAL5. AAL5 required.
- One packet per cell
- 64 kbps PCM µ-law or A-law (G.711)

<table>
<thead>
<tr>
<th>DSS2 Q.2931</th>
<th>G.711</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAAL</td>
<td>AAL</td>
</tr>
<tr>
<td>ATM</td>
<td></td>
</tr>
<tr>
<td>Physical</td>
<td></td>
</tr>
</tbody>
</table>
VTOA Services

- N-ISDN
  - 64 kbps
  - 2×64 kbps
  - 384 kbps
  - 1536 kbps
  - 1920 kbps
  - Multirate N×64 kbps

- Analog
  - 3.1 kHz Voice
  - 7 kHz tones and announcements
Supplementary Services

- Direct Dialing In (DDI)
- Multiple Subscriber Number (MSN)
- Caller Id Presentation
- Caller ID Restriction
- Connected Line ID Presentation
- Connected Line ID Restriction
- Subaddressing

Note: All these are available from UNI 4.0
ISO Supplementary Services

- Name Id
- Call Transfer
- Call Diversion/forwarding
- Call Completion
- Call offer
- Call Intrusion
- Do Not Disturb
- Call Interception
## AAL1

<table>
<thead>
<tr>
<th>Convergence Sublayer Indication</th>
<th>Sequence Count</th>
<th>Sequence Number Protection</th>
<th>Parity</th>
<th>Payload</th>
</tr>
</thead>
<tbody>
<tr>
<td>1b</td>
<td>3b</td>
<td>3b</td>
<td>1b</td>
<td>47B</td>
</tr>
</tbody>
</table>

- Misordering bad $\Rightarrow$ Sequence number
- Convergence Sublayer Indication (CSI)
  Used for clock synchronization
- Constant Bit Rate (CBR)
- Indication of lost or errored cells (Seq #)
AAL 1 Problems

- Fixed size (47B) payload
- Single user per VC
- No partial fill $\implies$ Bandwidth
- Only 64k or N×64k
- No support for
  - Forward error correction
  - Compression (VBR),
  - Silence suppression,
  - Idle channel removal
- Not generally available
### AAL 5

- Designed for data traffic
- No per cell length field, No per cell CRC
- One voice packet/cell ⇒ Payload = 8 to 40 bytes

<table>
<thead>
<tr>
<th>User Payload</th>
<th>PAD</th>
<th>Common Part Convergence Sublayer</th>
<th>Common Part Indicator</th>
<th>Length</th>
<th>CRC-32</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-64kB</td>
<td>0-47B</td>
<td>1B</td>
<td>1B</td>
<td>2B</td>
<td>4B</td>
</tr>
</tbody>
</table>

AAU bit in PTI indicates last cell

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Delay

- 48 bytes at 64 kbps = 6 ms  ⇒  Need Echo cancellers
- 48 bytes at 16 kbps = 24 ms  ⇒  too long
- Can't fill a cell completely
- Current AALs allow segmentation (long packets to multiple cells).
- Do not allow blocking (short packets in one cell)
Low-Bit Rate Voice

- Time to fill 48-byte payload
  @8 kbps = 48 ms
AAL2: History

- Sept 95: T1S1.5 "Short Multiplexed AAL (SMAAL)"
- May 96: ITU-T started AAL-CU
- Feb 97: ITU-T Completed AAL2 (Record: 9 Months)
AAL2

- Ideal for low bit rate voice
- Variable/constant rate voice
- Multiple users per VC
- Compression and Silence suppression
- Idle channel suppression
Protocol Structure

- Common Part specification (CPS)
- AAL2 Negotiation procedure (ANP)
- Service Specific Convergence Sublayer (SSCS)
  Null for Mobile Voice. May have SSCS for Trunking
Cell Format

- STF: Start field = CPS PDU header
- OSF: Offset of the first packet
- SN: Sequence number mod 2, 0 or 1
- P: Parity (odd) of start field
- Pad: Padding (0-47 bytes)
CPS Packet Format

- **Channel ID (CID):** 0 = Not used, 1 = Mgmt, 2-7 = Reserved, 8-255 = User ID
- **Length (LI):** 0-64, Default = 45B
- **User-to-User Indication (UUI):** 0-27 = ID, 28-29 = Resvd, 30-31 = OAM
## Protocol Efficiency

<table>
<thead>
<tr>
<th></th>
<th>Fill Delay</th>
<th>Size</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>32 kbps ADPCM</td>
<td>4 ms</td>
<td>16 B</td>
<td>84%</td>
</tr>
<tr>
<td>32 kbps ADPCM</td>
<td>8 ms</td>
<td>32 B</td>
<td>91%</td>
</tr>
<tr>
<td>64 kbps PCM</td>
<td>4 ms</td>
<td>32 B</td>
<td>91%</td>
</tr>
<tr>
<td>64 kbps PCM</td>
<td>8 ms</td>
<td>64 B</td>
<td>96%</td>
</tr>
<tr>
<td>64 kbps PCM</td>
<td>5.6 ms</td>
<td>45 B</td>
<td>94%</td>
</tr>
</tbody>
</table>
AAL2: Status

- Sept 97: I.363.2 approved
- Sept 97: Segmentation and reassembly
  I.366.1 frozen
- June 98: I.trunk to be frozen
- On-Going:
  - AAL2 negotiations procedures (ANP)
  - Operations, Administration and Maintenance (OAM)
- Future: Interworking with
  - Voice over IP
  - Voice over Frame Relay
VTOA

ATM Network (LAN, WAN, or Satellite)

Desktop

PBX

ISDN

Desktop

Legacy networks

IWF

IWF

IWF

IWF

IWF

IWF

Desktop

Legacy networks

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ATM-ISDN Interworking

- One ATM connection per N-ISDN channel per call (Current)
- ATM signaling channel (VC=5) mapped to ISDN D channel

```
ATM Terminal
<table>
<thead>
<tr>
<th>ATM Terminal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private ATM</td>
</tr>
<tr>
<td>IWF</td>
</tr>
<tr>
<td>Public ISDN</td>
</tr>
</tbody>
</table>

Private UNI

<table>
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<tr>
<td>Private ATM</td>
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<tr>
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</tr>
<tr>
<td>Private ISDN</td>
</tr>
</tbody>
</table>

UNI T or S/T

<table>
<thead>
<tr>
<th>PNNI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q</td>
</tr>
</tbody>
</table>
```
IWF Functionality

- User Plane Protocols
- Signaling: Control Plane Protocols
- Timing & Synchronization
- Addressing
User Plane Protocols

G.711
AAL
ATM
Phy
B-TE
Private B-ISDN
S_B
PNNI or T_B
IWF
Q or T
T or S/T
ISDN TE

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Control Plane Protocols

- Q.Sig Private N-ISDN (PSS1)
- Q.921+DSS1 Public N-ISDN
- SAAL+DSS2 Public B-ISDN
- PNNI Signaling Private B-ISDN

Diagram:

```
+-----------------+     +-----------------+     +-----------------+     +-----------------+
| DSS2            |     | DSS2            |     | DSS2            |     | DSS1            |
| SAAL            |     | SAAL            |     | SAAL            |     | Q.921           |
| ATM             |     | ATM             |     | ATM             |     | Q.921           |
| Phy             |     | Phy             |     | Phy             |     | Phy             |
| B-TE            |     | Private B-ISDN  |     | T_B             |     | IWF             |
| S_B             |     | T_B             |     | IWF             |     | S/T Public ISDN |
```
Q.2931 Signaling

Setup

Call Proceeding

Alerting

Connect

Connect Ack

Accept
Setup Mapping

- Terminate each protocol, or
- Map each message

ATM | IWF | ISDN

Connect → Connect → Connect → Connect Ack
Connect ← Connect ← Connect ← Connect Ack
Call Clear Mapping

ATM | IWF | ISDN

Release - - Disconnect
Release Complete

T305
Release Complete
T308
Release Complete

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Timing & Synchronization

- Phy based (Stratum 4)
- Adaptive (buffer fill based)
- Free-running
E.164 Numbers

- North American Numbering Plan (NANP): 1(614)-555-1212
- E.163 numbering plan for telephony: 12 digits
- E164 numbering plan for ISDN: 15 digits
- Defined in ITU-T recommendation E.164 for ISDN
- ISDN numbers uniquely identify interfaces to public networks
- Administered by public networks (Therefore, are not easily available for private network use)
ATM Addresses

- ATM Forum specifies three NSAP-like address formats: DCC Format, ICD Format, E.164
- NSAP = Network Service Access Point

<table>
<thead>
<tr>
<th>AFI</th>
<th>Initial Domain Id</th>
<th>Domain Specific Part (DSP)</th>
<th>End System Supplied</th>
<th>Not Used in Routing</th>
</tr>
</thead>
<tbody>
<tr>
<td>39</td>
<td>Data Country Code (2B)</td>
<td>High-Order DSP (10B)</td>
<td>End System ID (6B)</td>
<td>Selector (1B)</td>
</tr>
<tr>
<td>47</td>
<td>International Code Designator (2B)</td>
<td>High-Order DSP (10B)</td>
<td>End System ID (6B)</td>
<td>Selector (1B)</td>
</tr>
<tr>
<td>45</td>
<td>E.164 Number (8 B)</td>
<td>High-Order DSP (4B)</td>
<td>End System ID (6B)</td>
<td>Selector (1B)</td>
</tr>
</tbody>
</table>

Network supplied
Addressing

- Authority and Format Identifier (AFI)
  39 = ISO DCC,
  47 = British Standards Institute ICD,
  45 = ITU ISDN

- Initial Domain Identifier (IDI). Domain Specific Part (DSP)

- ISDN uses E.164 numbers (up to 15 BCD digits)

- ATM forum extended E.164 addresses to NSAP format. E.164 number is filled with leading zeros to make 15 digits.
Addressing (Cont)

- End System Identifier (ESI):
  48-bit IEEE MAC address
- Selector is for use inside the host and is not used for routing.
- All ATM addresses are 20 bytes long.
- ATM forum removed the division of DSP into areas, etc.
Private networks must support all three formats
Type of Number field = Unknown
Numbering Plan Indication field = ISO NSAP

Public networks must support native E.164 and may optionally support three NSAP-encoded formats. For E.164:
Type of Number field = International number
Numbering Plan Indication field = Recommendation E.164
NSAP is a Misnomer!

- NSAP = Network Service Access Point
  Identifies network layer service entry
- SNPA = Subnetwork point of attachment
  Identifies the interface to subnetwork
- SNPA address (or part of it) is used to carry the packet across the network.
- CLNP uses NSAP to deliver the packet to the right entity inside the host.
- ATM uses NSAP-like encoding but ATM addresses identify SNPA and not NSAP.
Summary

- Circuit emulation services for CBR using AAL1 or AAL5.
- ATM Trunking using AAL2 is being developed. Allows low bit rate VBR, multiple users/cell.
- IWF has to deal with data forwarding, signaling, addressing, and clock synchronization.
References

- For a tutorials on VTOA, Signaling, and PNNI see: http://www.cis.ohio-state.edu/~jain/
ATM Forum, "ATM Trunking using AAL1 for Narrowband Services V1.0," af-vtoa-0089.00, July 1997.

ATM Forum, "PNNI V1.0," af-pnni-0055.000, March 1996.

ATM Forum, "UNI Signaling 4.0," af-sig-0061.000, July 1996.

ITU-T, "B-ISDN ATM Adaptation Layer Specification: Type 2 AAL," I.363.2

VOA Products

- CISCO, Stratacom ATM Switches, Not AAL2.
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAL</td>
<td>ATM Adaptation Layer</td>
</tr>
<tr>
<td>AAL-CU</td>
<td>AAL Composit User</td>
</tr>
<tr>
<td>ADPCM</td>
<td>Adaptive Differential Pulse Code Modification</td>
</tr>
<tr>
<td>ANSI</td>
<td>American National Standards Institute</td>
</tr>
<tr>
<td>ATM</td>
<td>Asynchronous Transfer Mode</td>
</tr>
<tr>
<td>CBR</td>
<td>Constant Bit Rate</td>
</tr>
<tr>
<td>CCS</td>
<td>Common Channel Signaling</td>
</tr>
<tr>
<td>CES</td>
<td>Circuit Emulation Service</td>
</tr>
<tr>
<td>CID</td>
<td>Channel Identifier</td>
</tr>
<tr>
<td>CPS</td>
<td>Common Part Sublayer</td>
</tr>
<tr>
<td>ITU-T</td>
<td>International Telecommunications Union -</td>
</tr>
<tr>
<td></td>
<td>Telecommunications Sector</td>
</tr>
<tr>
<td>LI</td>
<td>Length Indicator</td>
</tr>
<tr>
<td>Acronym</td>
<td>Description</td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
</tr>
<tr>
<td>PCM</td>
<td>Pulse Code Modulation</td>
</tr>
<tr>
<td>PCR</td>
<td>Peak Cell Rate</td>
</tr>
<tr>
<td>PDU</td>
<td>Protocol Data Unit</td>
</tr>
<tr>
<td>SMAAL</td>
<td>Short Multiplexed AAL</td>
</tr>
<tr>
<td>SSCS</td>
<td>Service Specific Convergence Sublayer</td>
</tr>
<tr>
<td>UUI</td>
<td>User-to-User Indication</td>
</tr>
<tr>
<td>VBR</td>
<td>Variable Bit Rate</td>
</tr>
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<td>Voice and Telephony over ATM</td>
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</tbody>
</table>
Thank You!