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Asynchronous Transfer Mode (ATM) Package for the Media Gateway Control Protocol (MGCP)

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Abstract

This document describes an Asynchronous Transfer Mode (ATM) package for the Media Gateway Control Protocol (MGCP). This package includes new Local Connection Options, ATM-specific events and signals, and ATM connection parameters. Also included is a description of codec and profile negotiation. It extends the MGCP that is currently being deployed in a number of products. Implementers should be aware of developments in the IETF Megaco Working Group and ITU SG16, which are currently working on a potential successor to this protocol.

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1.0 Conventions Used in this Document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14, RFC 2119.

MGCP identifiers are case-insensitive. This includes package names, event names, local connection options and other elements of the MGCP header.

2.0 Introduction

The Media Gateway Control Protocol or MGCP [36] is used to control voice media gateways from external call control elements. Even though the bearer network might be IP, ATM, TDM or a mix of these, MGCP is transported over IP. Packages such as the MGCP CAS packages [38] are modular sets of parameters such as connection options, signal, event and statistics definitions that can be used to extend it into specific contexts. A related, IP-based mechanism for the description of ATM connections [18] has been generated by the IETF MMUSIC group. Due to the IP-centric nature of all aspects of the MGCP device control protocol, and for consistency with other MGCP package definitions, it is desirable to publish the MGCP ATM package in an IETF document.

MGCP [36] allows the auditing of endpoints for package versions supported. The package version for the MGCP ATM package, as specified in this document, is 0. Even if the ATM package is the default package for some endpoints, the package prefix "atm" shall not be omitted in local connection option names, event names, signal names etc. If the ATM package is the default package for an endpoint, it will be listed as the first package in the audit response list. It is not necessary for the MGCP ATM package to be the default package for ATM to be supported on an endpoint.

The ATM package in this document consists of Local Connection Options (Section 3.0), Events and Signals (Section 4.0) and ATM Statistics Parameters (Section 5.0). Section 6.1 has guidelines for consistency in the use of Local Connection Options. Section 6.2 describes codec and profile negotiation. Section 7.0 addresses security considerations.

In the ATM networks addressed in this document, services are carried directly over ATM without an intervening IP layer. The Local Connection Options, Events, Signals and Statistics Parameters described in this section are not needed for VoIP calls which can be carried, in whole or in part, over an ATM network. In that case, the constructs defined elsewhere for IP are sufficient.

The ATM local connection option names, event names and signal names MUST always have an "atm" package prefix. Backward compatibility with older implementations that use X-atm as the package name is desirable.

MGCP grammar [36] must be followed with regard to the use of white spaces. The examples in this document attempt to follow MGCP grammar in this and all other respects.

3.0 Local Connection Options

The Local Connection Options (LCOs) defined in this section are specific to ATM applications. Like other LCOs, these can be used in commands to create connections, modify connections and audit connections. However, unless noted otherwise below, they are not to be returned when an endpoint is audited for capabilities.

ATM Local Connection Options are divided into the following categories: ATM bearer connection, ATM adaptation layer, service layer, ATM bearer traffic management and AAL dimensioning.

When parameter values are represented in decimal format, leading zeros are omitted.

3.1 ATM Bearer Connection

These local connection options are used to parameterize ATM bearer connections.

TABLE 1: Local Connection Options for ATM Bearers

LCO	Meaning	Values
ct	Connection Type	AAL1, AAL1_SDT, AAL1_UDT, AAL2, AAL3/4, AAL5, USER_DEFINED_AAL
vc	VC/Bearer type	PVC, SVC, CID
se	Enable path set-up	on, off
ci	Connection Element Identifier	See below

Connection type (ct): This parameter describes the ATM adaptation layer. The values that can be assigned to it are: AAL1, AAL1_SDT, AAL1_UDT, AAL2, AAL3/4, AAL5 and USER_DEFINED_AAL. The user defined adaptation layer is per amendment 2 of ITU-T Q.2931.

Type of Bearer/VC (vc): This indicates whether a PVC, CID or an SVC is to be used for an ATM connection. Possible values are: PVC, SVC or CID. Omitting this parameter will result in the use of a default, which could be embedded or provisioned. The value "PVC" covers both classical PVCs and SPVCs. The value "CID" covers subchannels within AAL1 [35] and AAL2 [10] virtual circuits. A value of "SVC" for atm/vc does not necessarily imply that the addressed media gateway should initiate signaling for bearer set-up, since this might be done by another node such as the far-end media gateway.

Enable path set-up (se): This local connection option is used to explicitly enable or disable the use of bearer signaling for path set-up. Permitted values of this local connection option are "on" and "off". Examples of bearer signaling are SVC signaling, ITU Q.2630.1 signaling and combinations thereof. Examples of such combinations are the set-up of an AAL2 SVC and the assignment of a CID within it or the set-up of a concatenation of an AAL2 single-CID SVC and a CID channel within a multiplexed AAL2 VC. This parameter can be used with both the backward and forward bearer connection

set-up methods. In the former case, the call-terminating gateway sets up the bearer connection. In the latter case, the call-originating gateway sets up the bearer connection.

This option may or may not be used in conjunction with atm/sc event notification. When this option and the atm/sc event notification are omitted, creating and modifying connection commands, the call agent is deferring any relevant decision to set up an ATM or AAL2 connection to the media gateways. In the absence of this parameter, a media gateway's autonomous decision to set up an ATM or AAL2 path via bearer signaling depends on default/provisioned behaviors, such as the applicability and nature (backward/forward) of a bearer connection set-up model, the network type ('nt'), connection type ('atm/ct') and bearer type/VC ('atm/vc') local connection options, and the media gateway's awareness of whether it is the originating gateway or terminating gateway in a call. This awareness may be based on the presence or absence of an SDP remote connection descriptor in the initial create connection command.

Connection Element Identifier (ci): This indicates the Virtual Circuit or CID to be used for the bearer connection. It is used when the call agent manages VC and/or CID resources in the bearer network.

The ci parameter can be in one of the following formats:

* VCCI-<vcci>
* VCCI-<vcci>/CID-<cid>
* <ATMaddressType>-<ATMaddress>/VCCI-<vcci>
* <ATMaddress>/VCCI-<vcci>
* <ATMaddressType>-<ATMaddress>/VCCI-<vcci>/CID-<cid>
* <ATMaddress>/VCCI-<vcci>/CID-<cid>
* BCG-<bcg>/VCCI-<vcci>
* BCG-<bcg>/VCCI-<vcci>/CID-<cid>
* BCG-<bcg>/VPI-<vpi>/VCI-<vci>
* BCG-<bcg>/VPI-<vpi>/VCI-<vci>/CID-<cid>
* PORT-<portId>/VPI-<vpi>/VCI-<vci>
* PORT-<portId>/VPI-<vpi>/VCI-<vci>/CID-<cid>
* VPCI-<vpci>/VCI-<vci>
* VPCI-<vpci>/VCI-<vci>/CID-<cid>
* <ATMaddressType>-<ATMaddress>/VPCI-<vpci>/VCI-<vci>
* <ATMaddress>/VPCI-<vpci>/VCI-<vci>
* <ATMaddressType>-<ATMaddress>/VPCI-<vpci>/VCI-<vci>/CID-<cid>
* <ATMaddress>/VPCI-<vpci>/VCI-<vci>/CID-<cid>

The subparameters of the ci parameter are defined as follows:

Subparameter	Meaning	Representation
vcci	VC connection Id	Decimal Integer (16-bit equivalent)
cid	Channel Id	Decimal Integer (8-bit equivalent)
ATMaddressType	ATM address type	"NSAP", "E164", "GWID", "ALIAS"
ATMaddress	ATM address	40 hex digits ("NSAP") upto 15 digits ("EI64") upto 32 chars ("GWID") upto 32 chars ("ALIAS")
bcg	Bearer Connection Group	Decimal Integer (8-bit equivalent)
vpi	Virtual Path Id	Decimal Integer (8 or 12-bit equivalent)
vci	Virtual Channel Id	Decimal Integer (16-bit equivalent)
portID	Port Id	Decimal Integer (32-bit equivalent)
vpci	VP connection ID	Decimal Integer (16-bit equivalent)

The CID, or Channel ID, can refer to AAL1 as well as AAL2 applications. In AAL1 applications based on [35], it refers to the octet position, starting from one, within an n x 64 SDT frame.

The VPCI is a 16 bit field defined in Section 4.5.16 of ITU Q.2931. The VPCI is similar to the VPI, except for its width and the fact that it retains its value across VP crossconnects.

The VCCI is a 16 bit field defined in ITU Recommendation Q.2941.2 [14]. The VCCI is similar to the VCI, except for the fact that it retains its value across VC crossconnects.

In general, <vpci> and <vcci> values are unique between a pair of nodes. When they are unique between a pair of nodes, but not unique within a network, they need to be qualified at any node, by the ATM address of the remote node. These parameters can be pre-provisioned or signaled via SVC signaling messages. When VPCI and VCCI values are pre-provisioned, administrations have the option of provisioning them uniquely in a network. In this case, the ATM address of the far end is not needed to qualify these parameters.

The <portId> parameter is used to identify the physical trunk port on an ATM module. It can be represented as a decimal or hex number of up to 32 digits.

In some applications, it is meaningful to bundle a set of connections between a pair of ATM nodes into a bearer connection group. The <bcg> subparameter is an eight bit field that allows the bundling of up to 255 VPCs or VCCs.

In some applications, it is necessary to wildcard some elements of the ci local connection option. The "$" wildcard character can be substituted for some of the terms of this parameter. While wildcarding, the constant strings that qualify the terms in the ci parameter are retained. The concatenation <ATMaddressType>-<ATMaddress> can be wildcarded in the following ways:

* The entire concatenation, <ATMaddressType>-<ATMaddress>, is replaced with a "$".
* <ATMaddress> is replaced with a "$", but <ATMaddressType> is not.

Examples of wildcarding the ci parameter in the AAL1 and AAL5 contexts are: VCCI-$, BCG-100/VPI-20/VCI-$.

Examples of wildcarding the ci parameter in the AAL2 context are: VCCI- 40/CID-$, BCG-100/VPI-20/VCI-120/CID-$.

If the addressType is NSAP, the address is expressed in the standard dotted hex form. This is a string of 40 hex digits, with dots after the 2nd, 6th, 10th, 14th, 18th, 22nd, 26th, 30th, 34th and 38th digits. The "0x" prefix is not used, since this is always represented in hex. The last octet of the NSAP address is the 'selector' field that is available for non-standard use. For example:

```
L: atm/ci:NSAP-47.0091.8100.0000.0060.3e64.fd01.0060.3e64.fd01.00/
          VCCI-65
```

If the ATMaddressType is E164, the ATMaddress is expressed as a decimal number with up to 15 digits. For example:

L: atm/ci:E164-9738294382/VCCI-100

The E.164 numbers used can be in the International Format E.164 or conform to a private numbering plan.

If the ATMaddressType is GWID, it means that the address is a Gateway Identifier or Node Alias. This may or may not be globally unique. In this format, the ATMaddress is expressed as an alphanumeric string ("A"-"Z", "a"-"z", "0" - "9",".","-","_"). For example:

L: atm/ci:GWID-officeABCmgx101vism12

The keyword "ALIAS" can be substituted for "GWID". For example:

L: atm/ci:ALIAS-officeABCmgx101vism12

An example of a GWID (ALIAS) is the CLLI code used for telecom equipment. For all practical purposes, it should be adequate for the GWID (ALIAS) to be a variable length string with a maximum size of 32 characters.

When an endpoint supporting the ATM package is audited for capabilities, the following local connection options from Section 3.1 shall be returned: connection type (atm/ct) and VC/bearer type (atm/vc). If more than one value is supported, these shall be expressed as a list of semicolon-separated values. Although this is not very useful, it is permissible for these values to have overlapping semantics (e.g., AAL1 and AAL1_SDT). An example of returning, in audit response, the local connection options defined in Section 3.1 is:

A: atm/ct:AAL1_SDT;AAL2, atm/vc:PVC;CID

3.2 ATM Adaptation Layer (AAL)

These local connection options are used to parameterize the ATM adaptation layer (AAL). These are further classified as: generic AAL connection options, AAL1-related connection options and AAL2-related connection options. Currently, there are no local connection options defined in this category that pertain to AAL5.

TABLE 2: Generic Local Connection Options for the AAL

LCO	Meaning	Values
aalApp	Application	itu_h323c,af83,AAL5_SSCOP, itu_i3661_unassured, itu_i3661_assured itu_i3662, itu_i3651, itu_i3652, itu_i3653, itu_i3654, FRF5, FRF8, FRF11,itu_h2221
sbc	Subchannel Count	1...24 for T1-based applications 1...31 for E1-based applications

AAL application (aalApp): This connection option specifies the controlling standard for an application layer above the ATM adaptation layer. Other strings can be defined. If used, these need to be prefixed with an "X-".

"itu_h323c"	Annex C of H.323 which specifies direct RTP on AAL5 [12].
"af83"	af-vtoa-0083.001, which specifies variable size AAL5 PDUs with PCM voice and a null SSCS [13].
"AAL5_SSCOP"	SSCOP as defined in ITU Q.2110 [14] running over an AAL5 CPS [27]. No information is provided regarding any layers above SSCOP such as Service Specific Coordination Function (SSCF) layers.
"itu_i3661_unassured"	SSCS with unassured transmission, per ITU I.366.1 [11].
"itu_i3661_assured"	SSCS with assured transmission, per ITU I.366.1 [11]. This uses SSCOP [14].
"itu_i3662"	SSCS per ITU I.366.2 [2].
"itu_i3651"	Frame relay SSCS per ITU I.365.1 [15].
"itu_i3652"	Service-specific coordination function, as defined in ITU I.365.2, for Connection Oriented Network Service (SSCF-CONS) [16]. This uses SSCOP [14].

"itu_i3653"	Service-specific coordination function, as defined in ITU I.365.3, for Connection Oriented Transport Service (SSCF-COTS) [17]. This uses SSCOP [14].
"itu_i3654"	Service-specific coordination function, as defined in ITU I.365.4 [28].
"FRF5"	Use of the FRF.5 frame relay standard [23], which references ITU I.365.1 [15].
"FRF8"	Use of the FRF.8 frame relay standard [24]. This implies a null SSCS and the mapping of the frame relay header into the ATM header.
"FRF11"	Use of the FRF.11 frame relay standard [25].
"itu_h2221"	Use of the ITU standard H.222.1 for audiovisual communication over AAL5 [22].

Subchannel count (sbc): This parameter indicates the number of DS0s in an n x 64 connection. Such connections use an ATM adaptation layer 1 (ATM forum af-vtoa-78) or 2 (ITU I.366.2). For T1-based applications, it can take on integral values in the inclusive range [1...24]. For E1-based applications, it can take on integral values in the inclusive range [1...31]. When this parameter is omitted, the subchannel count must be known by other means.

TABLE 3: Local Connection Options for AAL Type 1

LCO	Meaning	Values
pf	Partial fill	1...48
crt	Clock Recovery Type	NULL, SRTS, ADAPTIVE
fe	FEC enable	NULL, DELAY_SENSITIVE,LOSS_SENSITIVE

Partial Fill Count (pf): When present, the 'pf' parameter is used to indicate the fill level of cells. When this local connection option is absent, then other means (such as provisionable defaults) are used to determine the presence and level of partial fill.

This parameter indicates the number of non-pad payload octets, not including any AAL SAR or convergence sublayer octets. For example, in some AAL1 applications that use partially filled cells with padding at the end, this attribute indicates the number of leading payload octets not including any AAL overhead.

In general, permitted values of the pf parameter are integers in the range 1 - 48 inclusive. However, this upper bound is different for different adaptations since the AAL overhead, if any, is different. If a specified partial fill (e.g. 47) is greater than or equal to the maximum fill (in this example, 46 for AAL1 P-cells), then complete fill (46 in this example) is used. Using a 'partial' fill of 48 effectively disables partial fill. Values below or above the permissible range of 1-48 MUST be rejected with an error code of 532 {Unsupported value(s) in LocalConnectionOptions}.

In the AAL1 context, this parameter applies uniformly to both P and non-P cells. In AAL1 applications that do not distinguish between P and non-P cells, a value of 47 indicates complete fill (i.e., the absence of partial fill). In AAL1 applications that distinguish between P and non-P cells, a value of 46 indicates no padding in P-cells and a padding of one in non-P cells.

If partial fill is enabled (i.e., there is padding in at least some cells), then AAL1 structures must not be split across cell boundaries. These shall fit in any cell. Hence, their size shall be less than or equal to the partial fill size. Further, the partial fill size is preferably an integer multiple of the structure size. If it is not, then the partial fill size stated in the local connection options shall be truncated to an integer multiple of the structure size (e.g., a partial fill size of 40 is truncated to 36 to support six 6 x 64 channels).

Clock recovery type (crt): This is used in AAL1 UDT (unstructured data transfer) applications only. It can be assigned the values: "NULL", "SRTS", or "ADAPTIVE". A value of "NULL" is equivalent to omitting this parameter and implies that the stream (T1 or E1) encapsulated in ATM is either synchronous to the ATM network or is re-timed, before AAL1 encapsulation, via slip buffers. The default value used in the absence of this LCO can be hardcoded or provisioned.

Forward Error Correction Enable (fe): This indicates whether FEC, as defined in ITU I.363.1 [1], is enabled or not. Possible values are: "NULL", "DELAY_SENSITIVE" and "LOSS_SENSITIVE". FEC can be enabled differently for delay-sensitive and loss-sensitive connections. A "NULL" value implies disabling FEC for an AAL1 connection.

TABLE 4: Local Connection Options for AAL Type 2

LCO	Meaning	Values
pfl	Profile List	See below
smplCPS	Simplified CPS [21]	on, off
tmcu	Combined use timer	Integer microseconds (32-bit equivalent)
aalsap	Service access point	AUDIO, MULTIRATE
cktmd	Circuit mode	on, off
frmd	Frame mode enable	on,off
genpcm	Generic PCM setting	PCMA, PCMU
ted	Transmission error detection	on,off
rastimer	SSSAR reassembly timer	Integer microseconds (32-bit equivalent)

Profile List (pfl): This is a list of profiles. Profile types are followed by profile numbers for each type. The ordering of profiles can imply preference, with the most preferred profile first. There can be multiple instances of the same profile type in this list. Spaces are used as delimiters within this list. Therefore, to comply with MGCP syntax [36], it is necessary to enclose this list in double quotes.

The format of the pfl parameter is as follows:

"<profileType#1><format list#1><profileType#2><format list#2> ... <profileType #M><format list#M>"

where <format list#i> has the form <profile#i_1>...<profile#i_N>

The <profileType> parameter indicates the type of profile. It is expressed in the format AAL2/<profileClass> where <profileClass> identifies the source of the definition of the profile.

The <profileClass> can be assigned a string value indicating the source of the subsequent profile numbers until the next <profileType> field. The following rules apply to the contents of the <profileClass> field:

- <profileClass> = "ITU" indicates profiles defined by ITU. Examples: profiles defined in the I.366.2 specification [2].
- <profileClass> = "ATMF" indicates profiles defined by ATM forum. Examples: profiles defined in af-vtoa-0113 [3] or af-vmoa-0145.000 [21].
- <profileClass> = "custom" indicates profiles defined by a corporation or a multi-vendor agreement. Since there is no standard administration of this convention, care should be taken to preclude inconsistencies within the scope of a deployment.
- <profileClass> = <corporateName>
  An equipment vendor or service provider can use its registered, globally unique corporate name (e.g., Cisco, Telcordia etc.) as a string value of the <profileClass>. It is suggested that organizations maintain consistent definitions of the advertised AAL2 profiles that bear their corporate name.
- The <profileClass> can be based on IEEE Standard 802-1990, Section 5.1, which defines the globally unique, IEEE-administered, three-octet OUIs used in MAC addresses and protocol identifiers. In this case, the <profileClass> field shall be assigned a string value of "IEEE:" concatenated with <oui> where <oui> is the hex representation of a three-octet field identical to the IEEE OUI. Since this is always represented in hex, the "0x" prefix is not used. Leading zeros may be omitted. For example, "IEEE:00000C" and "IEEE:C" both refer to Cisco Systems, Inc.

The <profile#> parameter is expressed as a decimal number in the range 1-255.

An example of the use of the pfl parameter is:

```
L: atm/pfl:"AAL2/ITU 8  AAL2/ATMF 7 8 AAL2/custom 100  AAL2/cisco 200"
```

The syntax for pfl can be represented compactly in the following ABNF (RFC2234) form:

```
  pfl  = "%x22" 1*(profileType (1*profile#))"%x22"
  profileType = "AAL2/" profileClass space
  profile# = 1-255 space ; decimal integer followed by space
  profileClass  =
          "ATMF"/"ITU"/"custom"/corporateName/("IEEE:" oui)
  corporateName =  1*ALPHA   ;one or more alphanumeric characters
  oui  = 1*6 HEXDIG; 1-6 hex digits per IEEE Standard 802-1990
  space = %d32
```

Simplified CPS (smplCPS): This enables the AAL2 CPS simplification described in [21]. It can be assigned the following values: on, off. Under this simplification, each ATM cell contains exactly one AAL2 packet. If necessary, octets at the end of the cell are padded with zeros.

AAL2 combined use timer (tmcu): This is defined in ITU I.363.2 [10]. It is an integer number of microseconds, represented as the decimal equivalent of 32 bits.

AAL service access point (aalsap): The service access point for AAL2 is defined in ITU I.366.2 [2]. The aalsap local connection option can take on the following string values: AUDIO, MULTIRATE.

Circuit mode (cktmd): This is used to enable circuit mode data [2]. It can be assigned a value of "on" or "off".

Frame mode (frmd): This is used to enable frame mode data [2]. It can be assigned a value of "on" or "off".

Generic PCM setting (genpcm): This indicates whether generic PCM encoding in AAL2 profiles is A-law or Mu-law. It can be assigned the string values of "PCMA" and "PCMU".

Transmission error detection (ted): Transmission error detection is defined in ITU I.366.1 [11]. The ted local connection option can take on the following values: on, off. This local connection option is useful in qualifying the aalApp local connection option, when the value of the latter is "itu_i3661_unassured".

SSSAR reassembly timer (rastimer): This is defined in ITU I.366.1 [11]. It is an integer number of microseconds, represented as the decimal equivalent of 32 bits.

When an endpoint supporting the ATM package is audited for capabilities, the following local connection options from Section 3.2 shall be returned: application (atm/aalApp). Further, if one of the values atm/ct is "AAL2", the following additional local connection options shall be returned: profile list (atm/pfl), simplified CPS (atm/smplCPS), service access point (atm/aalsap), circuit mode enable(atm/cktmd), frame mode enable (atm/frmd) and generic PCM setting (atm/genpcm). If more than one value is supported, these shall be expressed as a list of semicolon-separated values. For atm/smplCPS, atm/cktmd and atm/frmd, an audit can return "on", "off" or "on;off" depending on whether the mode is mandatory, unsupported or optional for the endpoint.

An example of returning, in audit response, the local connection options defined in Section 3.2 is:

A: atm/aalApp:itu_i3662, atm/pfl:"AAL2/ATMF 7 8", smplCPS:on;off, aalsap:MULTIRATE, cktmd:off, frmd:off, genpcm:PCMU;PCMA

3.3 Service Layer

TABLE 5: Local Connection Options for the Service Layer

LCO	Meaning	Values
vsel	Voice codec Selection	See below
dsel	Data codec Selection	See below
fsel	Fax codec Selection	See below
ccnf	Codec Configuration	Even number (4 - 32) hex digits
usi	ISUP User Information	Two hex digits

Voice codec selection (vsel): This is a prioritized list of one or more 3-tuples describing voice service. Each vsel 3-tuple indicates a codec, an optional packet length and an optional packetization period.

The vsel local connection option is structured as follows:

```
"<encodingName #1> <packetLength #1><packetTime #1>
<encodingName #2> <packetLength #2><packetTime #2>
   ...
<encodingName #N> <packetLength #N><packetTime #N>"
```

where the <encodingName> refers to a codec name such as PCMU, G726-32, G729 etc. See [18] and [34] for a list of codecs with static payload types. The <packetLength> is a decimal integer representation of the packet length in octets. The <packetTime> is a decimal integer representation of the packetization interval in microseconds.

Voiceband data codec selection (dsel): This is a prioritized list of one or more 3-tuples describing voiceband data passthrough service. Each dsel 3-tuple indicates a codec, an optional packet length and an optional packetization period. Depending on the application, the dsel local connection option may or may not cover facsimile service. This is indicated via an <fxIncl> flag preceding the list of 3-tuples. This flag indicates whether the dsel list explicitly addresses facsimile ("on" value) or not ("off" value). This flag can also be set to "-", which is equivalent to setting it to "off".

If <fxIncl> is "on", then it is rarely useful to also include an fsel option. However, it is syntactically correct to do so as long as the dsel and fsel options include an identical set of 3-tuples, perhaps in a different order.

If <fxIncl> is "off", then any fsel list may still be ignored if the media gateway does not provide separate treatment of voiceband data passthrough and fax. Since, in this case, there is no distinct facsimile service from the media gateway’s perspective, any fsel list does not apply.

The dsel local connection option is structured as follows:

```
"<fxIncl> <encodingName #1> <packetLength #1><packetTime #1>
          <encodingName #2> <packetLength #2><packetTime #2>
          ...
          <encodingName #N> <packetLength #N><packetTime #N>"
```

where the <encodingName> refers to a codec name such as PCMU, G726-32, G729 etc. The <packetLength> is a decimal integer representation of the packet length in octets. The <packetTime> is a decimal integer representation of the packetization interval in microseconds.

Facsimile codec selection (fsel): This is a prioritized list of one or more 3-tuples describing fax service. Each fsel 3-tuple indicates a codec, an optional packet length and an optional packetization period. If the dsel option includes facsimile, the fsel connection option should be consistent with it. Each fsel 3-tuple indicates a codec, an optional packet length and an optional packetization period. The fsel local connection option is structured as follows:

```
"<encodingName #1> <packetLength #1><packetTime #1>
<encodingName #2> <packetLength #2><packetTime #2>
...
<encodingName #N> <packetLength #N><packetTime #N>"
```

where the <encodingName> refers to a codec name such as PCMU, G726-32, G729 etc. The <packetLength> is a decimal integer representation of the packet length in octets. The <packetTime> is a decimal integer representation of the packetization interval in microseconds.

Since spaces are used as delimiters within the vsel, dsel and fsel lists, it is necessary to enclose these lists in double quotes [36].

The vsel, fsel and dsel parameters complement the rest of the local connection options and should be consistent with them.

Examples of the use of these parameters are:

```
L: atm/vsel:"G729 10 10000 G726-32 40 10000"
L: atm/dsel:"off PCMA 10 10000 G726-32 40 10000"
L: atm/fsel:"PCMU 40 5000 G726-32 20 5000"
L: atm/vsel:"G729 10 10000 G726-32 40 10000"
L: atm/dsel:"on  PCMA 10 10000 G726-32 40 10000"
```

The <packetLength>and <packetTime> can be set to "-" when not needed. A <fxIncl> value of "-" is equivalent to setting it to "off". For example:

```
L: atm/vsel:"G729 - - G726-32 - -"
L: atm/dsel:"- G729 - - G726-32 - -"
L: atm/fsel:"G729-24 - -"
```

The vsel, dsel and fsel local connection options can be used in the AAL1, AAL2 and AAL5 contexts. The <packetLength> and <packetTime> are not meaningful in the AAL1 case and should be set to "-". In the AAL2 case, these local connection options indicate the preferred use of some or all of the rows in a given profile table. If multiple 3-tuples are present, they can indicate a preferentially ordered assignment of some rows in that profile to voice, voiceband data passthrough or facsimile service (e.g., row A preferred to row B etc). If multiple profiles are specified in the pfl parameter (described in section 3.2), the profile qualified by these local connection options is the first profile in the list.

Codec configuration (ccnf): This is used to convey the contents of the single codec information element (IE) defined in [30]. The contents of this IE are: a single-octet Organizational Identifier (OID) field, followed by a single-octet Codec Type field, followed by zero or more octets of a codec configuration bit-map. The semantics of the codec configuration bit-map are specific to the organization[30, 31]. Since this bit-map is always represented in hex format, the "0x" prefix is omitted. Leading zeros are not omitted. For example:

```
L: atm/ccnf:01080C
```

indicates an Organizational Identifier of 0x01(the ITU-T). Using [57], the second octet (0x08) indicates a codec type of G.726 (ADPCM). The last octet, 0x0C indicates that 16 kbps and 24 kbps rates are NOT supported, while the 32 kbps and 40 kbps rates ARE supported.

ISUP User Information (usi): This is used to convey the contents of the 'User Information Layer 1 protocol' field within the bearer capability information element defined in Section 4.5.5 of [32], and reiterated as the user service information element (IE) in Section 3.57 of [33]. The 'User Information Layer 1 protocol' field consists of the five least significant bits of Octet 5 of this information element.

The usi LCO represented as a string of two hex digits. The "0x" prefix is omitted since this value is always hexadecimal. These hex digits are constructed from an octet with three leading '0' bits and the last five bits equal to the 'User Information Layer 1 protocol' field described above. Digits to the left are more significant than digits to the right. The resulting values of the usi local connection option are as follows:

VALUE	MEANING
0x01	CCITT standardized rate adaption V.110 and X.30
0x02	Recommendation G.711 Mu-law
0x03	Recommendation G.711 A-law
0x04	Recommendation G.721 32 kbps ADPCM and Recommendation I.460
0x05	Recommendations H.221 and H.242
0x06	Recommendation H.223 and H.245
0x07	Non-ITU-T standardized rate adaption
0x08	ITU-T standardized rate adaption V.120
0x09	CCITT standardized rate adaption X.31 HDLC flag stuffing

3.4 ATM Bearer Traffic Management

These local connection options are used to convey ATM traffic parameters.

TABLE 6: Local Connection Options for ATM bearer traffic management

ATM LCO	Meaning	Values
atc	ATM transfer capability or service category	CBR, nrt-VBR, rt-VBR, UBR, ABR, GFR, DBR,SBR,ABT/IT,ABT/DT
sbt	atc subtype	1...5
qos	QoS class	0...5
bcob	Broadband Connection -Oriented Bearer Class	0...31 (Defined values listed below)
eetim	End-to-end timing required	on,off
stc	Susceptibility to clipping	0...3 (Defined values listed below)
upcc	User plane connection configuration	0...3 (Defined values listed below)

aqf	ATM QoS parameters, forward direction	List, see below
aqb	ATM QoS parameters, backward direction	List, see below
adf0+1	ATM traffic descriptor, forward direction, CLP-independent	List, see below
adf0	ATM traffic descriptor, forward direction, CLP=0	List, see below
adb0+1	ATM traffic descriptor, backward direction, CLP-independent	List, see below
adb	ATM traffic descriptor, backward direction, CLP=0	List, see below
abrf	ABR parameters, forward direction	List, see below
abrb	ABR parameters, backward direction	List, see below
abrSetup	ABR connection set-up parameters	List, see below

ATM transfer capability (atc): This parameter indicates the ATM Transfer Capability described in ITU I.371 [19], equivalent to the ATM Service Category described in the UNI 4.1 Traffic Management specification [8]. In applications conforming to ITU I.371, this parameter can be assigned the following values: DBR, SBR, ABT/IT, ABT/DT, ABR. In applications conforming to the UNI 4.1 Traffic Management specification, this parameter can be assigned the following values: CBR, nrt-VBR, rt-VBR, UBR, ABR, GFR.

Subtype (sbt): This qualifies the atc local connection option. It can be assigned integer values of 1...5. The following combinations of the atc and sbt local connection options are meaningful:

atc	sbt	Resulting transport
CBR/DBR	1	Voiceband signal transport (ITU G.711, G.722, I.363)
CBR/DBR	2	Circuit transport (ITU I.363)
CBR/DBR	4	High-quality audio signal transport (ITU I.363)
CBR/DBR	5	Video signal transport (ITU I.363)
nrt-VBR	1	nrt-VBR.1
nrt-VBR	2	nrt-VBR.2
nrt-VBR	3	nrt-VBR.3
rt-VBR	1	rt-VBR.1
rt-VBR	2	rt-VBR.2
rt-VBR	3	rt-VBR.3
UBR	1	UBR.1
UBR	2	UBR.2
GFR	1	GFR.1
GFR	2	GRR.2
SBR	1	SBR1
SBR	2	SBR2
SBR	3	SBR3

Subtypes for the atc values of CBR or DBR are per [29]. Subtypes for the remaining atc values are per [8] and [19].

QoS class (qos): This indicates the QoS class specified in ITU I.2965.1 [4]. It can take on the integer decimal values in the range 0 - 5. These values are mapped into QoS classes as follows:

VALUE	MEANING
0	Default QoS
1	Stringent
2	Tolerant
3	Bi-level
4	Unbounded
5	Stringent bi-level

Broadband Connection-Oriented Bearer Class (bcob): The bcob local connection option indicates the Broadband Connection-Oriented Bearer Class specified in ITU Q.2961.2 [5]. It is represented as a decimal number in the range 0 - 31, or its hex equivalent (range 0x0 - 0x1F). The following values are currently defined:

VALUE	MEANING
1	BCOB-A
3	BCOB-C
5	Frame relaying bearer service
16	BCOB-X
24	BCOB-VP (transparent VP service)

End-to-end timing (eetim): This indicates whether end-to-end timing is required (Table 4-8 of [29]). It can be assigned a value of "on" or "off".

Susceptibility to clipping (stc): The stc local connection option indicates susceptibility to clipping. It is represented as a decimal number in the range 0 - 3, or its hex equivalent (range 0x0 - 0x3). All values except those listed below are reserved.

VALUE	MEANING
0	Not susceptible to clipping
1	Susceptible to clipping

User plane connection configuration (upcc): The upcc local connection option is represented as a decimal number in the range 0 - 3, or its hex equivalent (range 0x0 - 0x3). All values except those listed below are reserved.

VALUE	MEANING
0	Point to point
1	Point to multipoint

ATM QoS parameters, forward direction (aqf) and backward direction (aqb): Here, forward is the direction away from the media gateway, backward is the direction towards the gateway. If the directional convention used by bearer signaling at the gateway is different, then appropriate translations must be done by the media gateway. These parameters have the following format:

"<cdvType><acdv><ccdv><eetd><cmtd><aclr>"

Since spaces are used in this list, it must be enclosed in double quotes for MGCP compliance [36].

The <cdvType> parameter can take on the string values of "PP" and "2P". These refer to the peak-to-peak and two-point CDV as defined in UNI 4.0 [6] and ITU Q.2965.2 [7] respectively.

The CDV parameters, <acdv> and <ccdv>, refer to the acceptable and cumulative CDVs respectively. These are expressed in units of microseconds and represented as the decimal or hex equivalent of 24-bit fields. These use the cell loss ratio, <aclr>, as the "alpha" quantiles defined in the ATMF TM 4.1 specification [8] and in ITU I.356 [9].

The transit delay parameters, <eetd> and <cmtd>, refer to the end-to-end and cumulative transit delays respectively in milliseconds. These are represented as the decimal equivalents of 16-bit fields. These parameters are defined in Q.2965.2 [7], UNI 4.0 [8] and Q.2931 [29].

The <aclr> parameter refers to forward and backward acceptable cell loss ratios. This is the ratio between the number of cells lost and the number of cells transmitted. It is expressed as the decimal or hex equivalent of an 8-bit field. This field expresses an order of magnitude n, where n is an integer in the range 1-15. The Cell Loss Ratio takes on the value 10 raised to the power of minus n.

If any of these parameters is not specified, is inapplicable or is implied, then it is set to "-".

Examples of the use of the aqf and aqb local connection options are:

```
L: atm/aqf:"PP 8125 3455 32000 - 11"
L: atm/aqb:"PP 4675 2155 18000 - 12"
```

This implies a forward acceptable peak-to-peak CDV of 8.125 ms, a backward acceptable peak-to-peak CDV of 4.675 ms, forward cumulative peak-to-peak CDV of 3.455 ms, a backward cumulative peak-to-peak CDV of 2.155 ms, a forward end-to-end transit delay of 32 ms, a backward end-to-end transit delay of 18 ms, an unspecified forward cumulative transit delay, an unspecified backward cumulative transit delay, a forward cell loss ratio of 10 raised to minus 11 and a backward cell loss ratio of 10 to the minus 12.

ATM traffic descriptors, forward direction CLP=0+1 (adf0+1), backward direction CLP=0+1 (adb0+1), forward direction CLP=0 (adf0), backward direction CLP=0 (adb0): Here, forward is the direction away from the media gateway, backward is the direction towards the gateway. If the directional convention used by bearer signaling at the gateway is different, then appropriate translations must be done by the media gateway. The adf0+1, adb0+1, adf0 and adb0 local connection options have the following format:

```
"<pcr><scr><mbs><cdvt><mcr><mfs><fd><te>"
```

Since spaces are used in these lists, they must be enclosed in double quotes for MGCP compliance [36].

These parameters are defined per the ATMF TM 4.1 specification [8]. Each of these parameters can be set to "-" if the intent is to not specify it via MGCP. These definitions are listed briefly in Table 7 below.

TABLE 7: ATM Traffic Descriptor Parameters

PARAMETER	MEANING	UNITS
pcr	Peak Cell Rate	Cells per second
scr	Sustained Cell Rate	Cells per second
mbs	Maximum Burst Size	Cells
cdvt	Cell Delay Variation Tolerance	Microseconds
mcr	Minimum Cell Rate	Cells per second
mfs	Maximum Frame Size	Cells
fd	Frame Discard Allowed	on/off
te	CLP tagging enabled	on/off

The pcr, scr, cdvt and mbs can be represented as the decimal equivalents of 24-bit fields. The mbs and mfs can be represented as the decimal equivalents of 16-bit fields.

Examples of these local connection options are:

```
   L: atm/adf0+1:"200   100  20   - - - on  -",
      atm/adf0:"200   80   15   - - - -  off",
      atm/adb0+1:"200   100  20   - - - on -",
      atm/adb0:"200   80   15   - - - -  off"
```

This implies a forward and backward PCR of 200 cells per second for all cells regardless of CLP, forward and backward PCR of 200 cells per second for cells with CLP=0, a forward and backward SCR of 100 cells per second for all cells regardless of CLP, a forward and backward SCR of 80 cells per second for cells with CLP=0, a forward and backward MBS of 20 cells for all cells regardless of CLP, a forward and backward MBS of 15 cells for cells with CLP=0, an unspecified CDVT which can be known by other means, and an MCR and MFS which are unspecified because they are inapplicable. Frame discard is enabled in both the forward and backward directions. Tagging is not enabled in either direction.

ABR parameters, forward direction (abrf) and backward direction (abrb): Here, forward is the direction away from the media gateway, backward is the direction towards the gateway. If the convention used by bearer signaling at the gateway is different, then appropriate translations must be done by the media gateway. The abrf and abrb local connection options have the following format:

```
   "<nrm><trm><cdf><adtf>"
```

Since spaces are used in these lists, they must be enclosed in double quotes for MGCP compliance [36].

These ABR parameters are defined per [6] and [8]. Their definition is summarized in Table 8 below. In MGCP, these are represented as the decimal equivalent of the binary fields mentioned below. If any of these parameters is meant to be left unspecified, it is set to "-".

TABLE 8: ABR Parameters

PARAMETER	MEANING	FIELD SIZE
NRM	Maximum number of cells per forward Resource Management cell	3 bits
TRM	Maximum time between forward Resource Management cells	3 bits
CDF	Cutoff Decrease Factor	3 bits
ADTF	Allowed Cell Rate Decrease Time Factor	10 bits

ABR set-up parameters (abrSetup): This local connection option is used to indicate the ABR parameters needed during call/connection establishment (Section 10.1.2.2 of the UNI 4.0 signaling specification [6]). The abrSetup local connection option has the following format:

"<ficr><bicr><ftbe><btbe><crmrtt><frif><brif><frdf><brdf>"

Since spaces are used in this list, it must be enclosed in double quotes for MGCP compliance [36].

These parameters are defined per [6]. Their definitions are listed briefly in Table 9 below. In these definitions, forward is the direction away from the media gateway, backward is the direction towards the gateway. If the convention used by bearer signaling at the gateway is different, then appropriate translations must be done by the media gateway. If any of these parameters is meant to be left unspecified, it is set to "-".

TABLE 9: ABR Set-up Parameters

PARAMETER	MEANING	REPRESENTATION
<ficr>	Forward Initial Cell Rate (Cells per second)	Decimal equivalent of 24-bit field
<bicr>	Backward Initial Cell Rate (Cells per second)	Decimal equivalent of 24-bit field
<ftbe>	Forward transient buffer exposure (Cells)	Decimal equivalent of 24-bit field
<btbe>	Backward transient buffer exposure (Cells)	Decimal equivalent of 24-bit field
<crmrtt>	Cumulative RM round-trip time (Microseconds)	Decimal equivalent of 24-bit field
<frif>	Forward rate increase factor (used to derive cell count)	Decimal integer 0 -15
<brif>	Backward rate increase factor (used to derive cell count)	Decimal integer 0 -15
<frdf>	Forward rate decrease factor (used to derive cell count)	Decimal integer 0 -15
<brdf>	Backward rate decrease factor (used to derive cell count)	Decimal integer 0 -15

3.5 AAL Dimensioning

The Local Connection Options in Table 10 are used to dimension the operation of the AAL. In these parameters, forward is the direction away from the media gateway. Backward is the direction towards the media gateway. These parameters are represented as decimal integers in the ranges listed in Table 10.

TABLE 10: Local Connection Options used to dimension the AAL

LCO	Meaning	Values (Decimal Integer)
str	Structure Size	1...65,535

cbrRate	CBR rate	Bit map per Table 4-6 of [29]
fcpcs	Forward maximum CPCS SDU size	AAL2: 45 or 64 AAL5: 1-65,535
bcpcs	Backward maximum CPCS SDU size	AAL2: 45 or 64 AAL5: 1-65,535
fSDUrate	Forward maximum AAL2 CPS SDU rate	24-bit equivalent
bSDUrate	Backward maximum AAL2 CPS SDU rate	24-bit equivalent
ffrm	Forward maximum frame block size	1-65,535
bfrm	Backward maximum frame block size	1-65,535
fsssar	Forward maximum SSSAR-SDU size	1-65,568
bsssar	Backward maximum SSSAR SDU size	1-65,568
fsscopsdu	Forward maximum SSCOP-SDU size	1-65,528
bsscopsdu	Backward maximum SSCOP SDU size	1-65,528
fsscopuu	Forward maximum SSCOP-UU field size	1-65,524

bsscopuu	Backward maximum SSCOP UU size	1-65,524

Structured Data Transfer Block Size (str): This parameter is meaningful only when structured AAL1 is used. It indicates the size (in octets) of the block used for structured data transfer. If not included as a local connection option, the structure size is to be known by other means. For instance, af-vtoa-78 [20] fixes the structure size for n x 64 service, with or without CAS. The L: atm/str parameter is coded as the decimal equivalent of a 16-bit field [29]. The theoretical maximum value of this parameter is 65,535, although most services use much less.

CBR Rate (cbrRate): This is a hexadecimal representation of the bit map defined in Table 4-6 of ITU Q.2931 [29]. This is represented as exactly two hex digits. For example:

```
L: atm/cbrRate:04
```

implies a CBR rate of 1.544 Mbps.

Forward maximum CPCS-SDU size (fcpcs): This is the maximum size of the AAL2 or AA5 CPCS SDU in the forward direction.

Backward maximum CPCS-SDU size (bcpcs): This is the maximum size of the AAL2 or AA5 CPCS SDU in the backward direction.

Forward maximum AAL2 CPCS-SDU rate (fSDUrate): This is the maximum rate of the AAL2 CPCS-SDUs in the forward direction.

Backward maximum AAL2 CPCS-SDU rate (bSDUrate): This is the maximum rate of the AAL2 CPCS-SDUs in the backward direction.

The fSDUrate and bSDUrate local connection options can be used to rate-limit AAL2 CIDs, especially when used in the SSSAR [1] and frame mode [2] contexts.

Forward maximum frame mode block size (ffrm): This is the maximum size, in the forward direction, of the AAL2 frame mode data unit (I.366.2) [2].

Backward maximum frame mode block size (bfrm): This is the maximum size, in the backward direction, of the AAL2 frame mode data unit (I.366.2) [2].

Forward maximum SSSAR-SDU size (fsssar): This is the maximum size, in the forward direction, of the AAL2-based SSSAR-SDU (I.366.1) [1].

Backward maximum SSSAR-SDU size (bsssar): This is the maximum size, in the backward direction, of the AAL2-based SSSAR-SDU (I.366.1) [1].

Forward maximum SSCOP-SDU size (fsscopsdu): This is the maximum size, in the forward direction, of the AAL2-based SSCOP-SDU (I.366.1) [1].

Backward maximum SSCOP-SDU size (bsscopsdu): This is the maximum size, in the backward direction, of the AAL2-based SSCOP-SDU (I.366.1) [1].

Forward maximum SSCOP-UU size (fsscopuu): This is the maximum size, in the forward direction, of the AAL2-based SSCOP-UU field(I.366.1) [1].

Backward maximum SSCOP-UU size (bsscopuu): This is the maximum size, in the backward direction, of the AAL2-based SSCOP- UU field (I.366.1) [1].

4.0 Signals and Events

Standard MGCP syntax and keywords [36] are used in Table 11 to define the events in this package. Since these are all connection events, they cannot be requested for endpoints. For consistency with MGCP [36], it is required that the suffix @<connection-id> NOT be omitted even if there is only one connection to an endpoint. This suffix can also be wildcarded per MGCP rules.

There are no auditable event-states associated with the ATM package.

Set-up complete ("sc"):

Within the RequestedEvents (R:) structure, "sc" is used to request notification of successful ATM or AAL2 connection set-up. The ATM OR AAL2 bearer path is ready for subscriber payload carriage when this notification is sent.

This could be the set-up of an SVC, the assignment of an AAL2 CID path and combinations thereof. Examples of such combinations are the set-up of an AAL2 SVC and the assignment of a CID within it or the set-up of a concatenation of an AAL2 single-CID SVC and a CID channel within a multiplexed AAL2 VC.

This event is included for backward compatibility. It is preferred that the call agent and the media gateway rely on provisional acknowledgements in the case in which connection set-up has a long

latency. However, if this event is requested, the media gateway must issue notification of connection set-up via this event. In this case, a provisional acknowledgement is not very useful, and full acknowledgement of the create connection or modify connection need not be deferred until connection set up.

The designated trigger for an ATM OR AAL2 connection set-up is an "on" value of the L: atm/se local connection option provided with a create or modify connection command. However, it is recognized that certain applications use the presence of an atm/sc event notification to initiate the set-up of an ATM or AAL2 connection.

TABLE 11: Signals and Events in the ATM package

SYMBOL	DEFINITION	R	S	DURATION
sc	Bearer path set-up complete	C		
sf	Bearer path set-up failed	C		
ec	Enable CAS via type 3 packets		oo	
etd	Enable DTMF tone forwarding via packets		oo	
etm	Enable MF tone forwarding via packets		oo	
etr1	Enable MF-R1 tone forwarding via packets		oo	
etr2	Enable MF-R2 tone forwarding via packets		oo	
uc (string)	Used codec changed to codec named by the string	C		
ptime (#)	Packetization period changed to #	C		

pftrans (#)	Profile element changed to row #	C		
cle (#)	Cell Loss threshold (#) exceeded	C		
pl (#)	Packet Loss Threshold exceeded (#)	C		
qa	Quality Alert	C		
of (#)	Operation failure: Loss of connectivity with reason code #	C		

Set-up failed ("sf"):

Within the RequestedEvents (R:) structure, "sf" is used to request notification of a failed ATM OR AAL2 connection set-up. The ATM OR AAL2 connection set-ups addressed by "sf" are the same as for the "sc" event.

In some ATM OR AAL2 applications with SVC set-up or bearer-signalled AAL2 path assignment, the "sf" event might not be used. In these cases, the following options are available:

* the call agent receives a spontaneous delete from the media gateway with an appropriate reason code (902).
* the call agent receives the "of" event described below with the optional reason code (902).

Enable CAS via type 3 packets ("ec"):

This signal indicates that the media gateway is to forward CAS signaling via type 3 packets on an AAL2 connection. This does not preclude the call agent from requesting notification of CAS state changes. On receiving this signal request, the gateway sustains a bidirectional type 3 CAS protocol over the AAL2 path. This comes to an end when the request is cancelled through a subsequent NotificationRequest command or when the VoAAL2 connection is deleted.

Enable DTMF tones via type 3 packets ("etd"):

A gateway will ignore this signal request if it normally forwards and receives DTMF tones via type 3 packets. This signal indicates that the media gateway is to forward and receive DTMF tones via type 3 packets on an AAL2 connection. This does not preclude the call agent from requesting notification of DTMF tones.

Enable MF tones via type 3 packets ("etm"):

A gateway will ignore this signal request if it normally forwards and receives MF tones via type 3 packets. This signal indicates that the media gateway is to forward and receive MF tones via type 3 packets on an AAL2 connection. This does not preclude the call agent from requesting notification of MF tones. This signal request does not specify the MF tone type, which is known by other means.

Enable R1 MF tones via type 3 packets ("etr1"):

A gateway will ignore this signal request if it normally forwards and receives R1 MF tones via type 3 packets. This signal indicates that the media gateway is to forward and receive R1 MF tones via type 3 packets on an AAL2 connection. This does not preclude the call agent from requesting notification of R1 MF tones.

Enable R2 MF tones via type 3 packets ("etr2"):

A gateway will ignore this signal request if it normally forwards and receives R2 MF tones via type 3 packets. This signal indicates that the media gateway is to forward and receive R2 MF tones via type 3 packets on an AAL2 connection. This does not preclude the call agent from requesting notification of R2 MF tones.

Used codec changed ("uc (string)"):

If armed via an R:atm/uc, a media gateway signals a codec change through an O:atm/uc. The alphanumeric string in parentheses is optional. It is the encoding name of the codec to which the switch is made. Although this event can be used with all ATM adaptations (AAL1, AAL2 and AAL5):

* The pftrans event is more suited to AAL2 applications.
* Codec switches do not generally occur mid-call in AAL1 applications.

Packet time changed ("ptime(#)"):

If armed via an R:atm/ptime, a media gateway signals a packetization period change through an O:atm/ptime. The decimal number in parentheses is optional. It is the new packetization period in milliseconds. In AAL2 applications, the pftrans event can be used to cover packetization period changes (and codec changes).

Profile element changed ("pftrans(#)"):

If armed via an R:atm/pftrans, a media gateway signals a mid-call profile element change through an O:atm/ptime. This event is used with AAL2 adaptation only. A profile element is a row in a profile table. Profile elements indicating silence should not trigger this event. The decimal number in parentheses is optional. It is the row number to which the switch is made. Rows are counted downward, beginning from 1.

Cell loss exceeded ("cle(#)"):

This event indicates that the cell loss rate exceeds the threshold #. If the threshold is omitted in the requested events and observed events parameters, it is known by other means. The optional decimal number is the number of dropped cells per 100,000 cells. For example, cle(10) indicates cells are being dropped at a rate of 1 in 10,000 cells.

Packet loss exceeded ("ple(#)"):

This event indicates that the packet loss rate exceeds the threshold #. If the threshold is omitted in the requested events and observed events parameters, it is known by other means. The optional decimal number is the number of dropped packets per 100,000 packets. For example, ple(10) indicates packets are being dropped at a rate of 1 in 10,000 packets.

When the bearer connection uses an AAL2 CID within a multiplexed VCC rather than an entire VCC, the ’ple’ event is used instead of ’cle’. The packets are AAL2 CPS PDUs.

Quality alert ("qa"):

This event indicates that the bearer path fails to any predetermined combination of quality criteria such as loss, delay, jitter etc. This criterion is not defined and is left to the application. The gateway reports this quality violation to the call agent if armed to do so.

Report failure ("of (#)"):

This indicates a connection failure. It can also indicate failure to establish a connection, in lieu of "sf".

The most common response to these events is for the media gateway to delete the connection. Some applications might choose to report an "of" with the appropriate reason code, a decimal number, optionally included in parentheses. Reason codes are the same as for spontaneous deletes by the gateway.

5.0 Connection Parameters

The MGCP connection parameters structure is returned in an autonomous delete connection message, and in a response to a delete or audit connection command. The standard connections parameters [36] it contains are redefined below for ATM. Also, a new extension parameter specific to the ATM package is defined.

The standard connection parameters redefined for ATM are:

Number of packets sent: If a VCC is assigned to the connection, this is the total number of ATM cells transmitted for the duration of the connection. If a CID within an AAL2 VCC is assigned to the connection, it is the number of AAL2 common part sublayer (CPS) packets transmitted for the duration of the connection.

Number of octets sent: If a VCC is assigned to the connection, this is the total number of ATM payload octets transmitted for the duration of the connection. If a CID within an AAL2 VCC is assigned to the connection, this is the total number of AAL2 CPS payload octets transmitted for the duration of the connection.

Number of packets received: If a VCC is assigned to the connection, this is the total number of ATM cells received for the duration of the connection. If a CID within an AAL2 VCC is assigned to the connection, it is the number of AAL2 common part sublayer (CPS) packets received for the duration of the connection.

Number of octets received: If a VCC is assigned to the connection, this is the total number of ATM payload octets received for the duration of the connection. If a CID within an AAL2 VCC is assigned to the connection, this is the total number of AAL2 CPS payload octets received for the duration of the connection.

Number of packets lost: If a VCC is assigned to the connection, this is the total number of ATM cells lost for the duration of the connection, in the direction towards the gateway. If a CID within an

AAL2 VCC is assigned to the connection, it is the number of AAL2 common part sublayer (CPS) packets lost for the duration of the connection, in the direction towards the gateway. If these losses cannot be assessed, then the gateway omits this parameter.

Interarrival jitter: If a VCC is assigned to the connection, this is the interarrival jitter for ATM cells. If a CID within an AAL2 VCC is assigned to the connection, this is the interarrival jitter for AAL2 common part sublayer (CPS) packets. If this cannot be determined, then it is omitted or set to 0.

Average Transmission Delay: This should be understood to be the average cell transmission delay in both cases: VCC assignment and CID assignment to the connection. This requires the use of ATM performance monitoring techniques. If it is not possible to assess this delay, it is omitted or set to 0.

The following extension parameter is defined for the connection parameters structure:

Connection qualification ("atm/CQ"): This qualifies the connection with enough granularity to be able to use the other connection parameters without a priori knowledge of network or connection type. Defined values are:

1	ATM Virtual Circuit Connection (VCC)
2	AAL2 Channel Identifier (CID)
3	Direct transfer i.e., without an ATM or other packet path

When omitted, the connection parameters must be interpreted on one of the following bases:

* The default interpretations for MGCP in Ref. 36.
* The call agent’s prior knowledge, if it governs the type of network and connection through the network type ’nt’ LCO [Ref. 36] and/or the connection type ’ct’ LCO defined here.
* The call agent’s snooping of the local connection descriptor provided by one or more media gateway. This is used to determine the network and connection type.

An example of connection parameter encoding for an ATM VCC is the following:

P: PS=1245, OS=59760, PR=1244, OR=59712, PL=20, JI=0, LA=0,atm/CQ=1

Note that the PL value refers to the receive direction and is unrelated to PS. Also, since atm/CQ=1, these parameters refer to ATM cells rather than to AAL2 CPS packets.

As in other applications, any of these parameters can be omitted if not relevant to an application. Also, the entire P: structure is optional.

When connection parameters are audited, all parameters normally returned with a delete connection are returned. This includes the connection qualification parameter, atm/CQ.

The measurement or estimation of some or all of these connection parameters might not be feasible or beneficial in some applications. In such cases, these may be individually omitted, or the entire connection parameters structure, which is optional in MGCP, might be omitted. Further, parameters which indicate impairments might be set to 0 to nullify their impact, if any.

6.0 Negotiation of Profiles and Codecs in ATM Applications

6.1 Consistency of Parameters

For ATM networks, the "nt" local connection option in MGCP must be set to "ATM".

In any ATM application, the following Local Connection Options should not be used:

Type of service, L: t
Resource reservation, L: r

This is because the Local Connection Options listed in Table 6 provide information equivalent to the L: t and L: r local connection options.

The following Local Connection Option is not meaningful in the AAL1 case and should not be used:

Packetization period, L: p

In AAL2 applications, the following Local Connection Options should not be used:

Encoding algorithm, L: a
Packetization period, L: p

The following ATM Local Connection Options provide equivalent information in the AAL2 case:

Profile list, L: atm/pfl
Priority list of voice codec selections, L: atm/vsel
Priority list of voiceband data passthrough codec selections, L: atm/dsel
Priority list of fax codec selections, L: atm/fsel

The use of a disallowed local connection option should be flagged with a return code of 524 (inconsistent local connection options). Although it is not recommended that these be ignored, it is recognized some applications choose to do so for the sake of backward compatibility. Note that the inconsistency in this case is between the local connection option (e.g., L:a) and the application (e.g., AAL2) which does not allow it.

6.2 Codec/Profile Negotiation in ATM Networks

In AAL1 and AAL5 applications, codec negotiation is similar to the IP case, although some of the local connection options and SDP connection descriptor parameters are different. See [18] for conventions for the use of the Session Description Protocol [26] in the ATM context.

In AAL2 applications, the L:a and L:p parameters are disallowed. Profile negotiation takes the place of codec negotiation. The remainder of this section addresses how this is done.

The specifics of the AAL2 bearer are not germane to profile negotiation. The bearer could be PVC-based or SVC-based, based on single-CID or multi-CID VCs, subcell multiplexed or not.

The most general case involves different prioritized lists of profiles at the originating gateway, the terminating gateway, the originating call agent and the terminating call agent. Whether these lists are based on network policies, end subscriber service level agreements or equipment design is immaterial to the profile negotiation that is done as part of the connection establishment process. It is also irrelevant whether these lists are hardcoded defaults or provisionable. In the connection establishment process, a series of ordered intersections is performed. This leaves a single ordered list in the end. The highest priority profile in this list is the selected profile.

The call agent conveys its priority list through the pfl local connection option. The gateway conveys intersection results through the media information line in SDP [18]. Whether these lists imply a real priority or not, a profile is, as a general rule, preferred to profiles that follow it in a list.

Each media gateway has a policy for assigning priorities to different lists (inter-list priority) which is different from the positional ordering of profiles within a list (intra-list priority). This policy might be a hardcoded default or provisioned. The inter-list priority specifies an ordering of the following lists with respect to each other:

* 'C-list', which is the priority list from the call agent, received through L: atm/pfl.
* 'R-list', which is the priority list from the remote end, received through the SDP remote connection descriptor.
* 'L-list', which is the local priority list, hardcoded or provisioned.

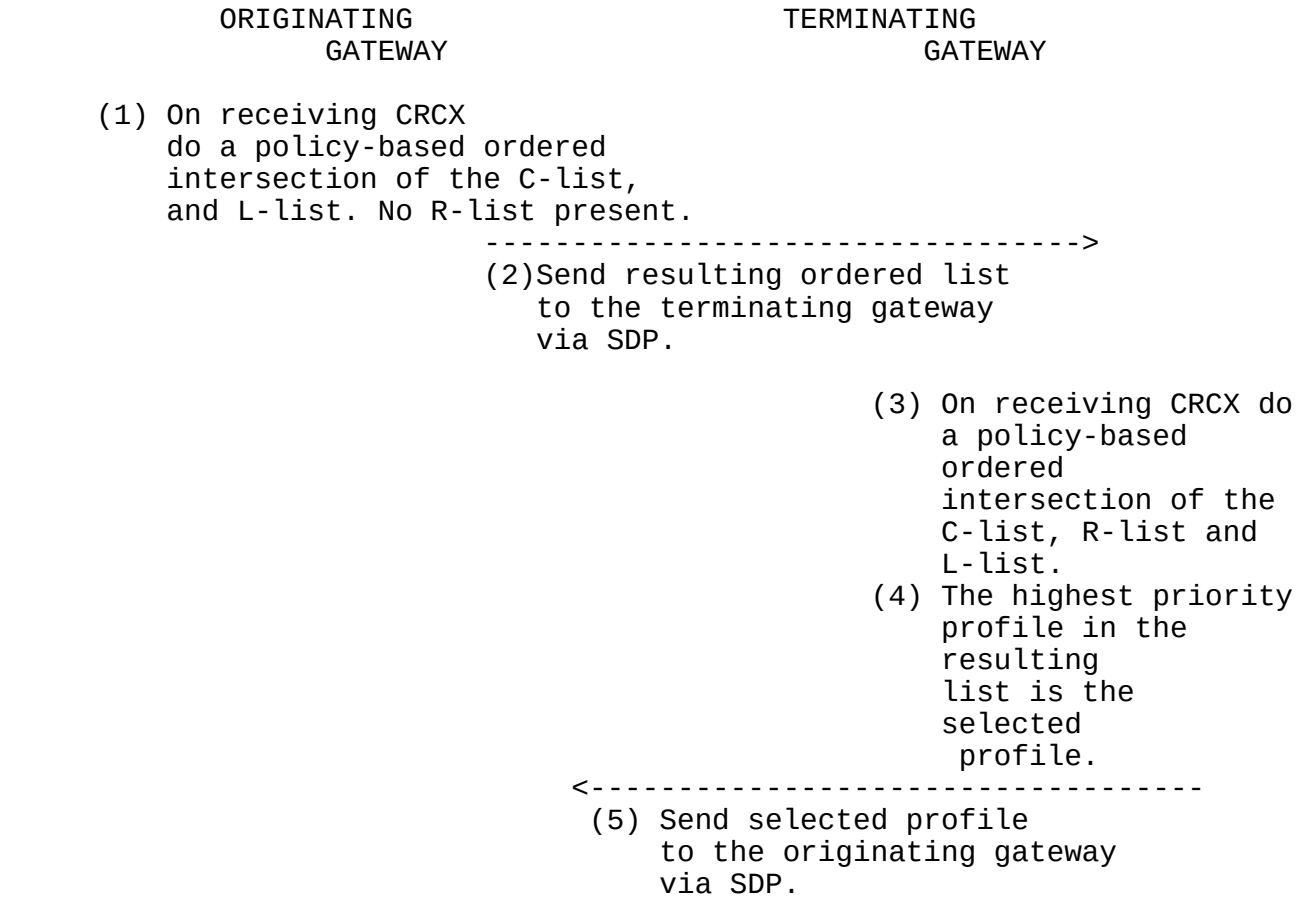
Depending on the application, different inter-list priorities may be used in cases where the gateway originates and terminates a call.

The policy mentioned above will vary depending on the type, capabilities and deployment of the media gateway. Network administrations or equipment vendors will provision/default this policy for various reasons such as resource usage optimization, quality of service, likelihood of finding a common profile etc.

When doing an ordered intersection of lists, the intra-list priorities of the highest priority list are used. Any profile that cannot be supported due to resource (bandwidth, processing power etc.) limitations is eliminated from the intersection.

In the absence of one or more of these lists, the remaining list(s) are used in the profile selection process. If the call agent does not provide a list of profiles, the C-list is absent. In this case, the intersection of the C-list, R-list and L-list simply becomes the intersection of the R-list and the L-list. If the R-list is also absent, no intersection is performed and the result of this null operation is the L-list. Previous values, if any, of the C-list and R-list are not used.

The process of profile negotiation is as shown below:



Prior to receiving the final profile in step 5, if the originating gateway has indicated multiple profiles in step 2, the originating gateway does not always have a usable basis for decoding AAL2 packets. This is because a combination of packet length and UUI (user-to-user indication) codepoint range may indicate different codecs in different profiles. The time lag between when the terminating gateways start sending AAL2 packets and when the originating gateway becomes aware of the selected AAL2 profile should be minimized so that any ensuing clipping of the front-end of the audio stream is tolerable for voice circuits. It is unlikely that this will introduce errors in modem or fax circuits since these will not have entered their user data transfer phase at this time.

When connection establishment is complete, there is only one profile associated with a connection. This implies that both endpoints are ready to receive, on the fly, packets that comply with any row in the profile. Some applications may elect to associate profile rows with

one or more of the following service types: voice service, voiceband data (modem) passthrough service and fax service. This binding can be by default, through provisioning or as part of profile negotiation during call establishment. Such service type associations, when communicated to another entity, are advisory and do not limit the requirement for supporting, at any time, on-the-fly switches to any profile element.

Media gateways can have internal default (or provisioned) bindings between service types and profile elements. Note that not all of these bindings might be meaningful in an application context (e.g., the fax service binding might be ignored and omitted). As part of profile negotiation, applications might choose to coordinate those bindings that are meaningful. When this is done, the vsel, dsel and fsel LCOs described in this document, and the vsel, dsel and fsel media attribute lines [18] are used to effect this coordination. Using these constructs, entities such as call agents and media gateways can indicate preferred bindings for the first, most preferred profile in a profile list.

When performing ordered intersections of the C-list, L-list and R-list in the call flow above, media gateways MUST use the inter-list priority to choose between a service to profile row binding suggested by the call agent, the remote gateway or it own internal (provisioned or default) binding. Thus, a service type to profile row binding inherits its relative priority from the profile list generated by the same source. If the C-list has the highest priority, and the first profile in the C-list is selected as the first profile of the intersected list, then any service type to profile row bindings provided by the call agent via the vsel, dsel and fsel LCOs are associated with the first profile. If the R-list has the highest priority, and the first profile in the R-list is selected as the first profile of the intersected list, then any service type to profile row bindings provided by the remote gateway via the vsel, dsel and fsel SDP attributes [18] are associated with the first profile. If the L-list has the highest priority, then any internal (default or provisioned) service to profile row bindings are associated with the first profile. At the end of profile negotiation (step 4 in the call flow above), there is one profile selected by the terminating media gateway. It MAY convey any applicable service type to profile row bindings for this profile to the originating gateway via the vsel, dsel and fsel SDP attributes [18].

If the first profile in the intersected list is not the first profile in the highest priority profile list, then any service to profile row bindings associated with the highest priority profile list cannot be used with the first (or only profile) in the intersected list. In this case, the originating or terminating media gateway MUST attempt

to associate internal (default or provisioned) service to profile row bindings with the first (or only profile) in the intersected list.

Since there is more than one service type, it is possible that the service type to profile row bindings for the first profile in the intersected list be derived from different sources (the call agent, the remote media gateway, internal defaults or provisioning). For consistency, if the voiceband data (passthrough) service mappings include fax, then a different set of fax service mappings cannot apply to the profile under consideration. If applied in this case, the set of fax service mappings must include the same codecs, packet lengths and packetization periods as the voiceband data service mappings. However, they may be in a different order.

If the media gateway lumps fax service with voiceband data (modem) passthrough service, then it can ignore any fax service to profile row bindings provided by another entity such as the call agent or the remote gateway. From the media gateway's perspective, there is no distinct fax service in this case. In this case, the media gateway will not indicate a separate preference for the use of certain profile rows in conjunction with fax service.

It is possible that the procedure described in this section for associating service types with profile rows fail to yield mappings between a given service type and the row(s) of the first profile in the intersected list of profiles. This is acceptable since these bindings are merely indications of the preferred codecs and packetizations in the context of a given service. They do not obviate the AAL2 requirement that, given a profile that is bound to a connection, a transmitter may switch to any profile row on the fly.

An example of profile negotiation:

The L-list at gateway #1, which is the originating gateway in this example, is:

```
custom 100, itu 3, itu 1, itu 8
```

The L-list at gateway #2, which is the terminating gateway in this example, is:

itu 2, itu 3, itu 1, itu 5

The originating call agent sends the following profile list (C-list) to the originating gateway in the first create connection command:

itu 8, itu 9, atmf 7, itu 3, itu 1, custom 100

Further, the originating call agent qualifies the first profile in its list with the following service type bindings:

L: atm/vsel:"G729 10 10000", atm/dsel:"on PCMU 40 5000"

There is no atm/fsel local connection option. Facsimile is included with voiceband data in the atm/dsel local connection option.

In step 1 at the originating gateway, there is no remote connection descriptor, hence no R-list. The policy for originating calls at gateway #1 is:

C-List > R-list > L-list

where '>' means 'has higher priority than'. The term 'R-list' can be omitted from this series of inequalities since, in case under study, profile negotiation does not include any further ordered intersections at the originating gateway.

In accordance with this policy, the originating gateway performs an ordered intersection of the C-list and the L-list to produce:

itu 8, itu 3, itu 1, custom 100

Since the C-list has the highest priority and the first profile in the intersected profile list is also the first profile in the C-list, the service bindings provided by the originating call agent are associated with the first profile, itu 8. The originating gateway sends this result(intersected profile list and service bindings for the first profile, itu 8) via the SDP remote session descriptor to the terminating gateway. The service bindings are expressed as follows [18]:

a=vsel:G729 10 10000
a=dsel:on PCMU 40 5000

The intersected profile list produced by gateway 1 becomes the R-list for gateway #2. The terminating call agent sends the following profile list (C-list) to the terminating gateway in the first create connection command:

```
itu 1, itu 4,   itu 3, custom 110, custom 100, itu 2
```

Any service bindings (not shown) sent by the terminating call agent apply to the first profile in this list, itu 1.

The policy for terminating calls at gateway #2 is:

```
R-list > L-list > C-list
```

Using this policy, gateway #2 produces the following ordered intersection of R-list, L-list and C-list:

```
itu 3, itu 1
```

The first profile in this list, itu 3, is to be used for this connection. Gateway 2 indicates this to the call agent through the SDP local connection descriptor.

Note that the service bindings provided by the originating gateway have not been specified with respect to itu 3. Therefore, these cannot be used even though the R-list has the highest priority at the terminating gateway. Any existing internal (default or provisioned) service bindings for AAL2 profile itu 3 must be associated by the terminating gateway with the selected profile, itu 3. Those service bindings that are internally unavailable are left unspecified.

Since the internal service type bindings do exist for the profile itu 3 at the terminating gateway, they are selected and bound to the connection. In these, fax service is lumped with voiceband data passthrough. These bindings are indicated to the originating gateway via the following SDP media attribute lines:

```
a=vsel:G726-32 20 5000 G726-24 15 5000
a=dsel:on PCMU 40 5000 G726-40 25 5000
```

The vsel line maps voice service to certain rows in the itu 3 profile table. The dsel line maps voiceband data service to certain rows in the itu 3 profile table. The "on" in the dsel line indicates that voiceband data includes fax, otherwise a separate fsel line might have been used. Two codecs each are indicated for voice and for voiceband data, with the first codec being the preferred one. Although the originating gateway is not constrained by these advisory indications of profile element to service type mapping, applications may choose to limit on-the-fly switches based on the current service state (voice, voiceband data etc.). If done, this provides greater simplicity at the expense of flexibility.

7.0 Security Considerations

The ATM package extends the base Media Gateway Control Protocol (MGCP) [36]. This package specifies no additional security requirements or recommendations over those of the base MGCP protocol.

8.0 IANA Considerations

The ATM package described in this document has been registered as an MGCP package under the name "atm", without the quotes. The current version of this package is 0 (default). This registration has been completed per the IANA considerations in the MGCP specification [36].

The contact for the MGCP ATM package is the author of this document (Section 12).

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10.0 Acronyms

AAL ATM Adaptation Layer
ABR Available Bit Rate
ABT/DT ATM Block Transfer/Delayed Transmission
ABT/IT ATM Block Transfer/Immediate Transmission
ATM Asynchronous Transfer Mode
ATMF ATM Forum
BCG Bearer Connection Group
CAS Channel Associated Signaling
CBR Constant Bit Rate
CDV Cell Delay Variation
CDVT Cell Delay Variation Tolerance
CID Channel Identifier
CLR Cell Loss Ratio
CPS Common Part Sublayer
DBR Deterministic Bit Rate
FEC Forward Error Correction
FRF Frame Relay Format
GFR Guaranteed Frame Rate
GWID Gateway Identifier
IP Internet Protocol
ITU International Telecommunications Union
LCO Local Connection Option
MBS Maximum Burst Size
MCR Minimum Cell Rate
MFS Maximum Frame Size
MGCP Media Gateway Control Protocol
nrt-VBR Non-real-time Variable Bit Rate
NSAP Network Service Access Point
PCR Peak Cell Rate
PDU Protocol Data Unit
PVC Permanent Virtual Circuit
QoS Quality of Service
rt-VBR Real-time Variable Bit Rate
SAR Segmentation and Re-assembly
SCR Sustained Cell Rate
SDT Structured Data Transfer
SDU Service Data Unit
SPVC Switched Permanent Virtual Circuit
SRTS Synchronous Residual Time-Stamp
SSCOP Service-specific Connection Oriented Protocol
SSSAR Service-specific Segmentation and Re-assembly
SVC Switched Virtual Circuit
TDM Time-Division Multiplexing
UBR Unspecified Bit Rate
UDT Unstructured Data Transfer
VC Virtual Circuit

VCCI Virtual Circuit Connection Identifier
VCI Virtual Circuit Identifier
VP Virtual Path
VPCI Virtual Path Connection Identifier
VPI Virtual Path Identifier

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