INTERNATIONAL TELECOMMUNICATION UNION

ITU-T D.224

(12/99)

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

SERIES D: GENERAL TARIFF PRINCIPLES

General tariff principles – Charging and accounting principles for international telecommunication services provided over the ISDN

Charging and accounting principles for ATM/B-ISDN

ITU-T Recommendation D.224

(Previously CCITT Recommendation)

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ITU-T RECOMMENDATION D.224

CHARGING AND ACCOUNTING PRINCIPLES FOR ATM/B-ISDN

Summary

This Recommendation sets out the general principles and conditions applicable by Administrations for the capability to transport ATM cells over ATM connections between standardized interfaces and for services using such connections.

Specific charging and accounting principles for point-to-multipoint ATM connections are not currently addressed in this version of this Recommendation.

Source

ITU-T Recommendation D.224 was prepared by ITU-T Study Group 3 (1997-2000) and was approved under the WTSC Resolution No. 1 procedure on 17 December 1999.

FOREWORD

ITU (International Telecommunication Union) is the United Nations Specialized Agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of the ITU. The ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Conference (WTSC), which meets every four years, establishes the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

The approval of Recommendations by the Members of the ITU-T is covered by the procedure laid down in WTSC Resolution No. 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

INTELLECTUAL PROPERTY RIGHTS

The ITU draws attention to the possibility that the practice or implementation of this Recommendation may involve the use of a claimed Intellectual Property Right. The ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the Recommendation development process.

As of the date of approval of this Recommendation, the ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementors are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database.

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Recommendation D.224

CHARGING AND ACCOUNTING PRINCIPLES FOR ATM/B-ISDN

(Geneva, 1999)

1 Preamble

This Recommendation covers charging and accounting principles applicable to B-ISDN/ATM services provided at the ATM layer.

2 Scope

This Recommendation sets out the general principles and conditions applicable by Administrations for the capability to transport ATM cells over ATM connections between standardized interfaces and for services using such connections (Recommendations F.811, F.813).

An ATM connection is characterized through a traffic contract encompassing the Quality of Service (QoS) class as specified in Recommendation I.356, ATM Transfer Capability (ATC) as specified in Recommendations I.371 and I.371.1, and applicable traffic parameters.

Specific charging and accounting principles for point-to-multipoint ATM connections are not currently addressed in this version of this Recommendation.

3 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; all users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published.

– ITU-T Recommendation F.811 (1996), *Broadband connection-oriented bearer service.*

– ITU-T Recommendation F.813 (1995), *Virtual path service for reserved and permanent communications.*

– ITU-T Recommendation I.356 (1996), *B-ISDN ATM layer cell transfer performance.*

– ITU-T Recommendation I.371 (1996), *Traffic control and congestion control in B-ISDN.*

– ITU-T Recommendation I.371.1 (1997), *Traffic control and congestion control in B-ISDN: conformance definitions for ABT and ABR.*

– ITU-T Recommendation I.630 (1999), *ATM Protection Switching.*

4 Terms and definitions

4.1 Definitions

This Recommendation defines the following terms:

4.1.1 Chargeable Cell Rate (CCR): The Chargeable Cell Rate of a connection is a single cell rate parameter used to determine the reservation based charge element for that connection. The CCR is a computed simplification of the traffic contract values of the connection to a single cell rate value. The concept of CCR applies only to charging and accounting. It is used only in the reservation based charge element. The CCR is computed as a function of the connection parameters, such as QoS class, ATC, source traffic descriptor and associated tolerances. The use and the calculation function for the CCR are Administration-specific.

4.1.2 Connection establishment: *Connection establishment* indicates the moment the connection has been set up and has become available to the user to transport ATM cells. For connections using signalling, this corresponds to the entry into the 'active' state.

4.1.3 Connection release: *Connection release* indicates the moment the connection has become unavailable to the user to transport ATM cells. For connections using signalling this corresponds to the departure from the 'active' state.

4.1.4 Connection's active phase: The *connection's active phase* indicates the entire period between connection establishment and connection release.

4.1.5 Distance: Distance in the context of this Recommendation is to be related to the facilities made available to realise the connection between the applicable interfaces. It is Administration-specific whether and how distance influences the charging parameters. If distance-dependent differentiation is used, an Administration may choose to define distance regions or distance zones to simplify its implementation.

4.2 Abbreviations and acronyms

This Recommendation uses the following abbreviations:

ABR Available Bit Rate (Rec. I.371)

ABT/DT ATM Block Transfer/Delayed Transfer (Rec. I.371)

ABT/IT ATM Block Transfer/Immediate Transfer (Rec. I.371)

ATC ATM Transfer Capability (Rec. I.371)

ATM Asynchronous Transfer Mode

B-ISDN Broadband Integrated Services Digital Network

CAC Connection Admission Control (Rec. I.371)

CCR Chargeable Cell Rate

CDR Connection Detail Record

CDV Cell Delay Variation (Rec. I.356)

CLP Cell Loss Priority (Recs. I.361, I.356, I.371)

CP_M(.) Charge Parameter – connection Modification

CP_R(.) Charge Parameter – Reservation

CP_S(.) Charge Parameter – connection Set-up

CP_U(.) Charge Parameter – Usage

DBR Deterministic Bit Rate (Rec. I.371)

GFR Guaranteed Frame Rate (Rec. I.371)

GIT Generic Identifier Transport (Rec. Q.2726.3)

ICU Imaginary Currency Unit

INI Inter-Network Interface

MBS Maximum Burst Size (Rec. I.371)

MCR Minimum Cell Rate (Rec. I.371)

NPC Network Parameter Control (Rec. I.371)

OAM Operation And Maintenance (Rec. I.610)

PCR Peak Cell Rate (Rec. I.371)

PVC Permanent Virtual Connection

QoS Quality of Service (Rec. I.356)

RM Resource Management (Recs. I.610, I.371)

SBR Statistical Bit Rate (Rec. I.371)

SCR Sustainable Cell Rate (Rec. I.371)

SVC Switched Virtual Connection

UNI User Network Interface (Recs. I.112, I.413)

UPC Usage Parameter Control (Rec. I.371)

VCC Virtual Channel Connection (Recs. I.311, I.150)

VPC Virtual Path Connection (Recs. I.311, I.150)

5 Units, elements, parameters and concepts for charging network utilization

This clause introduces the charging units, the charge elements and their parameters and the concepts recommended to be used to charge for network utilization. The network utilization charges cover the costs related to the utilization of the network resources.

Charge elements and their parameters are introduced below. The use (or not) of such elements and parameters and their values are administration-specific in case of charging, and subject to agreement between the Administrations involved in case of accounting.

5.1 Charging units

The following charging units are applicable to ATM-level charging.

- In case duration is used as element in the charge, the unit is second (s).
- In case a cell rate is used as element in the charge, the unit is cell per second (cell/s).
- In case usage is used as element in the charge, the unit is cell (cell).

NOTE – To ease notation, an Administration may choose to use kilocell or megacell as the unit in charging or accounting, instead of a single cell. Such a choice does not affect the essence of the charging or accounting.

5.2 Charge elements

For charging individual connections the following elements may be used:

- connection set-up charge element (see 5.2.1);
- connection set-up attempt (failed) charge element (see 5.2.2);
- connection modification charge element (see 5.2.3);

- connection modification attempt (failed) charge element (see 5.2.4);
- reservation based charge element (see 5.2.5);
- usage based charge element (see 5.2.6).

5.2.1 Connection set-up charge

A connection set-up charge may be applied to each successfully established connection. This connection set-up charge may reflect the resources to establish (and to release) the connection, e.g. transport and processing of signalling messages in all relevant nodes along the route, performing route calculations, performing CAC functions in all relevant nodes and the capacity reserved during the connection set-up phase in both directions. Its value is Administration-specific in the case of charging end customers, and its value is subject to (bilateral) agreements between Administrations in case of accounting.

5.2.2 Connection set-up attempt charge element

A connection set-up attempt charge may be applied in case a connection has not been successfully established. The connection set-up attempt charge may reflect the resources to attempt the connection set-up (see 5.2.1).

The application of such a connection set-up attempt charge may depend on the reason for the failure of the attempt. Different policies may be applied according to the cause of the failure. Such policies are Administration-specific in the case of charging end customers, and such policies are subject to (bilateral) agreements between Administrations in case of accounting.

5.2.3 Connection modification charge element

A connection modification charge may be applied to each modification to the ATM traffic descriptor performed on request of the connection user. The modification charge may reflect the resources to realise the requested modification, e.g. transport and processing of signalling messages in all relevant nodes along the route, performing CAC functions in all relevant nodes and the capacity reserved during the modification phase. Modification of the connection's traffic descriptor may also modify the value of the connection's chargeable cell rate.

The connection modification charge element is determined by summing the values of the modification charge parameter CP_M(.) associated with each of the modifications. The value of CP_M(.) may depend on the QoS class, the ATC, the distance between the applicable interfaces (region or zone), the magnitude of the modification and on the charging period. Its value is Administration-specific in the case of charging end customers, and its value is subject to (bilateral) agreements between Administrations in case of accounting.

5.2.4 Connection modification attempt charge element

A connection modification attempt charge could be applied in case a connection has not been successfully modified. The connection modification attempt charge may reflect the resources to attempt the modification of a connection's ATM traffic descriptor (see 5.2.3).

The application of such a connection modification attempt charge may depend on the reason for the failure of the attempt. Different policies may be applied according to the cause of the failure. Such policies are Administration-specific in the case of charging end customers, and such policies are subject to (bilateral) agreements between Administrations in case of accounting.

5.2.5 Reservation based charge element

The reservation based charge element applies a charge for the reservation made in the network for a specific connection. It relates to the resources the Administration reserves for the duration of the connection. Reservations are necessary for example to implement the QoS commitments applicable to the connection.

The reservation based charge may depend on the QoS class, the ATC, the source traffic descriptor and the associated tolerances. An Administration may choose to convert these parameters or some of these parameters into a single rate value expressing the reserved resources: the chargeable cell rate. The conversion from connection parameters into a chargeable cell rate is Administration-specific. The reservation based charge element is determined by multiplying the value of the reservation charge parameter CP_R(.) applicable to the connection with the value of the Chargeable Cell Rate and with the duration of the connection. The value of CP_R(.) may depend on the QoS class, the ATC, the distance between the applicable interfaces (region or zone) and the charging period. Its value is Administration-specific in the case of charging end customers, and its value is subject to (bilateral) agreements between Administrations in case of accounting.

The reservation based charge element takes into account neither the number of cells admitted into the network nor the number of cells transported by the network.

5.2.6 Usage based charge element

The usage based charge element applies a charge based on the number of cells admitted into the network and a charge based on the number of cells delivered by the network. The first charge relates to the work load inflicted upon the network, the second charge relates to the ATM transport service successfully delivered by the network.

The charge may depend on the QoS class, the ATC and on the value (0 or 1) of the Cell Loss Priority bit (CLP). The usage based charge element is determined by multiplying the value of the usage charge parameter CP_U(.) applicable to the connection by the corresponding number of cells. There may be more than one parameter CP_U(.), for example depending on the CLP bit, depending on whether the parameter relates to the admitted cells or the delivered cells and depending on the charging period. The value of CP_U(.) may depend on the QoS class, the ATC, the CLP bit, whether it relates to the admitted cells or the delivered cells, the distance between the applicable interfaces (region or zone) and on the charging period. Its value is Administration-specific in the case of charging end customers, and its value is subject to (bilateral) agreements between Administrations in case of accounting.

In case more than one Administration is involved in realising the connection, charging for cells delivered to the destination is possible only if the delivered cell counts are available from the terminating Administration by mutual agreement. If no such agreement is available, charging cannot (and shall not) rely on delivered cells. In such a case the usage based charge element will only relate to the number of cells admitted into the network.

5.3 Charging periods

An Administration may choose to apply different charges to different periods, e.g. peak and off-peak hours. Such periods are referred to as charging periods.

The reservation based charge element relates to the duration of a connection. The value of the reservation charge parameter CP_R(.) may differ between charging periods. In order to allow the reservation based charge element to differ for different charging periods, the duration of the connection within each charging period must be known. This information can be derived by comparing the start date and time and the end date and time of the connection to the charging periods.

The usage based element relates to the cells admitted into the network and cells delivered by the network. The value of the usage charge parameter(s) CP_U(.) may differ between charging periods. In order to allow the usage based charge element to differ for different charging periods, the number of cells within each charging period must be known. Therefore, separate cell counts for each charging period need to be available.

Note that it is not required that all charge elements are different for different charging periods. For example, it is possible to have two charging periods which have different reservation charge parameters, but identical connection set-up charge elements and identical usage charge parameters.

5.4 Connection characteristics that may affect the charge

The charge elements described in 5.2 depend on a number of characteristics and parameters of the connection. Table 1 lists the characteristics that can be used in the charge elements reservation and usage. The column 'available' indicates at what stage of the connection lifetime the parameter becomes available.

Table 1/D.224 – Connection characteristics that may affect the charge and the parameters expected to be affected

Characteristic	Reservation related charge affected through	Usage related charge affected through	When available?
Connection mode (permanent, reserved, on-demand) (Rec. I.140)	CP_R	CP_U	At connection establishment
The level of ATM protection switching requested for the connection (see 5.6)	CP_R	For 1+1 protection: CP_U None, for other configurations	At connection establishment
Connection type (VPC or VCC)	CP_R	None	At connection establishment
ATC (Rec. I.371)	CP_R	CP_U	At connection establishment
QoS Class (Rec. I.356)	CP_R	CP_U	At connection establishment
Traffic Descriptor (Rec. I.371)	CCR	None	At connection establishment
Identification of the interfaces (Note 1) relevant to charging (e.g. also used to determine distance)	CP_R	CP_U	At connection establishment
Identification of transit network(s) used (Transit Network Selection)	CP_R	CP_U	At connection establishment
Connection start date and time	CP_R	CP_U	At connection establishment
For each successful renegotiation: date and time and renegotiated traffic descriptor	CCR	None	After each modification (during the connection's active phase)
Connection end date and time	CP_R	None	At connection release
The number of user cells (Note 2) admitted into the network to which QoS guarantees apply (Note 3)	None	$N_{admitted,0+1}$ or $N_{admitted,0}$ (Note 4)	During the connection's active phase & at connection release

Table 1/D.224 – Connection characteristics that may affect the charge and the parameters expected to be affected *(concluded)*

Characteristic	Reservation related charge affected through	Usage related charge affected through	When available?
The number of user cells (Note 2) admitted into the network to which no QoS guarantees apply (Note 3)	None	$N_{admitted,1}$ (Note 4)	During the connection's active phase & at connection release
The number of user cells (Note 2) delivered by the network to which QoS guarantees apply (Note 3)	None	$N_{delivered,0+1}$ or $N_{delivered,0}$ (Note 4)	During the connection's active phase & at connection release
The number of user cells (Note 2) delivered by the network to which no QoS guarantees apply (Note 3)	None	$N_{delivered,1}$ (Note 4)	During the connection's active phase & at connection release
NOTE 1 – The relevant interfaces may be derived from the information provided about the connection endpoints. NOTE 2 – The number of user cells includes all the user-generated cells, i.e. including user-generated OAM cells and RM cells. NOTE 3 – This parameter is required for each charging period separately (in combination with the start date and time and end date and time of the charging period). NOTE 4 – The letter *N* indicates a number of cells registered by the network. The index indicates whether that number relates to the number of cells admitted into the network or delivered by the network and whether that number relates to CLP = 0 or CLP = 1 cells.			

5.5 Viable combinations of charge elements

Viable charging schemes can be constructed by using one or more of the charge elements described in 5.2.

- The connection set-up charge element and the connection set-up attempt charge element can be applied to any connection, regardless of its ATC or QoS class.
- The connection modification charge element and the connection modification attempt charge element can be applied to any connection for which in-call modification of the connection parameters has been specified (Rec. I.371).
- The ATC/QoS combination of a connection determines what charge elements can reasonably be used for reservation and usage. The reservation charge element is applied if reservations are made for the connection. Reservations are necessary to guarantee QoS commitments if they apply. Reservations may be made also in other cases. Whether to make such reservations is an Administration-specific choice. The usage charge element may be applied to connections to reflect the usage of network resources as a result of admitting cells

into the network and delivering them. Such a usage based charge can be applied in case QoS commitments do apply, and in case no commitments apply.

Viable charging schemes using the reservation charge element or the usage charge element or both are listed in Table 2 for all relevant ATCs and QoS classes. The shaded combinations of ATCs and QoS classes are not mentioned as possible associations in ITU-T Recommendation I.356.

Table 2/D.224 – Viable charging schemes for each combination of ATC and QoS class

QoS class → **ATC ↓**	**QoS class 1**	**QoS class 2**	**QoS class 3**	**U class**
DBR	Reservation or Reservation + Usage	Reservation or Reservation + Usage		Usage or Reservation (Note 1) + Usage
SBR1	Reservation or Reservation + Usage	Reservation or Reservation + Usage		Usage or Reservation (Note 1) + Usage
SBR2			Reservation (Note 2) + Usage (Note 3)	Usage or Reservation (Note 1) + Usage
SBR3			Reservation (Note 2) + Usage (Note 3)	Usage or Reservation (Note 1) + Usage
ABR			Reservation (Note 4) + Usage	Usage or Reservation (Note 1) + Usage
ABT/DT	Reservation or Reservation + Usage	Reservation or Reservation + Usage		Usage or Reservation (Note 1) + Usage
ABT/IT	Reservation + Usage	Reservation + Usage		Usage or Reservation (Note 1) + Usage
GFR			Reservation (Note 4) + Usage	Usage or Reservation (Note 1) + Usage

NOTE 1 – A reservation-related charge may apply if the Administration reserves some resources.

NOTE 2 – The reservation charge may be applied to the guaranteed part.

NOTE 3 – The usage charge may be applied to the non-guaranteed part of the cell stream (CLP = 1 cells), or to both parts.

NOTE 4 – The reservation charge may be applied to the guaranteed part (MCR).

5.6 Charging concepts related to ATM Protection Switching

Protection switching which equally affects all connections, such as Automatic Protection Switching for SDH or protection switching at the optical layer, is assumed to be incorporated in the connection charge and is not further addressed in this Recommendation.

This subclause addresses specifically for ATM protection switching, as defined in ITU-T Recommendation I.630, the issues related to charging. It applies to the following configurations of ATM protection switching:

- an ATM connection which is protected as an individual connection (ATM VP/VC protection switching);
- a group of ATM VP connections or a group of ATM connections (VC connections or VP connections) where ATM protection switching is applied to the group of protected ATM connections (ATM VP/VC Group protection switching).

5.6.1 Reservation charge element affected by ATM protection switching

The reservation charge parameter CP_R(.) for a protected connection may be assigned a higher value than for an equivalent unprotected connection. This higher reservation charge reflects that for each protected ATM connection additional capacity needs to be reserved. The additional capacity reserved for the protected connection depends on the ratio of protection capacity and working capacity.

5.6.2 Usage charge element affected by ATM protection switching

The usage charge parameter CP_U(.) for a 1+1 protected connection may be assigned a higher value than for an equivalent unprotected connection. This higher usage charge reflects that for a connection with ATM protection switching in the 1+1 configuration the same traffic stream is carried by the network over two routes.

Connections with ATM protection in other configurations than the 1+1 configuration do not incur additional usage on the protection route.

6 Charging end-customers

The charges for services delivered to end-customers normally consist of the following components:

- Network access component.
- Network utilization component.

6.1 Network access component

The network access component is intended to cover the cost for providing the access to the service for the customer. Its establishment is Administration-specific and is not addressed in this Recommendation.

6.2 Network utilization component

The network utilization charges cover the costs related to the utilization of the network resources.

The charge units, charge elements, charge parameters and concepts described in clause 5 apply to charging end-customers. The use (or not) of such elements and parameters and their values are Administration-specific.

7 Accounting between Administrations

For accounting between Administrations different approaches may be taken:

- Traditional accounting mechanisms may be used, possibly foregoing the calculation of settlements. It is for example possible that each provider charges only their respective end-customers, with no settlements established between providers.
- Accounting may be based on the charge units, charge elements, charge parameters and concepts described in clause 5. Accounting according to such principles is detailed in the following subclauses.

The method of accounting, the use (or not) of the elements and their parameters as described in clause 5 and their values, as well as the aggregation method, are subject to agreement between the Administrations involved.

7.1 Network access component

Accounting charges for access, in the case of Administrations for interconnect access, are an Administration-specific matter. Factors that determine the interconnect access charge may be similar to the factors in customer access charges. They are subject to agreement between the Administrations involved.

7.2 Network utilization component

For accounting charges that apply to connections, the same charge elements are relevant that were described in 5.2. Viable combinations of these charge elements are given in 5.5. The application of each principle in accounting is subject to (bilateral) agreement of the Administrations involved.

As accounting between Administrations relates to large numbers of connections, a simplification of the charging is sensible. An Administration need not be charged per connection, but may be charged for an aggregation of connections as described below.

7.2.1 Assumptions

Two assumptions underlie the description of accounting in this subclause. Figures 1 and 2 are used in the description of the assumptions.

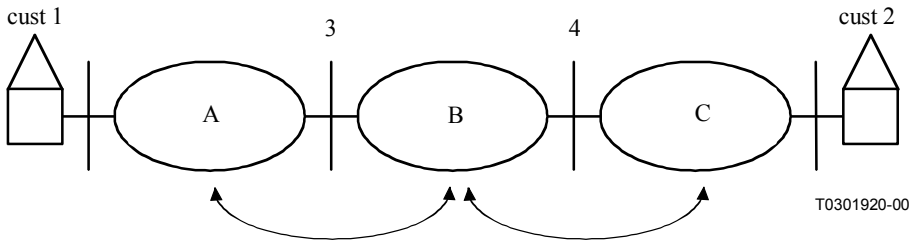

Figure 1/D.224 – Three Administrations realise a connection through interconnection (cascaded organization)

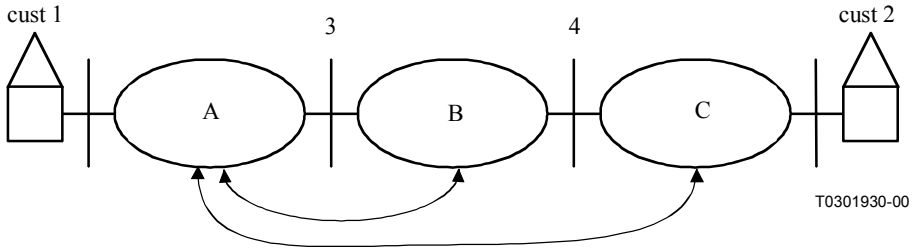

Figure 2/D.224 – Three Administrations realise a connection through interconnection (star organization)

Assumptions:

1) Two Administrations A and B that have an interconnect agreement, determine separately the accounting from A to B, and the accounting from B to A. It is up to the Administrations to determine the settlement arrangements.

2) In the cascaded organization (Figure 1) any Administration X realising an ATM connection deals with only two parties adjacent to Administration X:

   – the customer or the Administration Y that submits the connection that starts at the edge of the network of that Administration X;

   – the customer or Administration Z that continues the connection at the terminating edge of the network of Administration X.

   For example: Suppose that customer 1 in Figure 1 requests from Administration A a (unidirectional) connection to customer 2 , and that customer 1 is the charged party,

   – Administration A will charge customer 1 for the connection from customer 1 to customer 2.

   – Administration B will charge Administration A for the connection portion from '3' to customer 2.

   – Administration C will charge Administration B for the connection from '4' to customer 2.

3) In the star organization (Figure 2) there is one root organization and one or more leaf organizations.

   – The Administration that submits the connection acts as root and deals with its customer and with each of the Administrations acting as leaf. It realises the connection from the customer to the edge of network interfacing to the next Administration.

   – An Administration acting as leaf deals only with the Administration acting as root and, when applicable, with its customer. It realises the connection as requested by the root between two network edges or, when it is the destination Administration, between a network edge and its customer.

   For example: Suppose that customer 1 in Figure 2 requests from Administration A a (unidirectional) connection to customer 2 , and that customer 1 is the charged party,

   – Administration A will charge customer 1 for the connection from customer 1 to customer 2.

   – Administration B will charge Administration A for the connection portion from '3' to '4'.

   – Administration C will charge Administration A for the connection from '4' to customer 2.

NOTE – An Administration will aggregate only the connections of a same Administration that enter the network. Connections realised for different originating Administrations are not combined together.

7.2.2 Aggregation within charge elements for accounting

To reduce the number of parameters stored and used for accounting between Administrations, parameters of several connections may be aggregated and summarized into a smaller set of parameters to which a charge is applied. Aggregation takes places over an agreed aggregation period, for example one month.

The aggregation of connection parameters is described in the following subclauses for the three charge elements that build the charging options for ATM. Subclause 7.2.2.1 describes aggregation for connection set-up charges. Subclause 7.2.2.2 describes aggregation for the reservation based charges. Subclause 7.2.2.3 describes aggregation for the usage based charges.

Each subclause describes a generic aggregation that allows for differentiated accounting by connection type, distance region or zone and time of day. It is Administration-specific whether to apply differentiation in accounting tariffs. Subclause 7.2.3 summarises the parameters that result from the generic case of differentiated aggregation. Any less differentiated aggregation can be inferred from the parameters for the generic case presented in Table 3.

7.2.2.1 Aggregation for the connection set-up charge element

Over the period of aggregation, all instances of connection set-up on the interconnection interface are cumulated. For an interface between two Administrations A and B, this implies that all connections set up by B at the request of A are counted. Separately, all the connections set up by A at the request of B are counted. Each of these two counts reflects the accounting information for the connection set-up charge element over the period of aggregation for one of the parties.

Aggregation of connection set-up charges may be differentiated depending on the characteristics of the connection that the Administrations choose to affect the set -up charge element. Examples are the Connection mode and the charging period.

7.2.2.2 Aggregation for the reservation based charge element

The reservation based element reflects resources reserved in the network for the connection. For a single connection the resource reservation is determined by a number of parameters: the QoS class, the ATC, and the associated traffic descriptor. The reservation related charge may also be affected by other connection characteristics as listed in Table 1, for example the distance between the applicable interfaces (region or zone) and the charging period.

For accounting, aggregation over several parameters for each connection is complex. To simplify aggregation of several connections, each connection is assigned to an aggregation group. Each aggregation group contains connections with the same value of the reservation charge parameter CP_R(.). For each connection, the value of the Chargeable Cell Rate (CCR) is multiplied by the connection duration; this yields a number of cells expressing the capacity that has been reserved for that connection. The resulting number of cells is added to the group's total of reserved capacity.

Administrations may differentiate the reservation charge parameter with respect to a number of characteristics. For example, it may be expected that the reservation based charge element may be differentiated according to the following connection characteristics (see Table 1).

- ATC/QoS class combination;
- connection mode;
- distance between the applicable interfaces (region or zone);
- charging period.

Therefore, accounting groups may be created for each relevant combination of these characteristics for which a different value of the reservation charge parameter CP_R(.) is used. Each of the relevant characteristics has a finite number of possibilities, if it is assumed that the distance between the applicable interfaces is distinguished by zones or regions[1]. Therefore, the number of aggregation groups required for aggregating the reserved capacity is finite. Per aggregation group the aggregation results in a single value expressing the aggregated reserved capacity. Multiplication with the reservation charge parameter CP_R(.) applicable to the group allows conversion into monetary units.

7.2.2.3 Aggregation for the usage based charge element

The usage based element reflects resources used in the network for the connection. For a single connection the resource usage is determined by a number of parameters: the QoS class, the ATC, and the associated number of cells given in 5.4. The usage related charge may also be affected by other connection characteristics as listed in Table 1, for example the distance between the applicable interfaces (region or zone) and the charging period.

For accounting, similar parameters are relevant. In view of the large numbers of connections to be accounted for at an interconnection interface between two Administrations, aggregation of usage charging parameters is described below.

One parameter considered for end-customer charging of ATM connections cannot be used for accounting. The number of delivered cells is not necessarily available if more than one Administration is involved in the connection. Also, if it is available, it cannot be verified by both parties involved in interconnection at an interface. Therefore the number of delivered cells cannot be used in accounting.

To allow reconciliation of cell counts by both parties, it is recommended that the receiving Administration also registers the number of cells discarded by the NPC, if an NPC is present at the INI, and that this number is aggregated and specified together with the corresponding number of cells admitted into the Administration's network.

Each connection yields a number of cells for the usage based charge in each charging period, at a given interface. To simplify aggregation of several connections, each connection is assigned to an aggregation group. Each aggregation group contains connections with the same value of the usage charge parameter(s) CP_U(.). For each connection, the relevant number of cells is added to the group's total number of cells. For each aggregation group, separate cell count values are used depending on whether QoS commitments pertain to the cells or not.

The ATC/QoS combination of a connection determines whether:

- QoS commitments pertain to all cells admitted into the network on a compliant connection;
- QoS commitments pertain to a subset of the cells admitted into the network on a compliant connection;
- QoS commitments do not pertain to cells admitted into the network.

The ATC/QoS combination of a connection thus determines whether one or two values are relevant to reflect the number of cells admitted into the network on the connection. The contribution of each connection to the aggregated usage based charge will be its relevant cell count values in the aggregation period.

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[1] The case where distance is not used as a differentiating factor can be viewed as a case with a single distance region or zone.

Administrations may differentiate the usage charge parameter with respect to a number of characteristics. For example, it may be expected that the usage based charge element may be differentiated according to the following connection characteristics (see Table 1).

- ATC/QoS class combination;
- connection mode;
- distance between the applicable interfaces (region or zone);
- charging period.

Therefore, accounting groups may be created for each relevant combination of these characteristics for which a different value of the usage charge parameter CP_U(.) is used. Each of the relevant characteristics has a finite number of possibilities, if it is assumed that the distance between the applicable interfaces is distinguished by zones or regions[1]. Therefore, the number of aggregation groups required for aggregating the used capacity is finite. Per aggregation group the aggregation results in one or more total values expressing the used capacity. Multiplication with the usage charge parameter(s) CP_U(.) applicable to the group allows conversion into monetary units.

7.2.3 Accounting parameters resulting from aggregation for network utilization

The aggregated parameters collected for accounting at an interface pertain to:

- connection set-up charge element;
- reservation based charge element;
- usage based charge element.

For the connection set-up charge element, the aggregated parameter is the number of connection set-ups at that interface, in the given direction. Different charging periods (time of day) can be applied to the connection set-up charge element.

For the reservation based charge element and the usage based charge element, Table 3 gives an overview of the parameters yielded by the generic differentiated accounting described in 7.2.2.2 and 7.2.2.3. The shaded areas are not relevant for charging.

In summary: for both charge elements 'reservation' and 'usage', aggregation is performed separately by:

- QoS class and ATC combination;
- connection mode;
- distance between the applicable interfaces (region or zone);
- charging period.

The aggregated parameters for the reservation based and the usage based charge elements are both expressed in cells. For 'reservation' they are the chargeable cells that are a result of resource reservations. For 'usage' they are actual cells admitted into the network. Thus the parameters are of a different nature, though expressed in a same unit.

Table 3/D.224 – Aggregated parameters, differentiated by ATC/QoS combination and charging period

		Charging period A			Charging period B			etc. …
		'reservation'	'usage'		'reservation'	'usage'		
ATC/QoS class	**conn #**	**chargeable cells**	**admitted cells (QoS)**	**admitted cells (no QoS)**	**chargeable cells**	**admitted cells (QoS)**	**admitted cells (no QoS)**	**…**
DBR/QoS 1	1	CCR × time	CLP=0+1		…	…		
	2	CCR × time	CLP=0+1		…	…		
	…							
	total	**Sum**	**sum**		**sum**	**sum**		
DBR/QoS 2	1	CCR × time	CLP=0+1		…	…		
	…							
	total	**Sum**	**sum**					
DBR/QoS U	1	CCR × time		CLP=0+1	…			
	…							
	total	**Sum**		**Sum**				
SBR1/QoS 1	1	CCR × time	CLP=0+1					
	…							
	total	**Sum**	**sum**					
SBR1/QoS 2	1	CCR × time	CLP=0+1					
	…							
	total	**Sum**	**sum**					
SBR1/QoS U	1	CCR × time		CLP=0+1				
	…							
	total	**Sum**		**Sum**				
SBR2/QoS 3	1	CCR × time	CLP=0	CLP=1				
	…							
	total	**Sum**	**sum**	**Sum**				
SBR2/QoS U	1	CCR × time		CLP=0+1				
	…							
	total	**Sum**		**Sum**				
SBR3/QoS 3	1	CCR × time	CLP=0	CLP=1				
	…							
	total	**Sum**	**sum**	**Sum**				
SBR3/QoS U	1	CCR × time		CLP=0+1				
	…							
	total	**Sum**		**Sum**				
ABR/QoS 3	1	CCR × time	CLP=0+1					
	…							
	total	**Sum**	**sum**					
ABR/QoS U	1	CCR × time		CLP=0+1				
	total	**Sum**		**Sum**				

An Administration defines values for the charge parameter for reservation CP_R(.) and for the charge parameter(s) for usage CP_U(.) to be used for accounting for each combination of ATC/QoS class, distance region or zone and charging period that it offers. This does not imply that such charge parameters must be different for each combination. In the most simple case, an Administration may choose to use a single reservation cell price and a single usage cell price for all ATC/QoS combinations it offers and for all charging periods.

APPENDIX I

Examples of use of concepts and parameters defined in this Recommendation

The aim of this appendix is to assist the reader in understanding the parameters and concepts defined in this Recommendation. The examples are only informative.

The following subclauses contain examples about charging a connection by an imaginary provider, indicated as "the provider". The same examples apply for accounting between Administrations, where one Administration is charged by another Administration.

I.1 Chargeable Cell Rate (CCR)

The parameter Chargeable Cell Rate (CCR) is defined in 4.1. Chargeable Cell Rate is a concept applied only to the *reservation based* charge element (see 5.2.5); it does not serve any purpose in relation to the usage based charge element (see 5.2.6). The concept of a Chargeable Cell Rate allows the Administration to reflect in a *single* parameter the resources reserved for a given ATM connection and to inform the relevant party (e.g. customer, other Administration) about the resources reserved and consequently charged. It is Administration-specific whether to make use of such a mechanism that simplifies the parameter 'reserved resources' into a single cell rate parameter: CCR.

Examples of CCR calculations

Though the amount of resources (e.g. link capacity, buffer space) reserved for a given ATM connection is Administration-specific, it is expected that this depends on the ATM Transfer Capability (ATC), the QoS class and the values of the traffic contract parameters (Recommendations I.371, I.356). Also the calculation of CCR (to reflect the Administration's policy to reserve resources for a given connection) is Administration-specific. It is expected that the calculation of CCR will be a function of the traffic contract elements of a connection. For example, the ATC, the QoS class and the cell rate values of the traffic contract parameters may be elements in the calculation of CCR. The following examples show how different Administrations each use the concept of a CCR but apply different calculation methods which yield different results.

Assume an SBR1 connection with QoS class 2 and the following source traffic parameters:

- PCR = 20 kcell/s
- SCR = 10 kcell/s
- MBS = 300 cells

Further assume three different Administrations X, Y and Z; and that each has decided to apply the concept of a CCR.

X) For example, Administration X has one or more network elements with buffering resources which are insufficient to absorb the specified burst size. Then, Administration X may decide to reserve link capacity the value of the PCR to accommodate the connection. To reflect these resources, Administration X may develop its formula which for this connection yields, for example: CCR = 20 kcell/s.

Y) For example, Administration Y has network elements with ample buffering resources to absorb the specified burst size. Then, Administration Y may decide to reserve link capacity no more than the value of the SCR. To reflect these resources, Administration Y may develop its formula which for this connection yields, for example: CCR = 10 kcell/s.

Z) For example, Administration Z has network elements with scarce buffering resources which may partly absorb the specified burst size. Then, Administration Z may decide to reserve link capacity less than the value of PCR but more than the value of the SCR. To reflect these resources, Administration Z may develop its formula which for this connection yields, for example: CCR = 14 kcell/s.

Note the similarity between the concept of Chargeable Cell Rate and the concept of 'effective bandwidth' used in some implementations of Connection Admission Control. Though the concepts are similar, the purpose of the calculations is different and also the calculated values may differ.

I.2 Examples of assigning a charge to a connection

I.2.1 Common assumptions

This subclause describes the common assumptions made for the examples.

I.2.1.1 Value of the Chargeable Cell Rate

For the concept of the Chargeable Cell Rate (CCR), see 4.1, 5.2.5 and I.1. The provider applies the following to determine the value of the CCR for a given connection.

- For a connection using DBR and QoS class 1, the provider sets the CCR equal to the value of the Peak Cell Rate (PCR) requested by the user.
- For a connection using SBR and QoS class 2 or QoS class 3, the provider sets the CCR equal to the Sustainable Cell Rate (SCR) plus 100 times the square root from the Maximum Burst Size (MBS), but not higher than the Peak Cell Rate. In formula:

$$CCR = \max\left(PCR, SCR + 100 \times \sqrt{MBS}\right)$$

I.2.1.2 Price per cell values

For the examples, values have been assumed for the charge parameters. All parameters and the resulting charges are expressed in Imaginary Currency Units (ICU).

The provider sets the following values for the *price per cell* parameters.

- For reservation the value of the reservation charge parameter:

  CP_R(DBR) = 1.0 [ICU/cell];

  CP_R(SBR) = 1.1 [ICU/cell].
- For usage with guaranteed properties the value of the usage charge parameter:

  CP_U(DBR) = 0.25 [ICU/cell];

  CP_U(SBR1) = 0.30 [ICU/cell];.

  CP_U(SBR2, CLP = 0) = 0.30 [ICU/cell];

  CP_U(SBR3, CLP = 0) = 0.30 [ICU/cell].
- For usage with non-guaranteed properties the value of the usage charge parameter:

  CP_U(SBR2, CLP = 1, admitted) = 0.10 [ICU/cell];

  CP_U(SBR3, CLP = 1, admitted) = 0.10 [ICU/cell].

I.2.2 Example of charging a DBR connection

Suppose a user requests a DBR connection with PCR = 1 kcell/s. Suppose the connection has lasted for 5 minutes and that 223 kcells have been transmitted.

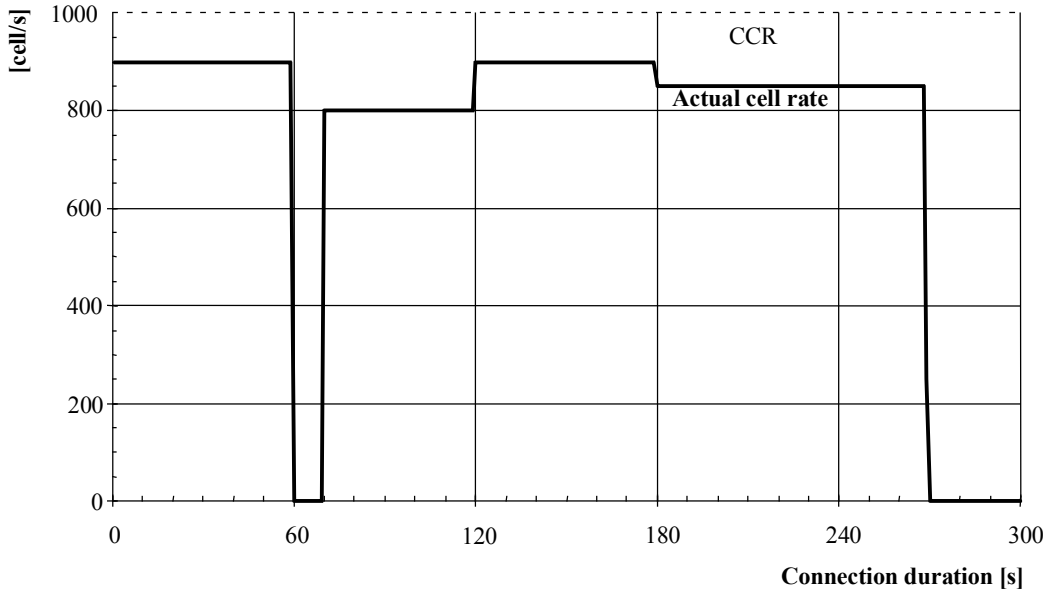
Reservation: Because the provider chooses CCR = PCR, it follows that the reservation charge relates to $1\ \text{k} \times 5 \times 60 = 300$ kcell reserved capacity. It is charged at 1.0 [ICU/cell]. Thus, this 5-minute connection is charged **300 kICU** for reservation. Note that multiplying the CCR by the price per cell for reservation yields the reservation charge per second: $1\ \text{k} \times 1.0 = 1000$ [ICU/s]. Multiplication with the connection duration leads to the same result.

Usage: In addition, the 223 kcell actually transmitted are charged at 0.25 ICU/cell. This leads to **55.75 kICU** for usage.

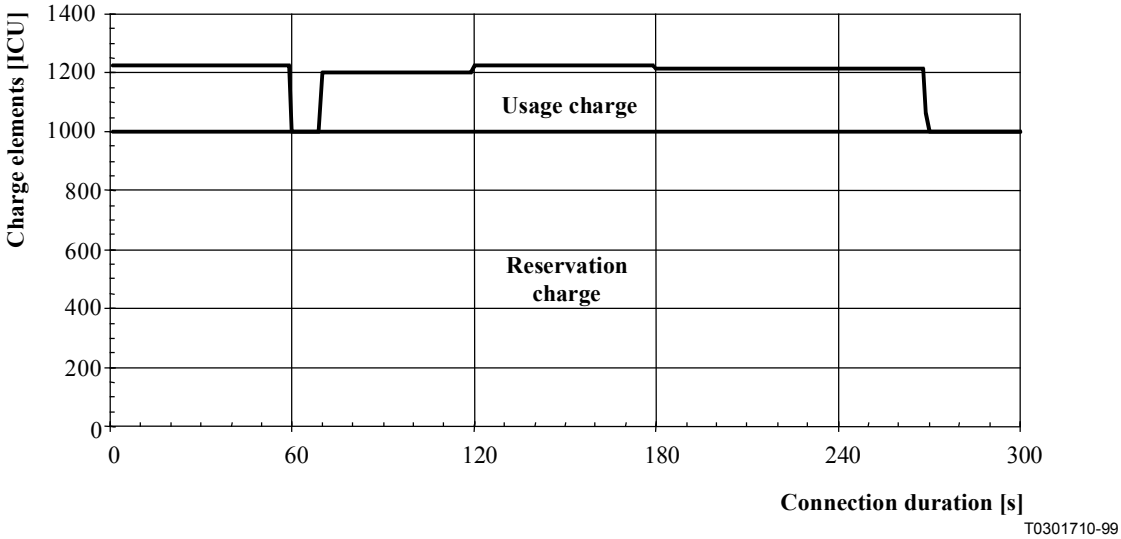
Thus, the total connection charge adds to **355.75 kICU**.

Illustration of the DBR charging example

The example of charging a DBR connection is illustrated in Figure I.1. The upper figure shows the actual behaviour of the source. It hovers between 800 cell/s and 900 cell/s; occasionally, the source is silent. The lower figure shows the contribution of the reservation charge and of the usage charge. Note that the contribution of the reservation charge (bottom line) is constant over time (1000 ICU/s); it depends only on the chargeable cell rate. The usage charge follows the actual usage. The top line indicates the aggregation of reservation and usage.



a) Cell rate actually transmitted and Chargeable Cell Rate for each second



b) Resulting reservation charge, usage charge and summation of these elements for each second

Figure I.1/D.224 – Example of charging a DBR connection

I.2.3 Example of charging an SBR1 connection

Suppose a user requests an SBR1 connection with PCR = 10 kcell/s, SCR = 1 kcell/s, MBS = 16 cell. Suppose the connection has lasted for 5 minutes and that 200 kcell has been transmitted.

Reservation: With the formula used by this provider ($CCR = \max(PCR, SCR + 100 \times \sqrt{MBS})$, see I.2.1.1), the Chargeable Cell Rate is calculated to be $CCR = 1000 + 100 \times \sqrt{16} = 1.4$ kcell/s. Therefore, the reservation charge ($CCR \times duration$) relates to $1.4 \times 5 \times 60 = 420$ kcell reserved capacity. It is charged at 1.1 [ICU/cell]. Thus, this 5-minute connection is charged **462 kICU** for reservation. Note that multiplying the CCR by the price per cell for reservation yields the reservation charge per second: $1.4 \times 1.1 = 1.54$ [kICU/s]. Multiplication with the connection duration produces the same result.

Usage: In addition, the 200 kcell transmitted are charged at 0.30 ICU/cell. This yields **60 kICU** for usage.

Thus, the total connection charge adds to **522 kICU**.

I.2.4 Example of charging an SBR2 connection

Suppose a user requests an SBR2 connection with PCR = 10 kcell/s, SCR = 1 kcell/s, MBS = 16 cell. Suppose the connection has lasted for 5 minutes and that 100 kcell of CLP = 0 cells have been transmitted. Finally, 1 Mcell of CLP = 1 cells have been offered to and admitted into the network; not all CLP = 1 cells have been delivered at the destination.

Reservation: The reservation related charge element is calculated as in the SBR1 example (see I.2.3), resulting in **462 kICU** for reservation.

Usage: In addition, the 100 kcell transmitted CLP = 0 cells are charged at 0.30 ICU/cell. This yields **30 kICU** for guaranteed usage. The 1 Mcell of CLP = 1 cells admitted into the network are charged at 0.10 ICU/cell. This yields **100 kICU** for non-guaranteed usage. The delivery of non-guaranteed cells is not separately charged by this provider.

Thus, the total connection charge adds to **592 kICU**.

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Printed in Switzerland
Geneva, 2000