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Elements of Accounting Management for the ATN Internet Communications

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SUMMARY

This Working Paper is a very first draft addressing ATN internet accounting management. The focus is on defining meter services which provide basic capabilities for measuring the ATN internetwork utilization. The intent is to identify the Managed Object Classes and/or attributes that will have to be implemented in ATN systems for ATN internetwork accounting purpose.

ATN Internet accounting deals only with measuring traffic at the CLNP level, and therefore addresses only one part of the perceived requirements for accounting management in the ATN. Other perceived requirements such as accounting at subnetwork level, and at transport and/or application levels are not addressed in this document.

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1. Introduction

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2. About Accounting Management

Note: the material provided in this chapter is derived from the following 2 documents:

- *European Network Operating Concept*
- *RFC 1272*

2.1.1 Motivation for Accounting

The dominant motivations for accounting management (i.e. usage reporting) are:

- Understanding/Influencing Behaviour.

  Usage reporting provides feedback for the subscriber on his use of network resources. The subscriber can better understand his network behaviour and measure the impact of modifications made to improve performance or reduce costs.

- Measuring Policy Compliance.

  From the perspective of the network provider, usage reports might show whether or not a subscriber is in compliance with the stated policies for quantity of network usage. Reporting alone is not sufficient to enforce compliance with policies, but reports indicate whether it is necessary to develop methods of enforcement.

- Rational Cost Allocation/Recovery.

  Implementation of the ATN will incur a considerable capital expenditure, and it will also have significant running costs. It will be necessary to charge the ATN users, so that the investment can be recovered, and the running costs funded. Where ATN development has been funded by commercial investment, it will also be necessary to provide a return on the investor' capital. Accounting can be used as the basis for billing.

The chief deterrent to accounting management is the cost of measuring usage, which includes:

- Reporting/collection overhead.

  This offers an additional source of computational load and network traffic due to the counting operations, managing the reporting system, collecting the reported data, and storing the resulting counts. Overhead increases with the accuracy and reliability of the accounting data.

- Post-processing overhead.

Resources are required to maintain the post-processing tasks of maintaining the accounting database, generating reports, and, if appropriate, distributing bills, collecting revenue, servicing subscribers.

- Security overhead.

  The use of security mechanisms will increase the overall cost of accounting. Since accounting collects detailed information about subscriber behaviour on the network and since these counts may also represent a flow of money, it is necessary to have mechanisms to protect accounting information from unauthorised disclosure or manipulation.

The balance between cost and benefit is regulated by the GRANULARITY of accounting information collected. This balance is policy-dependent. To minimise costs and maximise benefit, accounting detail is limited to the minimum amount to provide the necessary information for the research and implementation of a particular policy.

2.1.2 Network policy and accounting

Accounting requirements are driven by policy. Conversely, policy is typically influenced by the available management/reporting tools and their cost. This section is NOT a recommendation for billing practices, but intended to provide additional background for understanding the problems involved in implementing a simple, adequate usage reporting system.

Determining an appropriate charge on each user is potentially a complex problem. The ATN will consist of networks of varying sizes and capacities, operated both by administrations and commercial organisations. Subsidies and funding mechanisms appropriate to non-profit organisations often restrict commercial use or require that "for profit" use be identified and billed separately from the non-profit use. Tax regulations may require verification of network usage. Some portions of the ATN will be distinctly "private", whereas other ATN segments will be treated as public, shared infrastructure. Each of the administrations may have different policies and by-laws about who may use an individual network, who pays for it, and how the payment is determined. Also, each administration will balance the OVERHEAD costs of accounting (metering, reporting, billing, collecting) against the benefits of identifying usage and allocating costs.

Different billing schemes may be employed. In certain cases a flat-fee, usage-insensitive model, similar to the monthly unlimited local service phone bill, could be sufficient and could be preferable for financial, technical, or other reasons. In other cases, usage-sensitive charges may be preferred or required by a local administration’s policy. The wishes of ATN users with low or intermittent traffic patterns may force the issue (note: flat fees are beneficial for heavy network users. Usage-sensitive charges generally benefit the low-volume user).

2.1.3 The Nature of Usage Accounting

Although the exact requirements for internet usage accounting will vary from one network administration to the next and will depend on policies and cost trade-offs, it is possible to characterise the problem in some broad terms and thereby bound it. Rather than try to solve the problem in exhaustive generality (providing for every imaginable set of accounting requirements), some assumptions about usage accounting are posited in order to make the problem tractable and to render implementations feasible. Since these assumptions form the basis for our architectural and design work, it is important to make them explicit from the outset and hold them up to the scrutiny of the ATN community.

2.1.3.1 General interconnection scenarios

Referring to existing practice in commercial data communications, a number of basic principles can be identified regarding the interconnection network resources owned or operated by different parties:

1. Owner interconnection of network resources, requires a bilateral agreement between the operators of the RDs, identifying the technical and administrative aspects of the interconnection

2. A clear distinction is made between « retail » and « wholesale » interconnection. With a retail interconnection, one party makes the interconnection as a consumer of a service, and the other as a supplier. With a « wholesale » interconnection, both parties make the interconnection as part of the supply of service to customers.

3. A « retail » interconnection is between a Service Provider and a User, and the User is charged for the cost of the interconnection and for the value added service provided.

4. A « wholesale » interconnection is between two Service Providers and such an interconnection exists because it is in the business interest of both parties or required by a national law enforced by a regulator or some other statutory body.

5. Both parties share the cost of a « wholesale » interconnection, and value added service charges are shared either on the basis of « sender keep all », or by an agreement providing financial compensation for traffic imbalances

2.1.3.2 Interconnection of Administrations

Administrations will interconnect partly as independent users directly exchanging data and partly as service providers, providing a communications path between another Administration and an aircraft, and possibly between two other Administrations. The hybrid nature of the interconnection needs to be recognised, and the different natures of traffic (ground/ground vs air/ground) recognised, and separately accounted for.

2.1.3.3 Interconnection of Administrations and Commercial Service Providers

There are three possible options for such an interconnection:

1. The Administration is simply a user of the supplied service and pays a commercial tariff

2. The Administration's data network is used by the service provider as a route to aircraft, other Administration's and possible other organisations. The interconnection is « wholesale » in nature, and charging and accounting will be agreed on a case by case basis.

3. A combination of the above. The hybrid nature of the interconnection and the different classes of traffic need to be recognised, and separately accounted for.

It is assumed that option 3 will be adopted.

2.1.3.4 Relaying between Service Providers

The above provides a common basis for interconnection. However, complications arise if Service Providers interconnect through another Service Provider. A typical example is a service provider in country « A », passes data for the delivery to destinations in country « C », to a service provider in country « B ». There are three possible charging models for this scenario:

1. « Sender keeps all »: this is the simplest model, in which the first service provider in the delivery chain keeps all the revenue and the others receive nothing. It is satisfactory when traffic flows are balanced and there is little opportunity for competition between the service providers.

2. « multiple bilateral agreements »: the first service provider in the delivery chain negotiates a separate bilateral agreement with each service provider en route, and shares the revenue according to that agreement. Typically a traffic balance is assumed as the normal situation, with financial compensation agreed in the event of imbalances during an accounting period. This

approach is satisfactory provided the route can be computed in advance and does not vary dynamically.

3. « Incremental charging »': the bilateral interconnection agreement between service providers separately itemises the total cost of delivering packets to destinations not served directly by the service provider, including charges payable to other service providers en route. The charging arrangements are similar to a retail interconnection and it is up to each service provider to route the packets to their destination along the most appropriate route. The route may vary and does not have to be known in advance by the sender.

2.1.4 Meters

2.1.4.1 General

ISO 7498-4 (OSI Reference Model Part 4: Management Framework) defines a generalised accounting management activity which includes calculations, usage reporting to users and providers and enforcing various limits on the use of resources.

The OSI accounting model defines three basic entities:

1) the METER, which performs measurements and aggregates the results of those measurements;

2) the COLLECTOR, which is responsible for the integrity and security of METER data in short-term storage and transit; and

3) the APPLICATION, which processes/formats/stores METER data. APPLICATIONS implicitly manage METERS.

This paper is concerned with specifying the attributes of METERS and, with little concern at this time for COLLECTORS and APPLICATIONS

2.1.4.2 Purpose of the meters

A METER is a process which examines a stream of packets on a communications medium or between a pair of media. The meter records aggregate counts of packets belonging to FLOWs between communicating entities (hosts/processes or aggregations of communicating hosts (domains)). The assignment of packets to flows may be done by executing a series of rules. Meters can reasonably be implemented in any of three environments -- dedicated monitors, in routers or in general-purpose systems.

Meter location is a critical decision in accounting. An important criterion for selecting meter location is cost, i.e., REDUCING ACCOUNTING OVERHEAD and MINIMISING THE COST OF IMPLEMENTATION.

In the trade-off between overhead (cost of accounting) and detail, ACCURACY and RELIABILITY play a decisive role. Full accuracy and reliability for accounting purposes require that EVERY packet must be examined. However, if the requirement for accuracy and reliability is relaxed, statistical sampling may be more practical and sufficiently accurate, and DETAILED ACCOUNTING is not required at all. Accuracy and reliability requirements may be less stringent when the purpose of usage-reporting is solely to understand network behaviour, for network design and performance tuning, or when usage reporting is used to approximate cost allocations to users as a percentage of total fees.

Overhead costs are minimised by accounting at the coarsest acceptable GRANULARITY, i.e., using the greatest amount of AGGREGATION possible to limit the number of accounting records generated, their size, and the frequency with which they are transmitted across the network or otherwise stored.

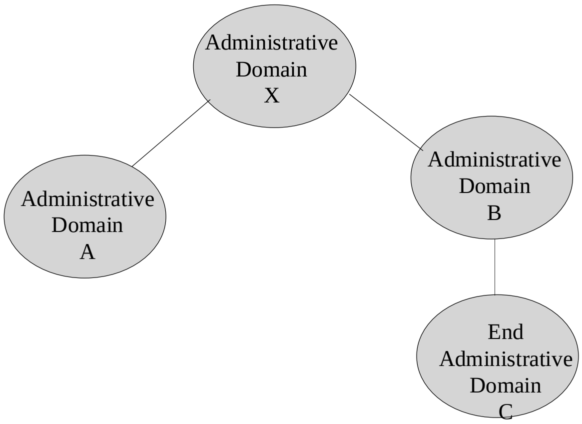
The other cost factor lies in implementation. Implementation will necessitate the development and introduction of accounting software components into the ATN. It is important to design an architecture that tends to minimise the cost of these new components.

3. A Model for ATN ICS Accounting

3.1 Basic principles

We begin with the assumption that there is an ATN Administrative Domain for which accounting is of interest. This Administrative Domain "owns" and operates some subset of the ATN and has well defined boundaries.

For accounting purpose, we assume that the network administrator is interested in traffic crossing the boundaries of his Administrative Domain. Accounting within the boundaries of the Administrative Domain is out of the scope of ATN SARPs and not considered in this paper.



The network administrator is usually not interested in accounting for end-systems outside his administrative domain; his primary concern is accounting to the level of other ADJACENT (directly connected) administrative domains. Consider the viewpoint of the administrator for domain X of the internet. The idea is that he will send each adjacent administrative domain a bill (or other statement of accounting) for its use of his resources and it will send him a bill for his use of its resources. When he receives an aggregate bill from Network A, if he wishes to allocate the charges to end users or subsystems within his domain, it is HIS responsibility to collect accounting data about how they used the resources of Network A. If the "user" is in fact another administrative domain, B, (on whose behalf X was using A’s resources) the administrator for X just sends his counterpart in B a bill for the part of X’s bill attributable to B’s usage. If B was passing traffic for C, them B bills C for the appropriate portion X’s charges, and so on, until the charges percolate back to the original end user, say G. Thus, the administrator for X does not have to account for G’s usage; he only has to account for the usage of the administrative domains directly adjacent to himself.

This paradigm of recursive accounting may, of course, be used WITHIN an administrative domain that is (logically) comprised of sub-administrative domains.

3.2 Implications of the Model

The significance of the model sketched above is that ATN internet accounting must be able to support accounting for adjacent intermediate systems.

Adjacent Intermediate System accounting information cannot be derived from end-system accounting (even if complete end-system accounting were feasible) because traffic from an end-system may reach the administrative domain of interest through different adjacent domains, and it is the adjacent domain through which it passes that is of interest.

The need to support accounting for adjacent intermediate systems means that accounting will require information not present in CLNP PDU headers (these headers contain source and destination addresses of end-systems only). This information will come from lower layer protocols (SNAcP or link layer) in the form of the source/destination SNPA address.

3.3 Meter Placement

In the model developed above, the ATN may be viewed as a hierarchical system of service providers and their corresponding constituencies. In this scheme the service provider accounts for the activity of the constituents or service consumers. Meters should be placed to allow for optimal data collection for the relevant constituency and technology. Meters are needed at administrative boundaries and data collected such that service provider and consumer are able to reconcile their activities.

Boundary Intermediate Systems are by definition and design placed at these boundaries and so it follows that the most generally convenient place to position accounting meters is in the BISs.

3.4 Meter granularity

In the model developed above, meters implemented in the BISs will retain the information that will be required to generate a possible bill for the adjacent Administrative Domain. The granularity of the information retained in the meters needs to be specified.

The minimum granularity of accounting is to associate counters on exchanged packets, with an adjacent Administrative Domain without retaining further information.

Finer granularity of accounting will require that counters on packet exchanged with an adjacent Administrative Domain, be differentiated function of certain attributes of the packets such as:

- The source Domain or ES of the packet
- The destination Domain or ES of the packet
- The traffic type
- The priority
- etc...

Where verification is required, a service provider could be required to be able to perform accounting at fine levels of granularity (subscriber may require detailed bills).

Depending on its own charging policy, a service provider may also be willing to implement some levels granularity (e.g. for charging differently function of the priority or the traffic type of the packets).

Another issue is whether packets should be counted on entry into an Administrative Domain with the idea to charge the adjacent Administrative Domain from which the packet is received, or upon exit with the idea to charge the adjacent Administrative Domain to which the packet is delivered.

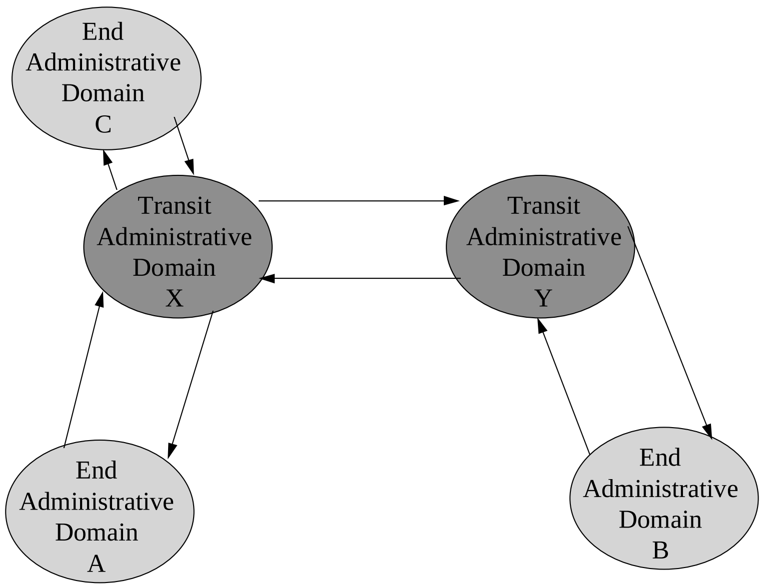
4. Accounting Scenarios for the ATN

4.1 General

On the basis of the model introduced above, this chapter describes a series of possible accounting scenarios.

4.2 Accounting for Ground/Ground ATN communications

4.2.1 CLNP traffic



Consider the figure above, and the traffic exchanged between the Administrative Domains a and b.

According to the model introduced in chapter 3, we assume that X will implement an accounting meter in the BIS at the boundary between X and A. In the same way, we assume that Y will implement an accounting meter in the BIS at the boundary between Y and B.

The interconnection between X and Y is « wholesale » by nature. The implementation of accounting meters at the boundary of these 2 service providers is dependent of the charging models (« sender keeps all », « multiple bilateral agreements » or « incremental charging ») that has been agreed between X and Y. It can however be assumed that meters will be implemented on both sides, for measuring policy compliance, if not for charging the communications.

We assume that the accounting policy is usage-sensitive. X and Y could have the choice between the three different policies:

1. charging the CLNP packets received from the adjacent domains. With such a policy, only A would pay for CLNP packets sent from A to B

2. charging the CLNP packets delivered to the adjacent domains. With such a policy, only B would pay for CLNP packets sent from A to B

3. charging both the received and delivered CLNP packets. With such a policy, both A and B would pay (half the price) for CLNP packets sent from A to B

By considering these 3 possible scenarios a first important remark can be raised: both X and Y must use the same accounting policy. This becomes obvious if you consider a counter example where X would charge packets on delivery and Y would charge the packets on receipt: in such a case any CLNP traffic from A to B would not be accounted.

Let us now consider the advantages and drawback of each approach.

The first approach has the advantage of being the most natural: the domain which takes the initiative of issuing the CLNP traffic is charged. Its drawback his that packets may be accounted even in cases they do not reach the destination.

The second approach has the opposite advantage and drawback: charged packets have reached their destination; on the other hand, the domains are charged for traffic they are not at the origin of.

The third approach has the advantage to solve for the service providers any problem of traffic imbalances. However considering that traffic imbalance problems can be solved with the 2 first scenarios by implementing meters at the boundaries between service providers, this seems not to be a sufficient reason to promote this approach. The third approach has the drawbacks of the 2 other approaches (lost sent packets and remotely initiated packets are accounted for a domain) but each domain is accountable only for the half of the traffic and will therefore have to pay only the half for any possible errors (packet losses and unexpected traffic from a remote domain). The third approach has also the drawback to double the size of the meters (both incoming and outgoing packets have to be counted). This is the weak point and the main reason why this solution will not be recommended.

The 2 first approaches are acceptable. However, considering that for ground-ground ATN communication the likelihood for packet loss will be minimal, and that ATN users will prefer to be accountable for the traffic they are at the origin of, the first approach is assumed as the most appropriate.

The recommended usage sensitive accounting policy in the ATN for ground-ground communication is to charge the CLNP packets received from the adjacent domain.

4.2.2 Other accounting requirements

The above recommendation may not be satisfactory for an administration or organisation providing application level services. Consider for example the case of an organisation providing access to a meteorological data base: this meteorological server allows remote clients to download consequent amount of information on reply to simple requests. With the recommended accounting policy, the administration or organisation providing the service will also be the one which has to support most of the charges associated with the derived CLNP traffic.

This accounting problem cannot be solved at CLNP level. The solution lies in the introduction of accounting meters at transport or application protocol level in the End Systems. The administrations or organisations implementing End Systems providing services to remote (client) ESs and willing to be paid for this service or reimbursed for the incurred network traffic expenses will have to implement meters in ESs at transport or application protocol level.

Therefore, accounting at transport or application level in ATN ESs is certainly required. This issue is however not addressed in this paper.

4.2.3 Minimal meter granularity required for G/G internet communications accounting

At a first sight, and according to the recommendation above the minimal granularity of meters required for G/G internet communications accounting seems limited to the count of CLNP NPDUs and/or the number of octets of CLNP NPDUs received from the SNPA of an adjacent BIS.

However, such a simple meter granularity will certainly be not sufficient. Indeed, with such a basic granularity, all received CLNP packets would be all taken into account in the same counters without consideration to packets characteristics such as their destination address, their priority, etc...; all packets sent would be charged at the same unique price whatever their destination or the required Quality of Service.

It is assumed that in practice, the charges for packets will depend as a minimum of the destination of the packets and therefore that the number of CLNP packets (and/or of octets of CLNP packets) received will have to be counted separately in different counters each being associated with a different address prefix of a possible destination.

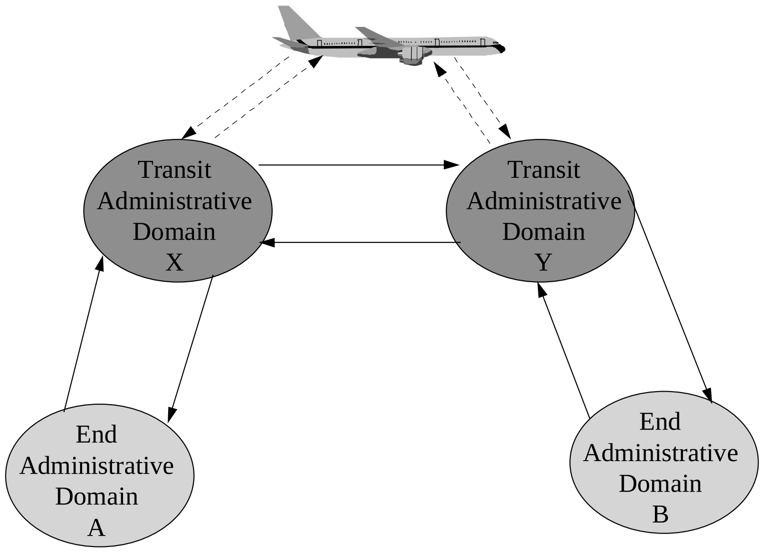
As an example, an ATN internet service providing service to a French ATN user will certainly implement different counters for:

- packets sent to another French Routing Domain (i.e. the destination address of which matches the French ATN address prefix)
- packets sent to another European Routing Domain (i.e. the destination address of which matches the European ATN address prefix)
- packets sent to another region

The meter structure must therefore allow to configure separate counters associated with different configurable destination address prefixes. The complexity of the meter will then depend on the possibilities of address aggregation that are permitted by the addressing plans. This complexity may become a problem with regard to the addressing of the AINSC Routing Domains (which is not well known at this time).

The introduction of finer levels of granularity (e.g. charging differently function of the packet priority or its security tag), and of the associated metering mechanisms are assumed to be local issues to be considered by the organisations willing this level of accounting.

4.3 Accounting for Air/Ground ATN communications



Consider the figure above and assume that an ES in Administrative Domain A is communicating with an ES on board the aircraft. We must consider whether the accounting principles recommended in section 4.2.1 can be applied in an A/G internet communication scenario context.

At a first sight, the earlier recommended principles seem to be valid for A/G communication as well: X can charge A for the CLNP traffic exchanged from A to the aircraft; and X can charge the aircraft for the CLNP traffic exchanged from the aircraft to A.

There is a difference, however, with respect to the traffic from A to the aircraft. The problem is that the BIS in X at the boundary with A will not a priory know how far is the aircraft: the destination aircraft may be directly connected to X, but it could as well be connected to Y instead, or to another A/G domain on the other side of the planet. In the case of ground to air communication, the destination address (i.e. the airborne NSAP address) does not allow to know how far is the destination, and therefore how much it will cost to convey the packet to the destination.

The recommended policy for G/G ATN internet accounting (i.e. charging the packets received from the adjacent BIS) is suitable for air to ground but not for ground to air traffic.

The suitable accounting policy for ground to air traffic is the second approach identified in section 4.2.1. Ground to Air packets should be charged on delivery to an adjacent BIS and the charge should be function of the source address.

5. Conclusion

The discussion in this documents leads to the following recommendations:

1. Meters for accounting should be implemented in the BISs.

2. The recommended usage sensitive accounting policy in the ATN is to

    - charge the CLNP packets received from the adjacent domain when these packets are addressed to a ground destination. For this case, the meter structure should allow to configure separate counters associated with different configurable destination address prefixes .

    - charge the CLNP packets delivered to the adjacent domain when these packets are addressed to an airborne destination. For this case, the meter structure should allow to configure separate counters associated with different configurable source address prefixes

3. All ATN administrations and organisations performing usage sensitive accounting shall follow the same accounting policy approach

4. The administrations or organisations implementing End Systems providing services to remote (client) ESs and willing to be paid for this service or reimbursed for the incurred network traffic expenses should implement meters in ESs at transport or application protocol level.