다중 서비스망 환경에서의 실시간 과금 관리 시스템설계 및 구현

(Real-Time Full Accounting Management System in Multi-services Access Integrated Network : Design and Implementation)

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요 약 과금 관리를 포함한 대부분의 망관리 기술들은 단일 서비스망을 중심으로 연구 개발되어 왔으며, 국내외적으로 ATM 기반의 이종 서비스망환경에서의 과금 관리는 현재 많은 연구 기관들에 의해 개발 중에 있다. 본 논문에서는 광대역 통신망의 복수 서비스를 통합·지원하는 액세스망에서의 실시간 과금 관리 시스템을 설계하고 구현한다. 과금 관리 시스템은 ATM 크로스커넥팅 기능을 수행하는 액세스 노드상에서 과금 정보를 측정하고 기록하는 에이전트와 워크스테이션 상에서 과금 정보를 수집하고 처리하는 매니져 구조로 설계·구현되었다. 에이전트의 관리정보는 OSI 시스템 관리 서비스와 CMIP 프로토콜을 사용하는 TMN 표준 Q3 인터페이스를 통해 매니저로 전달된다. 이후 과금정보는 매니져에 의해 과금 레코드로 변환되어 해당 서비스 제공자에게 제공되고 웹을 통해 실시간으로 열람할 수 있다.

Abstract The billing techniques to support multiple services in an ATM based broadband access network have been rarely developed. In fact, the management techniques including accounting management have only focused on a single service environment such as PSTN thus far. In this paper, we present an accounting management system, called rtFAMS, designed and implemented to provide multiple Value Added Service Providers (VASPs) the charging records for the multiple services in a broadband access network. The architecture is based on OSI system management infrastructure and TMN Q3 interface to acquire accounting information from agents in the ATM cross-connecters as well as to process the billing mechanisms in the manager. This system is designed to actively adopt the rapidly changing service environments and B-ISDN network management techniques. It also provides real-time accounting information to users using Web in addition to supplying the billing records to VASPs.

1. Introduction

Because being designed for individual services, the telecommunication networks have been generally not well suited for different types of services. For instance, public switched network, data network, and broadcast networks have been designed for voice, computer communication, and television, respectively. Thus, they are inherently different in network requirements such as bandwidth, holding times, end-to-end delays, and error rates [15]. Consequently, the network technologies were redundant and not cost effective. Further, users frequently complained complex ways of using the networks.

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Thus, the concept of high speed integrated network for various services has become highly desired in communication community and brought a series of innovative ideas.

B-ISDN access network using various types of ATM technology such as xDSL, HFC, and FTTx that are classified based on the services provided, geographical distribution of subscribers, types of transport medium, and/or connecting methods [3][6][16] has been proposed to support high speed multiple services. In this network, ATM is the core of the network because ATM is superior to network equipments in the provision of guaranteed Quality of Service (QoS), and scalable bandwidths for new class of voluminous applications. Even though the idea of providing multiple services in an ATM based access network is attractive, it makes the billing mechanisms much more complex due to the lack of billing models.

Recently the standards for Full Service Access Network (FSAN) environment were proposed by multiple organizations - ETSI, NTT, and BT [3][6], for integration of multiple service providers and heterogeneous service environments via integrated access nodes. Multiple organizations and industries strive to develop FSAN in accordance with the standards. One of the examples of recently developed FSAN is the Multi-services Access Integrated Network (MAIN) from the Electronic and Telecommunications Research Institute (ETRI) in Korea. Figure 1 shows a reference model of MAIN with an integrated access node that interconnects service providers and associated service networks.

As mentioned above, accounting management systems have been rarely developed for FSAN, and even the developed ones are for a single service environment. Therefore, the efficient billing techniques in ATM based broadband access network are needed so that discriminative billing that reflects QoS and network status as well as the traffic usages is possible. Also, a billing system which can adopt rapidly changing services is wanted for the future services and various access networks. In this paper, we present the real-time Full Accounting Management System (rtFAMS) which is designed and implemented to provide Value Added Service Providers (VASPs) the billing information. It consists of agents which perform a real-time monitoring and metering over the MAIN, and a manager which produces billing records based on the usage of per-connection, per-service, per- contents, and/or per-user basis. The manager and agents of rt-FAMS exchange charging information via the TMN Q3 interface and generate the reasonable billing records on the basis of collected information.

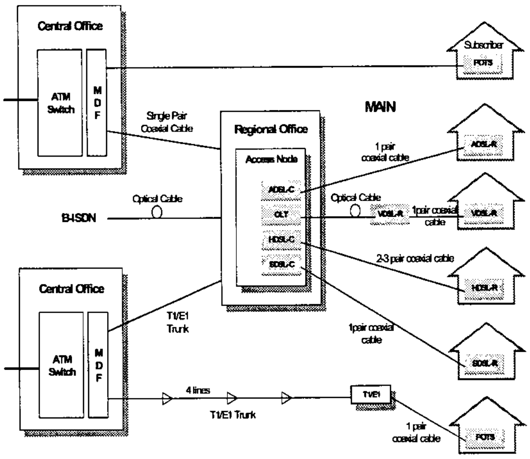

Fig. 1 Reference model of MAIN

This paper is organized as following. In section 2, the related work and design alternatives are presented before presenting the architecture of rtFAMS in sections 3. In section 4 and 5, we present the design issues of the system and the details of implementation. Finally, the conclusion and the future work are drawn in section 6.

2. Related Work and Design Alternatives

Recently, billing recommendations for ATM networks have been proposed by several standard bodies in order to compute a reasonable charge for both subscribers and VASPs [20][21][23][24][27][28]. Among them ITU's SG 3 and SG 13 have defined charging parameters and charging records over an ATM level. SMART billing team of NMF (Network Management Forum) has also been proceeding the accounting management projects such as the accounting processes and charging records, and related work. Besides, many other organizations such as ACTS (Advanced Communication Technologies & Service) projects CANCAN, CAPITAL, CA$HMAN, ATM Forum, AT&T, and NTT, are working on charging and billing schemes over ATM networks. We summarize these schemes in this section and point out the deficiency of the accounting management systems in a practical point of view.

As shown in Figure 2, billing management consists of four parts such as political, economical, technical, and operational domains [8][10]. Economical domain deals with charging schemes to recover network cost in a competitive and fair way for the diverse population of users. Political domain covers the government's economic policies concerning network cost. However, the economic domain does not deal with the networking techniques in the technical domain - QoS, congestion, ATM, frame relay, and network protocol which are also important because of a fair billing even though it has nothing to do with economical issues. Finally, operational domain includes elements to effectively allocate and manage network resources [10].

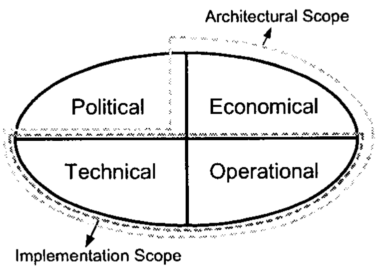

Fig. 2 Scope of billing management

In general, a billing mechanism can be classified as a fixed or a dynamic charging scheme [10]. Fixed charging is a pricing method irrelevant to the quantity or duration of service usage, and users pay a fixed fee for the period. For example, access charge is a monthly subscription fee for the access to the network or services. On the contrast, a fee is dynamically changed by charging rate which is usage-based, or transaction-based [4][9][10][11][14] in dynamic charging.

Most conventional accounting management systems use fixed or flat rate charging scheme to calculate network charges because it is easy to implement compared to usage-based charging schemes whose charges are determined by applying the rate to the connection time for the services. This characteristic is probably fair to the users on a single-service environment. However, it is almost impossible to apply the same rule in a multi-service environment such as MAIN because of various requirements raised by the service providers and subscribers. However, it does not imply that usage-based dynamic charging is better than fixed or flat-rate charging. It only means that dynamic charging scheme that reflects the current network status provides proper charge to the users by taking into account the use of the network resources. The dynamic charging scheme could also resolve the problem related to network abuse. To say the least, dynamic scheme helps users to effectively manage their use of network resources.

For user oriented billing, usage-based charging uses feedback signal that allocates bandwidth through users interaction with feedback signal. This scheme allocates resources effectively and sets a user acceptable price. However, the disadvantage of feedback pricing is that it is not applied to real world due to a large overhead. We cannot apply the overhead of user interaction to application level because it is fixed in the initial price during connection, otherwise user must put up with such interaction overhead. Moreover, it is quite difficult to find an adequate service model for billing.

The schemes proposed to calculate network charges in multi-service environment have the disadvantages mentioned above. Thus, we developed integrated accounting management schemes and implemented rtFAMS to resolve the problem without these drawbacks. The rest of the paper describes the design and implementation of rtFAMS.

3. rtFAMS Architectural Model

The rtFAMS architecture based on OSI system management and TMN model is shown in Figure 3. The TMN model was developed to easily categorize management functions into layers. A logical and consistent separation of management functions according to the role of the operations are employed [23][24].

The operation system function (OSF) of rtFAMS processes information related to the billing and billing management itself. The model defines three OSFs and one GUI as workstation function (WSF): OSF_{NEML} is a process that monitors and meters the usage as a role of agent. OSF_{NML} contains functions for collecting and formatting the charging records. OSF_{SML} contains functions for charging and WSF_{SML} is a graphical user interface (GUI) function which communicates with operators and users. Both OSF_{SML} and GUI_{SML} are connected throug the TMN f reference point.

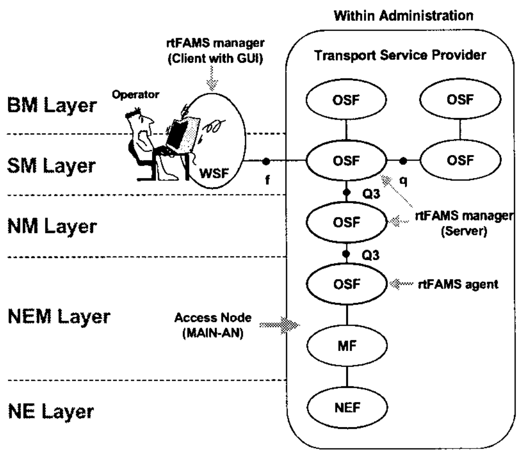

Fig. 3 Relationship rtFAMS with TMN

We first describe the ATM accounting management information base (MIB) consisting of traffic descriptors, traffic parameters, and QoS parameters for monitoring and metering. The charging records are generated on the basis of usage-metering and QoS parameters of ATM level that collected through the TMN Q3 interface between a manager and an agent.

Accounting MIB and billing processes have already been regulated by standard bodies such as ITU-T, IETF, NMF, and ATM forum [20][27]. They only have a little differency that is an added management information or detailed sub-functionality.

3.1 Accounting MIB

Accounting MIB of rtFAMS are derived from [18][19][20][21][22][25][26][27]. It includes both usage parameters defined by ATM Forum and basic accounting parameters such as start and end time of connection used in the MIB for PSTN. The parameters are classified into three classes, registration parameters, duration parameters, and complete parameters. Registration parameters include basic elements for each connections such as the call reference, the calling and called number, and the traffic contract parameters that are Peak Cell Rate (PCR), Sustainable Cell Rate (SCR), Minimum Cell Rate (MCR) and Maximum Burst Size (MBS). Duration parameters include the metered traffic and the number of transmitted cells with QoS parameters which are maximum Cell Transfer Delay (maxCTD), Peak-to-peak Cell Delay Variation (ppCDV), Cell Loss Ratio (CLR). Complete parameters include the connection end time and the connection clear cause. Other MIB parameters could be listed as ConnectionType, CastType, IFName, Vpi, Vci, CallingPartyAddr, CalledPartyAddr, CallReference, StartTime, CollectionTime, CallingPartySubAddr, CalledPartySubAddr, and more.

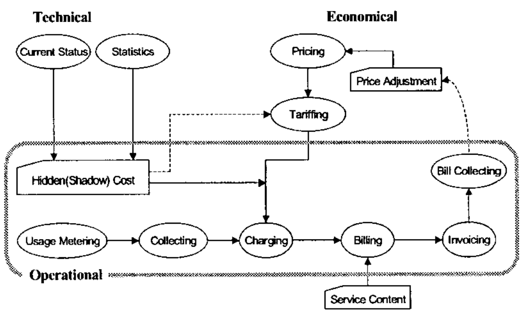

Fig. 4 Billing process of rtFAMS

3.2 Billing processes

Billing processes of rtFAMS consist of usage metering/monitoring process, collecting process, and charging process. Figure 4 describes the billing processes of rtFAMS. It is expanded from the conventional accounting management processes in telecommunications [1][2][23][26].

Usage Metering process

Usage metering performs the real-time metering of the accounting information such as the type of service, the quantity of service used by a subscriber, and QoS. At a call set-up procedure, this process decides the ATM level service contract for each subscriber by metering traffic parameters and QoS parameters. Main task of the real-time metering is counting incoming and outgoing cell numbers for the established connections. As a matter of fact, this process is implemented an agent using the meter object and the log object defined in the CMIP's MIB as the related objects[26]. The meter object must include the data it records and reported to a manager, and the control information about when and how it is recorded and reported. The log object takes a role of logging these data.

Collecting process

Collecting process acquires the accounting information from an agent. In practice there are two ways to collect the accounting information. One is that an agent reports the information to manager by the notification generated when accounting events occurs, the other is that a manager polls an agent periodically for the information. The former is implemented by the notifications using the CMISE M-EVENT-REPORT service and the latter collects charging parameters periodically in terms of File Transfer Access and Management (FTAM). The real time transmission of charging parameters is responsibility for Event Forwarding Discriminator (EFD) managed object. We will explain the detail of these collecting schemes later in this paper.

Charging process

Charging process is the process that consists of formatting module and rating & discounting module. The formatting module converts the collected accounting information to charging records and stores it into the charging record database, the rating & discounting module calculates the bill, using the charging formula that takes charging record as an input.

3.3 Charging record

As we mentioned above, the activities for standardizing the form of charging records and charging parameters have been operational for years. For instance, ITU-T's Charging Detailed Record (CDR) and NMF's universal accounting record (UAR) are the good examples of these activities. However, it still needs little more time to settle the standard because the parameters in charging records are determined in the consideration of complicated factors from multiple service providers. It also depends on metering intervals, collecting environments, and the traffic control mechanisms over ATM networks.

User Access	CI	Connection Identifier
	MST	Metering Start Time
	ST	Service Type
	UID	User ID
Current Network Status	ToD	Time of Day
	CongRate	Congestion Rate
Usage	CONN-T	Connection Type
	CALL-T	Call Type
	BC	Bearer Class
	CDV	Cell Delay Variation
	CLR	Cell Loss Ratio
	MAX CTD	Maximum Cell Transfer Delay
	PCR	Peak Cell Rate
	SCR	Sustainable Cell Rate
	MCR	Minimum Cell Rate
	MBS	Maximum Burst Size
	F-QOS	Forward QOS
	B-QOS	Backward QOS
	F-CC-0	Forward Cell Count with CLP = 0
	F-CC-1	Forward Cell Count with CLP = 1
	B-CC-0	Backward Cell Count with CLP = 0
	B-CC-1	Backward Cell Count with CLP = 1
	DISC	Discount Factor
	EXTRA-CH	Extra Charge Factor
Service Content	TS-ID	Transport Service ID
	VAS-ID	Value-Added Service ID

Fig. 5 Charging record

The charging record of rtFAMS consists of four types of parameter fields - fields for user access data, fields for current network status, fields for service usage, and fields for service content in Figure 5. The details of the fields are explained as follows.

User access fields:

Access fee for a user is computed by summing up the fixed price on contract and the dynamically determined price based on the access duration and frequency by the user. The user access fields include data to compute the access fee such as user ID, provider ID, service type, connection type, cast type and more for each individual configuration.

Current network status fields:

These fields contain positive integer values indicating quantity of QoS and congestion, and statistical data reflecting network status associated with time of the day. The statistical data can be used to support billing rate based on the network usage called congestion rate.

Usage fields:

Usage fields include parameters for the quantity of services used by a user. The quantity of services are measured by both volume and duration parameters. Occasionally, distance is taken into account if a service uses remotely located resources.

Service content fields:

rtFAMS accounts for quantities of transport, not for qualities of contents. Therefore, general network providers do not need these fields because they are only interested in pricing the transport services. These fields in a charging record are filled with positive values that indicate service contents when service providers optionally specifies. In general, VASP's billing systems consider the service content when they compute the final bills from the charging records provided by accounting management system.

3.4 Billing equation

Billing equation for TSP's wholesale charging is defined by $Bill_{TS}$, as shown below. It is represented as summation of three components such as access, usage, and hidden charge.

$$Bill_{TS} = A_C + \sum_{i=1}^{n} (U_C + H_C)_i$$

$$A_C = f_a(User\ access\ fields)_{ToS} = \eta$$

$$U_C = f_u(Usage\ fields)_{ToS} = \alpha \times D + \beta \times V + [\gamma \times Distance]$$

$$H_C = f_h(Current\ network\ status\ fields) = \frac{1}{QoS(delay, loss)} \times \delta \times \rho$$

TS : Transport Service

X_C : Type of Charge

(where, X = Access, Usage, Hidden)

Where fx is the charging function for charge of x, ToS is the type of service, η is a fixed charge, α is the "per unit time" rate, D is the duration of the call, β is the "per unit volume", V is the volume of the call, δ is a congestion rate, and ρ is a priority of statistical data such as ToD. Uc makes reference to [4][20] as to calculate usage charge.

Hc is the key component of our equation since it can calculate the hidden cost that is discriminative charge based on QoS, congestion, and statistical data. If the using QoS decreases, Hc is the higher cost than the ordinary time.

In this paper, we deal with only $Bill_{TS}$ for TSP's wholesale charging, and VASP's retail charging is out of the scope.

4. Design Issues

In the course of designing and implementing rtFAMS, we have faced a few technical issues. Among them we describe three important issues - collection schemes, accounting events, and charging schemes.

The collecting schemes of rtFAMS are classified as event-driven collection scheme and periodic collection scheme. In the event-driven scheme, agents voluntarily transmit charging parameters to manager immediately when an event occurs. Thus, manager may keep track of up-to-date information, but should be careful not to generate too much traffic for unnecessary event data between manager and agents. For the solution, the only pre-defined events are transmitted. This scheme is implemented by the notifications using the CMISE M-EVENT-REPORT service. On the other hand, manager periodically requests charging parameters using file transfer access and management (FTAM) in the periodic scheme. Note that the network management should not degrade the performance or the functionality of a network. By separating collection schemes into the two, the rtFAMS minimizes the degradation of the performance and the functionality of the network. The rtFAMS takes advantage of the event-driven charging scheme for real-time collection of the basic charging information and a periodic collection scheme for the total charging information.

The charging scheme of rtFAMS supports various bearer services over ATM networks. It is made up of two levels [2]. The first level is set-up level charging scheme based on the negotiated contracts between service providers and subscribers. The contracts are negotiated prior to the provision of services and traffic parameters and QoS parameters are initiated at call set-up procedure. This scheme is not directly related to the traffic to be transported over the connection, but it is closely related to the Call Admission Control (CAC) which is one of the ATM traffic control mechanisms [22]. The second is usage-based charging scheme in session level. This scheme is directly related to Usage Parameter Control (UPC) of User Network Interface (UNI) and Network Parameter Control (NPC) of Network to Network Interface (NNI) that performs a real-time monitoring on the validation of the negotiated traffic contract at the call set-up procedure.

As mentioned previously, ATM network could provide not only many different types of transport services such as CBR, VBR, ABR, and UBR [15], but also several degrees of QoS based on delay and loss [12][22]. If these services are not priced differently, billing would not be fair to the users for supporting the different types of services [10][11].

Most of current ATM transport services are PVC-based [2]. However, they may cause inefficient use of ATM network resources [15]. In order to maximize the utilization of network resources, SVC-based services should be provided to users by TSP. For this reason, we should consider the SVC-based services in designing the collection and charging schemes.

Because PVC-based services have no signaling information, the accounting information should be periodically sent from rtFAMS agents for real-time collection. On the other hand, the accounting events can be directly defined in MIB in terms of the signaling information of CAC, UPC,·or NPC for ATM SVC-based services. Thus, signaling events can be immediately collected when they occur. This real-time transmission of charging parameters is responsible for Event Forwarding Discriminator (EFD) object.

5. Implementation of rtFAMS

We have implemented the rtFAMS on a testbed consisting of SUN UltraSparcⅡ workstation as a server system, INTEL PentiumⅡ based PCs as clients, and an agent over the MAIN-AN. The environment for the development is summarized in Figure 6.

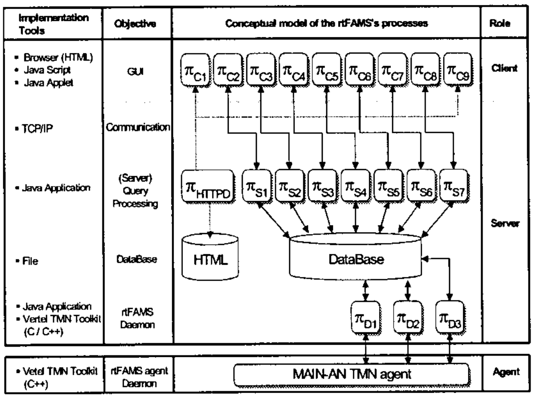

Fig. 6 Implementation environment of rtFAMS

The π_x is a process that performs a role of individual module. That is, π_{S1} is a process that processes queries from π_{C1}, where x denotes client(C), server(S), or daemon(D). As shown in Figure 7, rtFAMS consists of a manager and agent systems. Manager and agents exchange the accounting information, defined as GDMO of CMIP's MIB in terms of ASN.1 using OSI CMIP operations through TMN Q3 interface [25][26].

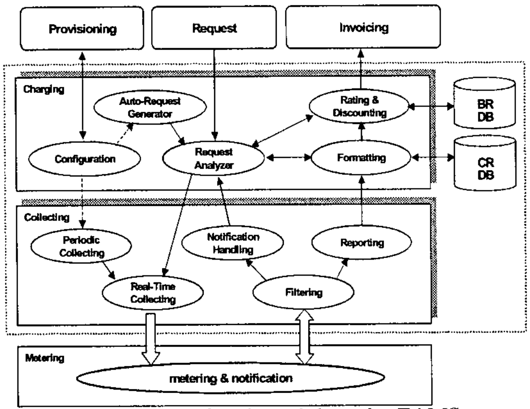

Fig. 7 Functional modules of rtFAMS

An agent initializes the accounting MIB as well as traffic contracts and QoS parameters the subscriber pre-configured at call set-up time. After then, it monitors whether or not the transmitting traffic over the network violates the contracts until the connection is released, and then it assigns the metered values to the topology attributes. Thus, its operations depend on ATM traffic control mechanisms such as CAC, UPC, and NPC. When accounting events occur, agents should record and notify them to a manager.

The manager filters the notifications which agents send, and then checks the validation and the type of those filtered notifications. If the notification requires a specific action, it is passed to the notification handling module to perform the specified action. Otherwise, it is passed to the formatting module and stored in the charging record database with the type of services and QoS. The stored charging records become the final charges by the specific charging formula applied at the rating and discounting time.

We implemented a manager of rtFAMS on the basis of client-sever model; that is, it consists of clients using the graphical user interface to process operator's commands while server consists of collecting, formatting, and charging process. The client is JAVA applets or HTML files with web-based TMN X interface using HTTP and TCP protocols. Web interface is used because they can support user mobility and system independent characteristics. It also provides a user-acquainted graphical interface for network operators. All operators' commands are transmitted to rtFAMS server by the communication modules in client. The server which communicates with agent through TMN Q3 interface is the main body that collects accounting information, generates charging records, calculates charges, and transmits the bills to service providers.

rtFAMS itself has nine view menus that provide seven main functions and two supplementary functions. The supplementary functions are information display and help operation, as shown in

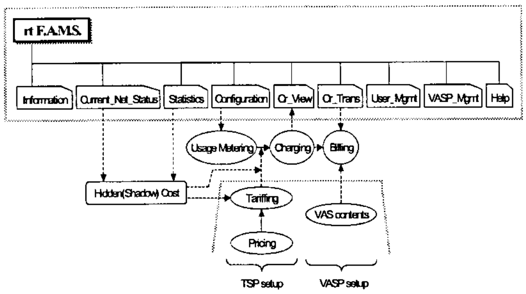

Fig. 8 Menu structure of rtFAMS

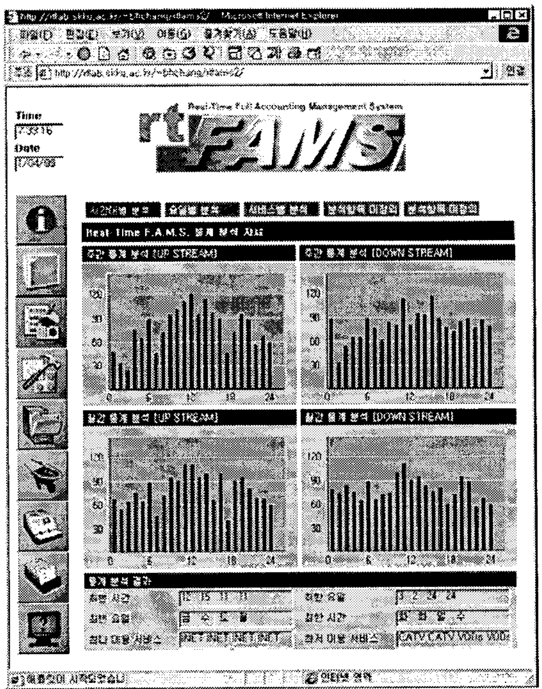

Fig. 9 An example of statistics of rtFAMS

Figure 8. The selected views based on the view menus are shown in Figures 9 to 11 and briefly explained.

Tariff including hidden cost could be computed in terms of current network status menu, statistics menu, or both. Traditionally, hidden cost is calculated only base on statistical information from the analysis of the predefined management parameters such as ToD. However, our system uses not only statistical data but also current network status information in order to make charges made by rtFAMS more comprehensive than traditional system. Figure 9 is the view to show the statistical data during a day.

Configuration menu allows the operator to initialize functions for metering and monitoring such as setting up collecting parameters and collecting period.

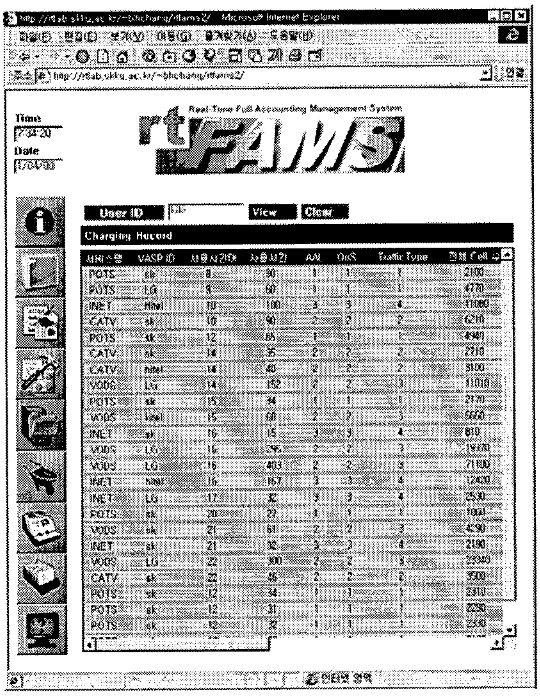

Fig. 10 Cr_View menu of rtFAMS

In Figure 10, operators can obtain users' charging records from the Cr_view menu, and user's private charging record can be displayed in on-line web browser by typing an user identification. Then, the charging records can be transmitted to VASPs by CR (Charging Records) transmission function of the Cr_Trans menu. VASP's billing system applies charging-rates to the records in terms of service contents and produces the final bills.

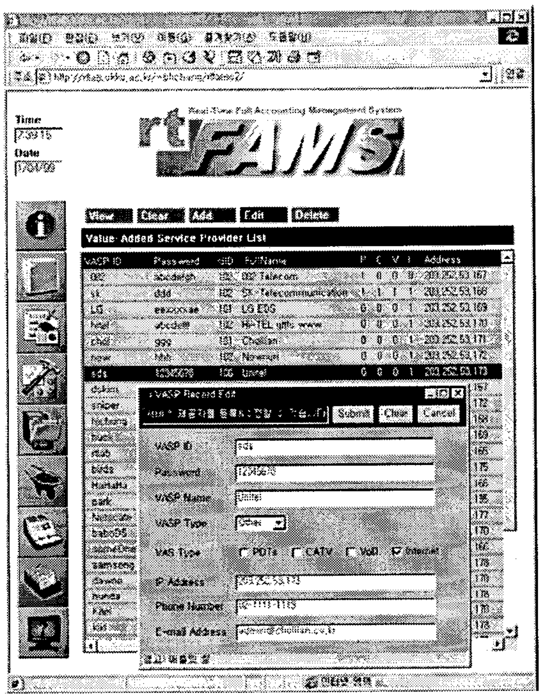

Fig. 11 VASP Management of rtFAMS

Operator uses VaspMgmt and UserMgmt menu to manage both the users and VASPs, as shown in Figure 11. These menus consist of add, change, delete, and view function, and all functions renew screen in real-time.

6. Conclusion and Future Work

In this paper, we designed and implemented the rtFAMS that is a real-time full accounting management system to manage various ATM services in an ATM based broadband access network environment. This system calculates charges and charging records base on the current network status and statistical data - different from the previous accounting systems. Also, this system provides

VASPs to the charging records so that they could generate the final bill and invoice to customers.

Currently, we are working on the final integrated test of rtFAMS for common use in the near future and the implementation of the quality of service billing system called Qbics. Qbics is a billing system model to support VASP's retail charging for end users.

The rtFAMS and the Qbics exchange the charging information through TMN standard X interface. Conclusively, the full accounting management in ATM networks is performed by wholesale charging as well as retail charging. Thus, we expect that rtFAMS and Qbics would be the complete solution for the full accounting management.

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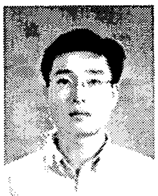

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