# A Rating Bureau Service for Next Generation IP Services

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The marked increase of IP-based services has resulted in the need for a more flexible rating process than the present 'flat-rate' accounting approach. This paper presents the design and development of a Rating Bureau Service for the IP telecommunications environment. It illustrates the architecture, information model, technologies, and standards used in development of the system, as well as expounding upon some of the key implementation goals. In the proposed rating environment, flexibility is achieved by decoupling the charging algorithm and the core rating system. Hence, algorithms can be changed independently of the core system, avoiding the need to recode and recompile. Algorithms can be swapped in and out of the system during rating, allowing a potentially limitless range of services to be rated by equal numbers of tailored algorithms. All algorithms in the system are spreadsheet-based. This approach moves the modelling and construction of algorithms from the programming domain into the business design arena. Anyone with a working knowledge of spreadsheets can effortlessly construct/update these arbitrarily complex charging algorithms. This paper focuses on the development of a fixed line call charging algorithm that may be employed by a large telecommunications company.

## 1 Impending Billing Requirements

Emerging IP networks, and alternative access devices (mobile phones, PDAs etc.), create significant challenges and opportunities for accounting & billing architectures within the next generation IP services sphere. In this environment the nature and range of services proliferate. While traditional telecommunications services have extended to call forwarding, voice mail, and premium call services, typically through Intelligent Network (IN) technology, the emerging environment sees services extending to email, VoIP (Voice over IP), media streaming, messaging, application usage, and various content-oriented access scenarios. These technologies enable service providers to prioritise services according to their perceived customer value, and rely increasingly on more sophisticated metrics such as Quality of Service (QoS) and content type indicators. This new business logic will replace present flat-fee charging algorithms [AND01]. Hence, next generation billing solutions will need to offer the flexibility to plug in arbitrary charging algorithms that reflect this business logic.

In the emerging environment, providers are moving to reposition themselves as integrated service and data providers. Providers are broadening their service offerings from the PSTN based services mentioned above to next generation IP services. They are currently in a position to leverage their existing customer base and establish an infrastructure to deliver support for these next generation services. Billing is an essential aspect of this industry's ability to introduce new services and one that may prove the most difficult for telecommunication providers. Telecommunications billing processes have traditionally been a proprietary function. Each provider has its own mechanisms for collecting service data, mediating that data, rating mediated data, and finally producing a bill. With the rollout of 'always on' next generation services based on 3G (Third Generation) technologies, telecommunications providers will need to establish new flexible charging models in order to rate these services correctly and efficiently.

Service provisioning in the domain of next generation services will need to be rapid and flexible to allow service providers to change and evolve with market demands. Billing represents a critical part of next generation Operation Support Systems (OSSs) that support service provisioning. Providers need accounting architectures with enough flexibility to support existing services while also supporting the rapid addition of new differentiated services.

The primary purpose of the Rating Bureau Service (RBS) is to convert the measurement of service specific usage data into realistic end-charges for the consumer of the service. End charges are calculated by massaging the various parts of the gathered usage data (time units, bandwidth allocation, and content type) with predefined charging algorithms. The charging scheme to be used for a customer is specified in each customer's Service Level Agreement (SLA). Traditional charging schemes rarely offer volume/quality related discounting as part of pricing plans, thus the graph of these charging schemes depicts the extreme linearity of the algorithms used to calculate such charges. Linearity allows consumers to easily pinpoint charge per unit but fails to capture the customer's perceived value for the service. Next generation charging schemes need to incorporate new business logic that supports usage/QoS/volume related discounting. In this environment Call Detail Records (CDRs) will need to be more informative (contain more usage parameters) to provide the necessary inputs to achieve discounting etc. Currently CDRs are automatically generated at the switch, and forwarded periodically in a standard format to processing centres. This format is generally 'switch' dependent. The CDRs are then rated in these processing centres, a process that involves application of proper tariffs, taxes, and discounts. After rating the resulting charge record is then forwarded to billing software for cyclic statements to be generated. This type of solution has historically been optimised for telephony services. The CDRs passed to the rating centre comprise call details such as origin (A) and destination (B) numbers, call duration and time of call. Current rating implementations are largely table driven, batch oriented, and rigidly focussed on these telephony services. The RBS delivers a spreadsheet based, near real time, flexible solution to rate any type of service.

The core element of the RBS is the recently defined (Internet Protocol Record) IPDR Network Data Management – Usage (NDM-U) specification [IPDR02]. The IPDR NDM-U can be seen as a breakthrough in establishing a platform wherein generic accounting architectures can now be framed. Previous attempts at general purpose rating services have been hampered by the absence of a single extensible standard. They are also tied to a CDR-oriented telecommunications approach, applying fixed charging regimes in a pre-determined manner. The IPDR, embodying an extensible XML based schema and Simple Object Access Protocol (SOAP) defined interchange protocol, is rapidly gaining acceptance as the standard format for specifying the usage metrics for sophisticated services. Additionally, the IPDR specification conforms to the TeleManagement Forum's Telecom

Operations Map (TOM) [TMF00], leveraging existing telecommunications management architectures.

The Rating Bureau Service (RBS) team have developed an innovative approach to composing and applying arbitrarily complex charging algorithms to any type of service. It is based on the most common metaphor in standard accounting practice, the cell-oriented worksheet, and the adaptation of this model to facilitate the composition, application, reporting, and reconciliation of diverse charging regimes. On a technological level the RBS incorporates and applies a number of emerging standards and tools. The RBS information model is based on the IPDR NDM-U specification [IPDR02]. IPDR's are schema instance documents for representing IP service details records and are used as the data transmission format of the RBS, both internally and externally.

The RBS Application was developed using Microsoft COM [RK97][WIL94] components hosted in COM+ [EWALD01]. COM+ is an application server and as an Application Server COM+ provides management facilities to the hosted application, or more correctly it manages the individual components within an application. COM+ controls the activation and destruction of a component, the pooling of an individual component for more efficient client connections, and also the clustering of applications in a distributed environment to encourage scalability. The further use of Web Service Description Language (WSDL) [WSDL01]to describe the RBS application allows it to be deployed as a Web Service [KREG01], which in turn enables other accounting components to exchange information in a seamless manner.

As rating is only one component within the overall accounting process it is important that it exists in a workflow environment. With the use of ebXML [EBXML01] and WSDL the RBS can be integrated into an existing service delivery chain. One of the main drivers for this kind of solution is the evolution of business processes. Managers look to integrated business solutions taking account of the life cycle management, physical distribution of activities and the speed of response to changing circumstances, especially in the brave new world of Communications. Managers want applications that are easier to maintain and evolve. They need a greater degree of compatibility between their systems and those of their partners and customers. The RBS focuses on:

- Metering and Mediation - Session data records are merged, aggregated, and converted into a standard data format suitable for rating. Because not all data collected constitutes rateable data, the metering and mediation process is extremely important, involving several steps to ensure consistency of data, elimination of duplicative records, and accuracy of format.
- Rating - After session data records are converted into chargeable data records (IPDRs), rating takes place against charging algorithms in spreadsheet based rating engines. Examples of rateable elements include, speed of transfer, length of transaction/service usage, content type, resource name and quality of service (QoS)
- Reporting -This enables an organisation to review a portfolio of reports/generate queries to measure service usage, bandwidth needs, historical and trend analyses, and a variety of other reports that support decision making efforts.
- Flexibility - Flexibility is required to ensure that services can be deployed rapidly, and that alternative rating strategies can be integrated. This was achieved by building a solution directly related to the world of financial planning and accounting – spreadsheets. This facilitates the application of familiar toolsets and accounting procedures, and ready composition of what-if scenarios and projections.
- Scalability - Scalability is required if new services are to grow to meet customer demands, and to facilitate multiple service providers to collectively deliver valuable services. This is a demanding requirement, but the explosive growth of the Internet

in recent years has yielded several robust and well tested architectural approaches and solutions to large-scale deployment of processor intensive services.

The remainder of this paper describes a trial concerned with validating the usability and flexibility of the spreadsheet approach adopted by the RBS.

## 2 Fixed Line Case Study

Initially a charging scheme for a large fixed line telephony operator was modeled using the spreadsheet approach. Sample CDRs for the service were obtained and a mediator was developed to convert the proprietary CDRs into the standardized IPDR format. The IPDRs and spreadsheet charging scheme represent the inputs of the RBS. The resulting output was a set of customer bills for each of the customers identified in the IPDRs generated. Various stages of the trial are documented below.

### *2.1 CDR Mediation to IPDR*

The RBS functions by interrogating an XML IPDR instance document, extracting element values that correspond to named cells in a spreadsheet charging scheme for that service, inserting these values into the charging scheme spreadsheet, which then calculates a charge for the service usage.

```xml
<?xml version="1.0"?>
<IPDRDoc xmlns="http://www.ipdr.org/namespaces/ipdr" xmlns:xsi="http://www.w3.org/1999/XMLSchema-instance" docid="01234"
      seqNum="1" version="2.5" startTime="2002-05-05T18:50:00Z">

      <IPDRRec info="ipdr-rec.wit.ie" startTime="2002-05-05T18:50:00Z" id="1"/>
      <IPDR seqNum="0" time="2002-05-05T18:50:00Z">
            <SS service="FixedLineTelephony" id="FLT_01">
                  <SC xsi:type="SC-FixedLineTelephony-Type">
                        <userID></userID>
                        <contextID></contextID>
                        <subscriberID></subscriberID>
                        <userApplicationHost></userApplicationHost>
                  </SC>
                  <SE xsi:type="SE- FixedLineTelephony-Type ">
                        <serviceProviderID>Operator_01</serviceProviderID>
                        <serviceChargingScheme> FLT_charge_scheme.xls </ serviceChargingScheme >
                        <serviceProviderHost>RSL020</serviceProviderHost>
                  </SE>
            </SS>
            <UE xsi:type="UE-FixedLineTelephony-Type">
                  <A_Nmr>050945556</A_Nmr >
                  <B_Nmr >1850282820</B_Nmr >
                  <startTme>2002-05-05T18:50:13Z </startTme>
                  <endTme>2002-05-05T18:58:43Z </endTme>
            </UE>
            <CE>
                  <CustomerCharge xlref="charge"/>
            </CE>
      </IPDR>
</IPDRDoc>
```

**Figure 1 Sample Fixed Line IPDR Instance**

The crucial aspect of this approach is that XML Elements can be matched with Spreadsheet Named Cells. In order to achieve this, the proprietary CDRs (switch related) were mediated into IPDRs. A sample IPDR is shown in Figure 1 This IPDR instance holds all the information that the RBS requires to perform number processing in an effort to identify the applicable fee code, which is then matched with a tariff for the particular pricing plan to which the A_Nmr owner subscribes.

### *2.2 Charging Scheme Construction*

Charging scheme construction, as previously cited, is carried out by the use of third-party spreadsheet applications such as OpenOffice Spreadsheet [OPOFF] or Microsoft Excel [Excel]. This approach to algorithm design and maintenance allows non technical persons, including accountants, revenue assurance managers etc. to create and modify customised algorithms. The initial phase of the trial involved the collection of publicly available information on the pricing plans implemented by a large telephony operator. This information was used to generate a comprehensive charging scheme for the telephony service. The parameters used to apply tariffs were identified from a sample CDR that was obtained from a telephony operator. These parameters included:

1. A Number – the number of the calling party
2. B Number – the number of the called party
3. Start Time – the time at which the call was initiated
4. Finish Time – the time when the call was terminated

The low number of CDR parameters suggests that the generation of a charging scheme would be a trivial task. However, this was not the case. Research conducted also identified that the provider also offers incentive volume-based discounting and that there are exceptions to call tariffs based on:

- The geographical proximity of the calling and called parties (physical distance)
- The date (holidays/weekends)
- The time of day (peak/off-peak

These factors resulted in the construction of a complex charging scheme presented in the sections that follow. The basic charging algorithm for each call is:

**C = maximum (a1*T : c_min)**

| | |
|---|---|
| **a1** | **= f (A_Nmr, B_Nmr, Start Time)** |
| T | = Finish Time – Start Time |
| c_min | = minimum session charge |
| a1 | = numeric coefficient (tariff) |
| C | = charge for the session. |

This algorithm describes a sequential series of steps that are required to determine the charge for a call. a1 is determined by first establishing the geographical/relative location of the A_Nmr and B_Nmr. When the location of each is established the call tariff is determined, i.e. local, national, mobile, international, premium etc. Subsequently geographical proximity exceptions are tested i.e. two parties may be located in different countries, yet may only be one kilometer apart, hence, the call should not be charged at an international rate. Then the A-Nmr’s volume based pricing plan is interrogated to determine the applicable tariff for the type of call e.g. local, international etc.

These steps are achieved using spreadsheets. The mathematical algorithms are constructed in a worksheet and reference other worksheets that contain tables of data that are interrogated to extract information.

A simple example is the process used to parse the prefix and body from an A_Nmr/B_Nmr. This approach uses simple spreadsheet functions to determine the prefix. Similar spreadsheet functions are used to determine if the A_Nmr and B_Nmr qualify for proximity based exceptions. To determine the tariff for a particular type of call for a particular customer, a table of fee codes (call type) is interrogated (using lookup functions) and the appropriate tariff is extracted. A set of tariff tables exist and represent different pricing plans. An example is shown in Table 2.

| | | | |
|---|---|---|---|
| ADigit1 | #N/A | 0 | |
| ADigit2 | #N/A | 05 | |
| ADigit3 | #N/A | 050 | |
| ADigit4 | TRUE | 0509 | {this prefix appears in the predefined table of prefixes} |
| ADigit5 | #N/A | 05094 | |
| ADigit6 | #N/A | 050945 | |
| ADigit7 | #N/A | 0509455 | |
| ADigit8 | #N/A | 05094555 | |
| Adigit9 | #N/A | 050945556 | {therefore the body is 45556} |

Formula Used: =OR(MATCH(F6,FLT_charge_scheme.xls!prefixGroup,0))

| prefixGroup |
|---|
| 01 |
| 05 |
| 051 |
| 053 |
| 052 |
| 0509 |
| 0698 |

**Table 1 A_Nmr Parsing**

Different tariffs are applicable depending on the type of call (local, international etc.), proximity exceptions, time of day, date and volume based pricing plans. Once the appropriate tariff is identified, it is massaged with the duration (T) to calculate a charge (C) for the call. This charge is then inserted into the Charge Element of the IPDR that is stored pending the billing cycle. The billing cycle is concerned with aggregating call charges/details to determine if:

- The minimum usage to qualify for a volume discount has been met
- The final bill total is greater than the minimum bill charge

| Fee Code | Tariff | | Day | Evening | Weekend | Min Fee |
|---|---|---|---|---|---|---|
| 1 | Local | | 0.0698 | 0.0174 | 0.0174 | 5.244 |
| 2 | Internet | 1891 | 0.0268 | 0.0133 | 0.0133 | 5.244 |
| 3 | National | STD | 0.129 | 0.0846 | 0.0174 | 5.244 |
| 4 | NCRTN | 085 | 0.402 | 0.268 | 0.2098 | 5.244 |
| 5 | NCRTN | 086 | 0.402 | 0.268 | 0.2098 | 5.244 |
| … | | | | | | |
| 29 | International | Band 1 | 12.063 | 12.063 | 12.0625 | 5.244 |
| … | | | | | | |
| 35 | Esat | 11880 | 0.6984 | 0.6984 | 0.6984 | 41.9014 |

**Table 2 Fixed Line Tariff Table**

Once these tests have been conducted a bill is produced that details each of the calls for the billing period. These details are extracted from IPDRs and include; time, date, duration, B_Nmr, call type, tariff etc. The bill may be delivered in various formats (PDF, RTF, HTML, XML etc.) by conducting XSL [XSL] transformations. In summary rating is achieved by extracting the elements of an IPDR XML instance and inserting them into Named Cells of a pre defined spreadsheet charging scheme that subsequently calculates a charge for the call that is inserted back into the Charge Element of the IPDR that contains the call information

## 3 Using Spreadsheets as the Charge Calculators

The idea of using a spreadsheet workbook to manipulate or process accounting type data is universally accepted. The practice is considered the norm in conventional accounting.

The workings of a spreadsheet are quite simple. Data is inserted into either index addressable or named cells. This information can then be modified or injected into some calculation by the use of standard formulae. Every workbook has this typical layout and structure. Microsoft Excel [Excel] is the de-facto standard for spreadsheet modelling in the workplace, adopted in the financial world as a standard document format.

Conventional rating engines extract usage information from a Charge Detail Record (CDR) and insert this information into programmatic variables for calculation in a hard-coded formula. Representing the same information in a workbook makes a considerable difference to this unyielding design. Cells in a workbook can be named so as to create an intuitive alias rather than a cell reference. The IPDR [IPDR02]is a standard XML [XML] document with named sections and data elements. Each element in this IPDR document can be mapped to a named cell in a workbook. This simple mechanism can serve as the foundation for a sophisticated rating process.

The composition of a workbook is a hierarchical tree structure and can easily be reverse engineered. Figure 2 contains a graphical view of a workbook schema for Excel XP and OpenOffice Spreadsheet. A workbook comprises zero or more worksheets each containing a table of rows. Within each row are a number of cells, each of which may contain data and an optional name reference for the cell. This name reference is the foundation to the simplicity of the data mapping. If a new service is provisioned for use, a charging algorithm is needed to rate for that service. Assuming that IPDR is the standard transmission medium for the usage data, it is possible to design a suitable workbook in Excel and name specific cells to match the names of the necessary data elements in the IPDR. Thus when an IPDR is received each element in the IPDR is placed into the workbook using the name of the element as the cell reference. A pre-loaded algorithm within the workbook operates on the newly populated cells and produces a result in a specified location. This result is then extracted from the workbook and inserted into a charge element field within the IPDR, which is then persisted as a rated IPDR.

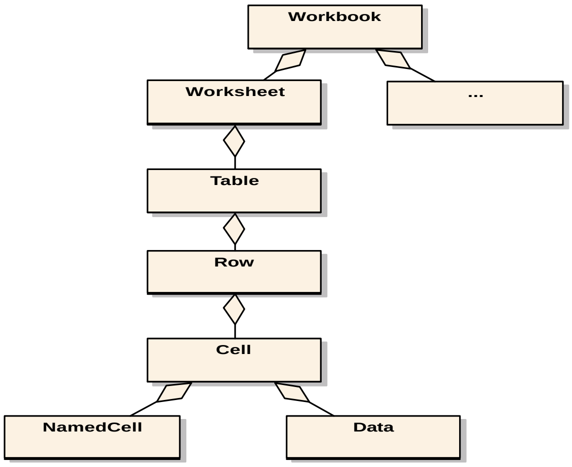


**Figure 2: Workbook Schema**

Workbook formulae are a simple correlation of basic mathematical functions, used to operate on the data contained within cells in a worksheet. These formulae can be constructed by anyone with a reasonable working knowledge of spreadsheets. The native interface of Excel lends itself to the non-taxing creation of arbitrarily complex charging algorithms. It makes sense that in a multi-service environment the service providers should be the authors of the algorithms and not the RBS system administrator.

The creation of an algorithm in a workbook is essentially composing formulae within the context of an IPDR aware spreadsheet. This formula takes data from other areas of the workbook and uses it to calculate a result, in this case a charge for the service being rated. The native interface of Excel or OpenOffice Spreadsheet provides a familiar working environment. Service providers can design algorithms offline and then when tested, can be uploaded to the system. The ability to address individual cells with named aliases is paramount to the success of this concept. By removing the need to design the workbook to a rigid standard the algorithm designer needs only to insert the named fields that correspond to the fields of the IPDR being rated. The named cells allow the designer to position cells anywhere that is desired for easy interpretation of the workbook and it will not make any difference to the working of the system. They can also use colours and other formatting methods as long as the basic underlying structure is present.

Clearly workbook-based algorithm design can deliver the flexibility and ease of use required to compose algorithms for next generation services. However, in the context of the RBS, if workbook-based algorithms are to be used then an engine to interpret these workbooks must become the core of the rating component. Tests have proven that Excel, operated programmatically using COM [RK97][WIL94] Automation technology, is capable of rating small amounts of IPDRs in a reasonably efficient manner. It has not yet been determined if Excel could handle the volume of IPDRs being generated by a live system rating for multiple services. Commercially available components exist that are tuned towards higher throughput processing. The RBS has chosen to engage the Formula One ActiveX control from Tidestone Technologies, Inc [FONE]. This control is a spreadsheet engine that understands the file format of Microsoft Excel workbooks. The Formula One package also has its own workbook editor but Microsoft Excel is a more fully featured interface, and thus continues to be used for design of algorithms.

## 4 Conclusions and future work

Workbook-based algorithms are a logical choice when it comes to rating systems. The decoupling of the algorithm format and composition from the core rating system has obvious and positive effects. Utilising the IPDR as a transmission and storage medium for records removes the old style CSV files and database tables. Instead research is being conducted into XML storage spaces and simple query based retrieval services, such as XML-Tuples and XML-Spaces [TUPL99]. Native XML databases are also being researched, such as Ipedo's XML Database [Ipedo].

The fixed line case study presented above has assisted in the validation of the RBS approach. Flexibility of the IPDR format and the use of spreadsheet-based charging algorithms have been validated through the successful billing of a non IP service with a complex charging scheme developed over a short period. Component-based architecture enables the incorporation of scalability features such as object pooling, object activation strategies, and security mechanisms into the application. The COM+ environment suits the needs of this type of system. An event driven core of pooled components allows for multiple rate engines to run concurrently. Although this will not increase overall throughput it will dramatically improve response times for rating small amounts of IPDRs. There is no longer a need to wait for large batch jobs to terminate.

The big question that remains to be answered is whether or not the large rating organisations such as telecommunications providers will adopt a radically new architecture in favour of the old systems. Most operators have an existing rating framework that has been tested and proven for reliability over many years. Reluctance to change from a working and reliable system will be a huge factor in gaining acceptance from this type of operator. However, in favour of systems like the RBS is that the flexibility which, is much sought after within rating systems is offered up front to subscribers of the system. Full reporting features can very easily be incorporated into the system, allowing service providers to analyse service usage under a customisable criteria base. Communications with such operators have confirmed this thinking. Existing systems offer reliability but are restricted in the services that they can rate for and are usually customised for a particular type of service. Reporting features are rather rigid and the ability to take a subset of records and rate them in different ways with different algorithms is currently unavailable for most systems.

The spreadsheet approach to algorithm modelling described in this paper is entirely flexible and decoupled from the core of the system. It is thought that moving the design of these charging algorithms, towards the service provider, will lead to more diverse and customised charging schemes and structures. Service providers in the next generation of services may not be large Telco's but rather individuals who offer useful services from a website that is mobile aware. This type of service provider will need to have control over the rating system for their services. This paper has shown how spreadsheets can make the task of rating for fixed-line services more flexible but it also paves the way for other services to adopt the same strategy towards algorithm modelling.

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