Essential Elements of Telephone Call Charging Systems

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There are many instances where a telephone call charge needs to be available immediately after a call is made. Usually, for a fee a telecommunications service provider can provide call charge for a particular call. Call charging systems provide this information automatically without recourse to a telecommunications service provider. The applications of call charging systems include private automatic branch exchange line cards, home telephone bill monitoring, monitoring telephones in a telephone café booth or payphones. This paper examines the design of hardware and software of the sub-systems for a subscriber based call charging system.

1. INTRODUCTION

Billing is a major component of telecommunications service provision. This enables telecommunications service providers to recoup costs met in the provision of the service. Usually, a telecommunications service provider supplies bills reflecting usage of a telephone on a monthly basis. However, in certain situations this information is required on a call-by-call basis. For example, in a telephone café booth, the bill for a telephone or telefax call is required immediately after the call, so that the customer can pay for it. It is in such situations that a call charging system is required to monitor calls made from a telephone. A call charging system is a monitoring system that identifies the destination of a call, times it and provides its cost. Although a telecommunications service provider can be requested to monitor and provide the cost of a particular call to be made, this service is expensive since it requires operator intervention.

2. PRINCIPLES OF CALL CHARGING

The requirements for call charge monitoring are:

i) Determination of the destination of a call.

ii) Determination of the start time of the call.

iii) Determination of the end time of the call.

iv) Calculation of the call charge.

The destination of a call is determined from the number dialled by the subscriber in response to the dial tone. The numbering scheme used in all countries follows a format, which provides each subscriber with a unique national number and allocation to areas to meet the forecasted growth. Usually, local exchanges have a capacity of 10000 lines and the last four digits of the national number are allocated to the subscriber's number in the exchange [1]. Of the remaining digits, some indicate the exchange number within the area and the area code. For automatic long-distance dialling, a trunk prefix digit is used. For calls terminating outside the country, up to three digits are appended to the recipient's national subscriber number to represent the country code.

Two schemes are used to determine the start time of a call. The first scheme takes advantage of call progress tones [2] present on the line before a connection is made. When a receiver goes off-hook, dial tone is presented to the calling party to indicate that dialling can proceed. This is followed by a ringing tone if the number is available, a busy tone if the called party is busy, a number unobtainable tone for an invalid number and a congestion tone if there are no free paths in the exchange. In this scheme, the start of the connection is indicated by the exchange removing the ringing tone within a defined timeout period. The second scheme uses subscriber pulse metering (SPM) tones from the exchange to permit call charging. In this scheme, the reception of the first subscriber pulse metering tone indicates a call connection. Unfortunately, telecommunications service providers do not guarantee the provision of metering pulses on subscribers' lines [2].

The action of a receiver going on-hook indicates the end time of a call. At this point the duration of the call can be determined. The duration of the call is converted into units from which the call charge is determined. On lines with SPM tones, the number of SPM tones received indicate the number of units used. The number of units accumulated will depend on the duration of the call and the destination.

For call charging purposes, a telecommunications service provider defines a single minimum call unit (mcu) with a standard cost. Depending on the destination of a call, each call has a different minimum call unit length (maximum length of a call corresponding to a minimum call unit), with the local minimum call unit length being the longest. International calls generally have short mcu lengths but the length varies from one charge band to another. If the duration of a call is known, the call charge is calculated using:

$$Cost = mcu \times ceiling\ [duration/mcu\ length],$$

where ceiling[expression] indicates the smallest integer in magnitude greater than the value of the expression, duration is the connection time of the call, and mcu length is the minimum call unit length. For lines with SPM tones the call charge is calculated using:

$$Cost = mcu \times number\ of\ received\ SPM\ pulses.$$

3. SYSTEM IMPLEMENTATION

Some hardware and software should be included to allow a flexible call charging system. These simplify the system since most of the actions can be implemented in software; software is easy to maintain and modify. The hardware for a call charging system include circuits to detect dialled digits, call progress monitoring, subscriber pulse metering, time and date maintaining. The design should finally meet the Standards Specification for Telecommunication-Line Terminal Equipment for connection to the Public Switched Telecommunication Network [2].

3.1 Hardware Implementation

Figure 1 shows a block diagram implementation of a call charging system. The telephone set sends dialling information to the exchange using dual tone multi-frequency (DTMF) principle [1]. When a key is depressed, a pair of tones at two unique frequencies is generated and applied to the telephone line. Each tone frequency corresponds to the row and column on the keypad uniquely identifying a digit that has been pressed. Detection of the dialled digit is done by monitoring the telephone line for the tone pairs. A DTMF receiver/decoder is used to receive and decode the tone pairs. The detected digits are processed by the micro-controller to determine the destination of a call.

Call progress tones are single and dual frequency tones in the range 350 Hz to 620 Hz specified widely for call progress signalling. A call progress detector uses a stochastic signal processing technique, analysing the signal both in the frequency domain and time domain. The analysis performed include a check on whether the signal's profile matches international standards for call progress tones, or a profile more likely to match that of speech, noise or other non-call-progress signals [3]. The output from

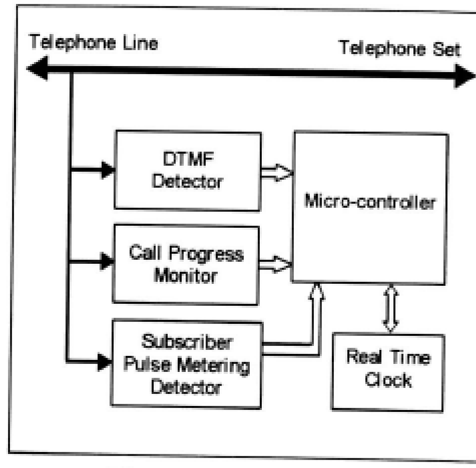

Figure 1. Call charging Unit

the call progress monitor indicates presence of a call progress tone, no signal or a non-call-progress signal such as voice. The micro-controller reads the output from the call progress detector to monitor the progress of a call and determine the start time of the call.

The SPM detector monitors and detects presence of either 12 kHz or 16 kHz call charge pulses placed on the telephone line by the local telephone exchange [4]. Each SPM pulse received represents one unit of charge. The number of pulses received per second determines how expensive a particular connection is. The rate of the pulses takes into account the cheap rate period. The micro-controller accumulates the number of SPM pulses to determine the call charges.

A universal call charge unit should have both the call progress detector and the SPM detector units, with software selecting to use SPM detector for lines on which SPM tones are available. The call progress monitor will be used on lines on which SPM tones are not provided.

The real time clock keeps the time of the day, date and year. This information is used for time and date stamping the calls on the call charge report and to determine when to use the cheap rate on lines with no SPM pulses.

3.2 Software Implementation

The implementation of a call charge system depends on the facilities included. This section assumes that the call charge unit is a universal type. Software for the SPM version of the call charge unit is much simpler since the cost of a call is determined by counting the number of pulses. The decoding of the destination in this case does not play any part. On lines without SPM pulses, determination of a calls' destination from the dialled number, is important as it determines the rate applicable for call charging. Essentially this involves a look-up table using some of the first few digits of the dialled number.

3.2.1 National Number Decoding

There is some flexibility in the use of numbering schemes within a country designed to avoid long call set-up times for the exchange equipment and inconvenience to a subscriber. For calls within the same area, the area code is omitted, and for small single-exchange areas no exchange code is used for calls terminating at the same exchange. In Botswana only exchange range based numbers are used.

Botswana Telecommunications Corporation (BTC) classifies calls as local, within zone, between zones and international [5]. A local call originates from a town and has its destination in the same town. A within zone call originates and has its destination in the same zone. A between zone call originates from one zone and has its destination in another zone. An international call originates in one country and has its destination in another country. For calls within the country, the country is divided into seven zones, 1 through 7, each with a group of towns. BTC currently does not use any distinct area codes but the first two or three digits of the phone number are used to identify the destination of the call. In a few cases, numbers in towns in different zones have similar first and sometimes second digits.

A look-up table based on area code and/or exchange number range can be used to decode the destination of a telephone number. A table decoding numbers beginning with 2 and 3 for Botswana [5] is shown in Table 2. With the first three digits of the dialled number, a search for a match is made beginning from the section dealing with the first digit. When a match is found the corresponding zone and area number are returned. The decoded zone and area numbers are then used to determine the call charge. A comparison of the decoded zone and area numbers with the local zone and area numbers identifies whether the call is local, within zone or between zone.

First 3 digits	Zone	Area	Section dealing with numbers starting with
"215"	3	1	2
"222"	3	2	-
"270"	3	3	-
"278"	3	4	-
"281"	3	5	-
"283"	3	6	-
"284"	3	7	-
"285"	3	8	-
"287"	3	9	-
"288"	3	10	-
"289"	3	11	-
"2**"	3	12	-
"320"	1	1	3
"329"	1	2	-
"337"	1	3	-
"339"	1	4	-
"33*"	1	5	-
"349"	1	6	-
"34*"	1	7	-
"36*"	1	8	-
"377"	1	9	-
"378"	1	10	-
"379"	1	11	-
"381"	1	12	-
"386"	1	13	-
"38*"	1	* 14	-
"390"	1	15	-
"392"	1	16	-
"394"	1	17	-
"399"	1	18	-
"3**"	1	8	-

"*" Indicates any digit

Table 1: National Number Decoding

3.2.2 IDD Code Decoding

All international calls use International Direct Dialling (IDD) codes to identify the destination country and hence the charge bands. A telecommunications service provider usually groups countries into charge bands for call charging purposes. As an example, in Botswana five international charge bands are used; A, B, C, D, and E. A further charge band can be included for calls via INMARSAT to vessels on one of the oceans. The task of the software in this case is to decode the dialled IDD code and return a charge band.

Figure 2 shows a finite state machine [6] description for an IDD decoding scheme for Botswana. The dialling procedure is considered as a state machine having six states. A dialled digit represented by a flag labelled with a digit dialled initiates transition from each state. The letter symbol indicates the return value of the IDD decoder.

To implement the IDD decoder in software require that data structures be set up to map in tabular form the information implicit in the state transition diagram of Figure 2.

The state table has a row representing each state in the state machine. Each row holds a number representing the state and a number used as an index of the action table. Each section of the action table contains information about a particular state. Each row of the action table corresponds to a dialled digit and the return value if it is a letter or the next state the machine would enter if it is a digit. The IDD decoder's state and action tables are shown in Table 2 and Table 3 respectively.

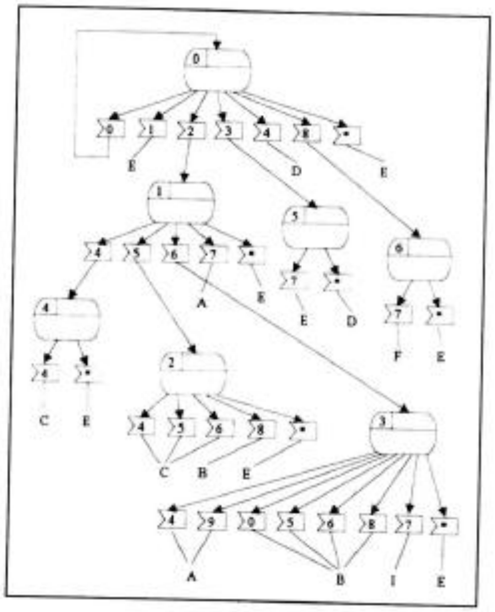

Figure 2: IDD Decoding

Once the tables have been created, a program simulates the action of a state machine by acting on the information in the data structures. The algorithm for the IDD decoder is as follows:

i) Get dialled digit.

ii) Search down the section of the action table for current state for the dialled digit.

iii) If next state/return value is a digit assign state to be value of digit else assign letter as return value.

iv) Go back to step i).

4. CONCLUSION

The design of call charging units is simplified by using SPM tones available from the local exchange. The use of SPM tones guarantee accurate call charging. Unfortunately, SPM tones are not guaranteed on a subscriber's line. However, a telecommunications service provider can activate this service on a subscriber's line for a fee. In situations such as telephone/telefax café booth where accurate call charging is required, the SPM tones are a must. For domestic applications this service is not required and call charging systems based on call progress monitoring alone suffice.

This paper has given an outline of the elements of call charging systems. It has discussed some hardware and software design aspects that need to be considered when designing call charging systems. The paper has presented the structure of a

State	Index
0	0
1	7
2	12
3	17
4	25
5	27
6	29

Table 2: IDD State Table

Digit dialled	Next state/ return value	Section describing
'0'	0	State 0
'1'	'E'	.
'2'	1	.
'3'	5	.
'4'	'D'	.
'8'	6	.
'*'	'E'	.
'4'	4	State 1
'5'	2	.
'6'	3	.
'7'	'A'	.
'*'	'E'	.
'4'	'C'	State 2
'5'	'C'	.
'6'	'C'	.
'8'	'B'	.
'*'	'E'	.
'3'	'A'	State 3
'4'	'A'	.
'0'	'B'	.
'5'	'B'	.
'6'	'B'	.
'8'	'B'	.
'7'	'I'	.
'*'	'E'	.
'4'	'C'	.
'*'	'E'	.
'7'	'E'	State 5
'*'	'D'	.
'7'	'F'	State 6
'*'	'E'	.

'*' Indicates any other digit

Table 3: IDD Action Table

typical decoding scheme using the BTC call charge structure as an example.

5. REFERENCES

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