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AUTOMATIC MESSAGE ACCOUNTING SYSTEM (AMA)

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AUTOMATIC MESSAGE ACCOUNTING SYSTEM (AMA)

ABSTRACT

Before subscriber dialing (STD) was introduced in the 1950’s, long-distance calls were handled manually and operators prepared tickets giving the date, called number and duration of calls. Telephone bills for long-distance call charges included these details. When subscriber dialing of long-distance calls was introduced in the fifties, only U.S.A., Canada and a few other countries provided toll ticketing equipment to record automatically the call particulars and included this information in customer bills. This system is known as the Automatic Message Accounting (AMA) system. However, most telephone administrators adopted a charging method, in which the local call charge counter was also used for recording the long-distance charges with the result that all the local and long-distance charges were bulked together in the telephone bill. This latter system of charging and billing has a number of major disadvantages to the administration and is a source of serious customer dissatisfaction.

Recent advances in electronics has made the realization of Automatic Message Accounting systems economical and attractive so that AMA systems now emerge as a clear choice in preference to bulk billing of long-distance calls. Information on AMA systems is not usually available with most telephone administrations. This paper will help in understanding the systems and thereby encourage adoption in developing countries.

Much of the information in this paper has been taken from the proposals submitted by four firms in response to a 1977 bid invitation for AMA systems in Thailand. These proposals reflect the requirements in the particular case. In other circumstances, the offers could well be significantly different; further many others manufacture AMA systems, which, though not dealt with here, may well be advantageous in some situations. Hence, the information given in this paper should be treated as illustrative only.

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AUTOMATIC MESSAGE ACCOUNTING SYSTEM (AMA)

Introduction

1. Tariffs for telephone services generally consist of a monthly rental together with charges for the local and long-distance calls made by the subscriber. It is usual for local calls charges to be recorded in a four or five-digit mechanical counter which advances one step per local call. 1/ Before subscriber-trunk-dialing was introduced, all long distance calls were handled manually, where the operators prepared tickets, giving details (calling and subscriber called numbers, date and duration) of the call; these tickets were later processed into bills which gave full particulars of the calls. 2/ When subscriber-dialing of long distance calls (subscriber-trunk-dialing or STD) was introduced in the fifties, USA, Canada and a few other countries provided toll ticketing equipment which recorded automatically all of the call details as in the previous manual systems and included this information in the bills sent to the customer. This system is known as the Automatic Message Accounting System (AMA) -- message is the word used in Bell System for calls. However, most telephone administrations in the world adopted a different method of charging called the Pulse Periodic Metering System (PPM), in which the local call charging counter was also used for recording the long distance charges by being stepped up for the duration of the call at periodic intervals, the timespan being determined on the relative distance (or other criteria) between the calling and called subscriber. Under this arrangement, the local and long-distance call charges were bulked together in the bills and no details of the long-distance calls were available to the administration or the customer.

2. The decision to adopt PPM to record long-distance call charges and to bill local and long-distance calls together in bulk without details (bulk billing) was based on historical, technical and cost considerations at that time (1950s).

3. With the advances in electronics and the availability of microprocessors and low-costs computers, the cost of equipment for automatic toll ticketing (recording of details of long distance calls) has come down to a one-time investment of about $15 to $25 per line for adding this facility in existing electromechanical (cross bar or step) equipment -- much less for future additions of electromechanical exchanges and at no additional cost in future electronic exchanges. The toll ticketing equipment is very reliable, requires little or no maintenance and can be applied to all types of exchanges

1/ This assumes tariffs based on the number of calls irrespective of the duration of calls, which is the usual arrangement in most countries. Where duration is also a factor for charging, the counter advances both in relation to the number and duration of calls.

2/ This is referred to as "toll ticketing" information and when done automatically as in AMA systems it is called automatic toll ticketing.
with only minor or no modifications of existing equipment. Also, since in the AMA system the long distance call details are recorded on a computer-compatible magnetic tape suitable for direct processing of bills without additional labor, the costs of billing are no greater than with bulk billing systems.

4. Most Bank staff and Bank borrowers are unfamiliar with AMA systems and particularly with recent advances. The paper provides information on the benefits and costs for providing AMA facilities. Further, these systems come in a variety of configurations, some requiring close interfacing with existing telephone switching systems, while others are relatively independent of the types of switching equipment. This paper is aimed at familiarizing Bank staff and borrowers with some of the configurations and to help in deciding on and implementing schemes for provision of AMA systems.

General Advantages of AMA Systems

5. Telephone subscribers, particularly in the developing countries, have been and are unhappy with the system of periodic metering and bulk billing of telephone call charges, because of their inability to exercise any effective control over unauthorized long-distance telephone calls or to satisfy themselves on the accuracy of the telephone bills. Even so, large business and government users accept it as being, in their view, an inescapable part of the subscriber trunk dialing (STD) package which, overall, provides prompt and improved service. However, many small businesses and residential customers often request the barring of their telephones from being used for STD. 1/ With the introduction of subscriber dialing of international telephone calls made possible by use of satellites, the method of periodic metering and bulk billing has become even more undesirable.

6. Without AMA, telephone administrations are faced with recurring complaints about the size of the customer bills and, in the absence of data, have to settle the amount due on an arbitrary basis. Further, to handle long-distance calls from subscribers who have opted out of the STD group, administrations have to provide and staff manual trunk exchanges which adds to the capital investments and significantly increases the operating costs. The substitution of manual in place of STD service for such subscribers leads to decreased use of long-distance facilities and of revenues. In short, without automatic toll ticketing of subscriber-dialed calls, subscribers are forced to choose between STD with only bulk billing and manual handling with full call particulars -- surely an unnecessary situation, particularly considering the very small investments required for AMA even without taking into account the increased revenues and savings.

1/ The AMA system providing long-distance calls details was commissioned in Bogota, Colombia, in February 1977 replacing the periodic metering (and bulk billing) of long-distance call charges. Before this only 67,000 out of a total of 360,000 subscribers used the STD facilities, and the rest had barred their telephones from STD. By April 1978, 60,000 more had opted for the STD group which, as other subscribers get to learn of the AMA system, is increasing at about 15,000 a month.
7. The provision of AMA has other advantages. The magnetic tape record, with call details, also provides readily:

(a) data on the quality of long-distance service, namely number of busy calls, time to answer calls, calls lost through congestion; the data helps identify the trouble spots;

(b) complete information on the origin, destination and routing of calls, essential for forecasting traffic growth and dimensioning of routes on a continuous basis and for maintaining good quality long-distance services with minimum investment; and

(c) complete information on call revenues separately from local and long-distance services with a detailed breakdown of such revenues; this information is necessary to make sound revenue forecasts and to help make investment decisions.

8. The provision of AMA systems opens up the subscriber dialing facilities, in which administrators have invested heavily, to all subscribers, significantly increases customer satisfaction, and reduces complaints about billing. Further, it provides vital operational and financial information to enable planning, maintenance, traffic and management staff to function effectively. The small investment needed for AMA is more than offset by the increased revenues and the savings from reduced manual call handling.

Description of AMA Systems

9. AMA systems are designed to operate in conjunction with automatic local long-distance and international telephone exchange to provide subscribers complete information (e.g., date, duration, calling and called numbers) in support of the call charges included in the bills sent to them.

10. The AMA systems also provide other optional facilities, such as coinbox control for dialed long-distance calls, automatic ticketing and billing of operator-assisted long-distance calls, e.g. special types of calls from credit card customers and calls originating from telephones other than the one to be charged, immediate information on call charges to hotels and other subscribers, detailed data on quality of service, traffic, etc. The capability of different systems to provide some or all of these additional facilities without major changes or costs varies widely among the systems.

11. Basically, an AMA system has to recognize the calling and called subscriber numbers (usually referred to as A and B numbers) and the events signifying the beginning and end of conversations. Together with the timing of these events, the call data has to be collated on a call-by-call basis, temporarily stored and then transmitted to a central place where it is to be recorded on a tape. The principles of operation for collecting the call data and the arrangements for transmitting and recording the data on tape vary from one suppliers to another. The content and format of the information recorded on magnetic tapes also differ, requiring more or less computer
time, but the information is always recorded in a format suitable for direct processing in a computer to produce the bills.

12. The differences in the configuration of the different AMA systems is best analyzed in relation to the following aspects:

(a) the location in the national telephone network of the different components of the system, namely:

(i) automatic calling number identification unit (ANI) -- the called number is available in the originating registers;

(ii) units for identifying the start and finish of conversations;

(iii) units for assembling the call data in one place, and for collating the data on a call-by-call basis; and

(iv) tape recorders;

(b) methods used for recognizing call particulars -- some require close integration and compatibility of the call data collection equipment units with the local and trunk telephone switching equipment.

13. In response to a bid invitation in 1977 by Telephone Organization of Thailand for AMA systems, four offers were received from L. M. Ericsson of Sweden (LME), Nippon Electric Co. of Japan (NEC), Bell Telephone Manufacturing Co. of Belgium (BTM) and Conrac Corporation of USA. The principal features of these four proposals are given briefly in the following paragraphs. A more detailed description is given in the Annex. It should be noted that these proposals reflect the requirements in the particular case. In other circumstances, the offers could well be significantly different; further, many others manufacture AMA systems, which, though not dealt with here, may well be advantageous in some situations. Hence, the information given in this paper should be treated as illustrative only.

14. The AMA systems offered by LME, NEC and BTM have many common structural features -- the individual component units, however, differ significantly. In these systems, the Automatic Number Identification unit is an integral part of the local exchanges and is designed to be compatible with only switching equipments of their own manufacture. The ANI units identify the A number (calling subscriber number) and hold this in storage. The B number (called subscriber number) is received by the originating register in the normal process of setting up the call. During the setting-up of the call the A and B numbers are on request from the Trunk Automatic Exchange (TAX), transferred to the TAXs and stored in the TAX register, both the request and transfer being accomplished through MF signalling. The TAX equipment directly recognizes the start and finish of conversations by monitoring the incoming trunk lines; for this purpose the relay sets associated with the TAXs of LME (type ARM) require some modifications and additions -- the NEC C-80 type TAX
does not require changes. The call details (A and B number and the start and finish of conversations) are transferred in turn from the TAX to an Automatic Message Recorder (AMR), which in the case of LME and NEC is located with the TAXs and connected to the latter with a relatively large number of wires.  

The AMR inserts data on the timing or duration of the call, then assembles the call, collates the call details on a call-by-call basis, which is then recorded on a magnetic tape. In the case of LME and NEC proposals, the recorded tapes are then transported physically to the bill processing center or the information is transmitted from the TAX to the bill processing center using data transmission sets. If physical transportation of tapes is used, duplicated tapes will have to be retained to ensure security. On the other hand, if data sets are used, circuits will be required linking all AMRs located at the TAXs to the central bill processing center. While the equipment additions and changes to the existing electromechanical local and trunk exchanges comprise switching equipment components, e.g., relays, the AMR equipment is made up of microprocessors, other large-scale integrated (LSI) chips, memories, etc., as in computers.

15. The AMA system configuration of the Conrac proposal is totally different from those of LME, NEC and BTM. This system is built up entirely with solid state components, e.g., LSI chips, microprocessors, memories, with the exception of a few test relays. The system comprises two units — a Call Processing Unit (CPU) located at the local exchanges and a Call Detail Data Recorder (CDDR) at the bill processing center. The CDDR is linked to all the CPUs in the different local exchanges by a four-wire party line. The CPU unit comprises:

(a) an input chassis which contains line units on a one-for-one basis and is jumpered to the tip and ring wires of each line in the local exchange. Each of the line units has a unique number associated with it;

(b) call detail monitors (one for 500 lines plus one S/B) which addresses the tip and ring voltages of each line from the associated input chassis;

(c) call detail collector (one for 5000 lines plus S/B unit) which scans the call detail monitors; accepts, analyzes, collates and stores the call details, and raises a flag to show it has information to send; and transmits the call details on receiving a command from the CDDR unit located at the bill processing center, using data associated transmission sets.

1/ In the case of BTM, the AMR is located in the bill processing center and receives the call details from special toll ticketing equipment located at the TAX using MF senders at the TAX and MF receivers at the AMR.

2/ The CPU unit offered by Conrac combines the function at (a): (i), (ii) and (iii) in paragraph 9. The CDDR unit is essentially a data set — with command facilities for interrogating the CPUs — and a tape recording system.
In this system, all the call data (A and B numbers, time of the start and finish of conversation) are collected at the local exchange by monitoring the tip and ring wires of the calling line. The voltages and polarity of the tip and ring wires are compared to recognize on hook, off hook and reversal conditions from which information on the beginning and end of calls are determined. The called party number is obtained directly from the dialed pulses. The input chassis identifies its own number: this number is then translated in the computer at the bill processing center to the calling subscriber number.

16. All the above AMA systems are provided with redundant units to provide security and to monitor the operations at every stage for checking the validity of data and for ensuring fault-free transmission. The systems are equipped with facilities for adequate maintenance and for automatic fault location. All the systems also provide a variety of traffic and other information as well as a number of optional facilities.

17. In all the AMA systems the call data is recorded on IBM and industry-compatible format on nine tracks and a half-inch magnetic tape. The call data is assembled and recorded in a block on a call-by-call basis as in a toll ticket used with manual systems. 1/ The information recorded varies from one system to another. In the LME system complete information on A and B numbers, duration of call and the call charge per unit is provided by the AMR and, hence, the computer time for processing the bills is minimal but requires additional equipment at the several AMRs. At the other end in the Conrac system, the information is that of input chassis number in place of A number, B number and time of start and finish of conversation. The bill processing computer has (additionally as compared with LME format) to translate the chassis number into A number and also compute the duration and call charges, but in terms of costs this difference is not significant.

Advantages and Disadvantages of Different AMA Systems

18. The main components, namely the ANI and AMR units of LME and NEC and, to a lesser extent, the ANI unit of BTM systems, as described in this paper are designed specifically to work with particular types of switching equipment of their own manufacture and cannot be applied to other types of equipment without significant design or engineering changes. The extent of wiring needed between the additional equipments and the existing exchanges is somewhat extensive. The calling and called numbers are sent from local to trunk exchanges during the setting up of the call and, hence, the call

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1/ The recording of call data in each block on a call-by-call basis is called single entry recording or toll ticket recording. An alternative system called multiple entry recording is to record the call data for each call in different blocks in time sequence as they become available, e.g., an initial entry comprising A and B numbers, a second for an answer entry and a third for the clear entry. This system of recording increases the capacity of the recording equipment at the cost of more computer processing time.
setting up time and, therefore, the post-dialing delay for the subscriber is slightly increased. The additional facilities that can be provided in the AMA systems of LME and NEC are comprehensive, e.g., toll ticketing of operator-assisted calls, providing immediate charging information to hotel, etc., charging to third numbers or to credit cards, control of coin box telephones, basic traffic information, etc. The equipment needed for collecting the call details comprises small quantities of additional equipment of the same types as the existing equipment and thus does not require specially trained personnel for maintenance of this part of the AMA equipment; however, the AMR part of the equipment (located at TAXs only) is based on use of solid state electronics and would require personnel with a different background and training for its upkeep.

19. The AMA system of Conrac described in this paper -- a number of other U.S. firms offer similar equipment -- can be used with most types of switching equipment. The interconnection with the switching equipment is simple, and requires only jumpering of the tip and ring wires of the subscriber's line to the input chassis of the AMA equipment. The call data information is collected and transmitted without slowing down the setting up of the call and hence without increase of the post dialing delay. The Conrac system has built in features to handle, separately or together, at no extra cost, local call metering, periodic metering and toll ticketing on calls, as well as to provide very detailed traffic information. With additional equipment at the subscriber premises immediate charging information on call details can be provided to special subscribers with additional equipment at subscriber premises. However, other facilities like automatic toll ticketing of operator-assisted calls, charging to third parties, etc., are not easily available; however, this may not be serious in developing countries where, because of low salaries for operators, these features can be taken care of through operator ticketing of the call particulars without significant increase in costs. The equipment is all solid state (except for a few test relays) and is installed in all local exchanges. This equipment is highly reliable and should require very little attention or maintenance; even so, it is located at all local exchanges and, hence, a maintenance organization for upkeep of the new types of equipment will be needed. The format for recording the call details is designed so that equipment at the exchanges is relatively simple but requires more processing time of the billing computer than, say, in the LME recording format. The Conrac system also requires a time-shared four-wire party line linking the central billing center with each of the local exchanges -- as compared for the LME, NEC systems as stated in para 14 above, which require either duplicate tape recorders or data circuits from the AMRs to the billing processing center.

Costs of AMA Equipment

20. In respect of the AMA system in Thailand, the ANI equipment is being supplied by LME, BTM and NEC each for their own switching systems, and the AMR equipment is being supplied by LME and NEC, again each for their own TAXs. The overall costs of the AMA system works out to an average of $19 per line, of which the ANI equipment costs an average of $13.6 per line. For future extensions only additional ANI equipment will be required since the AMRs have
a very high capacity and would not require to be augmented. However, for future extensions of the ARM type TAXs of LME manufacture, additional relay sets for incoming trunks will be needed at a cost of up to $90 per additional incoming trunk. 1/ For future electronic exchanges, facilities for extracting all call details are standard features and hence no additional cost for AMA is involved.

21. The costs of the AMA system in the Conrac proposal for all the exchanges in Thailand averages $25 per line. This price includes equipment to transfer automatically all data to tape recorders located at the central billing center; and to provide at no additional cost toll ticketing for all subscriber dialed calls without constraints on routing, for metering of local calls, and for providing comprehensive information on traffic and quality of service. A significant part of the cost of the Conrac proposal comes from costs for duplicated call detail collectors and data modems for security reasons at the numerous small local exchanges. In respect of large exchanges, such as in a metropolitan area, the average cost of the Conrac AMA system will average about $18 per line.

22. The cost structure of the LME, NEC and BTM systems on the one hand and of the Conrac system on the other are basically different, thus making one or the other more attractive in specific situations. Since a significant part of the costs of the Conrac system is for providing duplicated call detail collectors and data modems (with a capacity to serve up to 5000 lines) at each local exchange, the overall unit costs increase when numerous small local exchanges are involved. On the other hand, in the case of LME and NEC systems, the AMR equipment, required at each of the TAXs handling calls to be toll ticketed, have a high capacity and are expensive; hence, overall unit costs increase sharply when such TAXs are relatively small in size and large in number. The Conrac system is very economical in situations where calls from only a small proportion of subscribers of a local exchange are to be toll ticketed as for International Subscriber Dialing -- this is due to the equipment being available in small units on a per line basis.

23. The above general observations on the advantages and costs of the different systems have been generalized from proposals which were in response to a specific bid invitation reflecting the requirements in the particular case. Hence, these observations should be treated as comments on the AMA systems offered in this case and not generalized to cover all AMA systems from these and other manufacturers.

1/ The AMA systems in Thailand now require toll ticketing only for calls passing through the five tertiary centers. If calls passing through other TAXs were also to be toll ticketed at a future date, an AMR installation would be required in each of the additional TAXs at a unit cost of $500,000 for each TAX, together with TAX modification of the LME type TAXs (ARM exchanges).
Technical Specifications

24. Since several alternative approaches to a satisfactory AMA system are available, the specifications should be broad-based to permit widespread participation and to allow the optimal solutions to be chosen, possibly a combination of more than one method for covering the country’s requirements. Each of the different approaches has advantages and disadvantages, and care should be taken not to prescribe in the compulsory requirements facilities which will seriously impair competition, unless such facilities are of primary significance in a particular case. Information on the additional facilities which can be provided by the different systems is given in the detailed system description in the Annex. The technical specifications should contain adequate information on relevant aspects of national numbering, charging and routing plans, signalling information (line and register signalling between exchanges and loop signalling in local exchange subscriber loops) relevant to gathering of call data in the different systems, and a list of local and trunk exchanges by type, current and ultimate size, number of lines and trunks, traffic including number of busy hour calls for which call data is required, and other information, e.g., number of registers and incoming trunk lines, facilities in the trunk exchanges for storing of calling and called numbers, etc.

Conclusions

25. The inclusion of call details with telephone billing of long-distance calls provides for a significant increase of subscriber satisfaction and is essential to persuade all subscribers to avail themselves of facilities for subscriber dialing of trunk calls by removing the reservations caused by bulk billing and to enable the administrators to realize the full benefits of the large investments in subscriber dialing facilities. Apart from providing improved service to all subscribers, the universal use of STD improves revenues to the administration. AMA systems also help provide traffic information to assist planning. Recent advances in electronics have made the realization of Automatic Message Accounting systems economical and a preferred alternative to the widely prevalent periodic materials and bulk billing of long distance calls. Information on AMA systems is not usually available with most telephone administrations. This paper will help in understanding the systems and thereby encourage adoption in developing countries.
DESCRIPTION OF FOUR AMA SYSTEMS

Telephone Organization of Thailand (TOT) invited bids in 1977 for Automatic Message Accounting (AMA) systems and received four bids from: L.M. Ericsson of Sweden (LME), Nippon Electric Co. of Japan (NEC), Bell Telephone Manufacturing Co. of Belgium (BTM) and Conrac Corporation of USA. This annex describes in some detail the salient features of each of these proposals and supplements the broader coverage in the main text.

Perhaps with a view to keep the initial costs low, TOT had stipulated a somewhat unusual routing and charging plan. The specifications provided for:

(a) no direct routing between secondary centers and that all such calls would be routed via one of five tertiary centers;

(b) toll ticketing (call details for billing) of subscriber dialed calls would be limited to calls which are routed through at least one of the five tertiary centers; calls which originate and terminate in the same primary center would be charged as a local call, and calls which originate and terminate within the same secondary center would be charged on the basis of a simplified periodic metering.

Thus, the charging plan is a mixture of bulk billing (for calls within the primary and secondary centers) and automatic toll ticketing – the latter accounting for only some of the long-distance calls. The specifications also stated that the twin exchanges at the tertiary centers are equipped to receive and store the A and B numbers.

The specifications called for Automatic Number Identification equipment (ANI) for all of the existing subscribers, covering in all 417,700 lines in 196 exchanges (282,000 lines in 41 C-400 type NEC exchanges, 170,100 lines in 133 ARF and ARK type LME exchanges and 18,600 lines in 22 Pentaconta type exchange of BTM); of the five trunk exchanges at the tertiary centers, four were of the LME's ARM type and one of the NEC's C-80 type.

LME, NEC and BTM offers were largely limited to adding the AMA facilities to equipment of their own type, while the Conrac proposal covered all the exchanges. The proposals naturally reflected the specific requirements of this particular bid invitation. The information in the four AMA systems in this Annex is largely based on these proposals. Since the responses could well have been different if the specifications had been different – also other bidders may have participated – the descriptions of the AMA systems offered by these bidders and the comments in these offers should be taken as illustrative only.
The architecture of the AMA system in the LME proposal closely follows that envisaged in the specification. The Automatic Number Identification (ANI) facilities are obtained by small additions to the common control equipment (registers RELG and register finder marker RSM) in the local exchanges (ARF and ARK) of LME manufacture - in the case of ARK, a few changes are needed in addition. The Trunk Automatic Exchanges (TAXs) in the locations where the Automatic Message Recording equipment (AMR) is to be located (in the case of Thailand the tertiary centers) also require some modifications and provision of some additional relay equipment for requesting and storing of the A and B numbers, for identifying the beginning and end of conversations and for interfacing with the AMR equipment. The AMR equipment (type TTm2 in the LME proposal) is connected by wires to the TAX, the main connections being to the incoming trunks and registers. In addition, minor changes are also required in all Ericsson ARM type TAXs at primary and secondary centers.

The TTm2 equipment is all solid state comprising LSI chips, memories and microprocessors. The main functional units of TTm2 equipment are:

(a) trunk group equipment for performing periodic scanning of the connected trunk circuits (different types for calls requiring toll ticketing, pulse metering or operator assistance), sending and receiving messages from the bus, incrementing the occupation time counter, supervising internal functions together with associated logic for the control function and memory for storing the information;

(b) register group equipment for periodic scanning of connected registers, sending and receiving messages via the data bus, for receiving and verifying the received digits together with associated logic for control functions, and memory for storing the A and B numbers;

(c) charging processor for transporting data between different units, e.g. from trunk group circuits to register group units temporarily storing data about the call in progress, analyzing method of charge, e.g., pulse metering or toll ticketing, calculating tariffs and prices from analysis of A and B numbers, etc. ;

(d) a central store of magnetic core type whose contents are unaffected by power failure and which stores data containing the call details;

(e) charging data output to provide information about call charges on teleprinters for being passed on to special subscribers, e.g., hotels, with necessary data transportation, memory for storing call details, logic and print circuits;
(f) tape unit consisting of (i) a buffer unit functioning as a reservoir to enable verification of the received information before being written into tape, and (ii) tape recorder unit recording the information on nine tracks (IBM compatible); when writing the recorder checks with the buffer unit for accuracy.

The called subscriber number (B number) is recognized from the dialed (or MF pulsed) information and is stored in the common equipment in the originating exchange which, in addition, identifies and stores the calling subscriber number (A number). When the connection is established between the originating exchange and the register in the TAX, the A and B numbers are transferred to the TAX register which transfers this information to a call store in TTm2 equipment. The TAX identifies and monitors the incoming trunk circuit associated with the call, by monitoring of the MF signals for recognizing the beginning and end of the conversation. The TTm2 equipment receives the information and with the help of an electronic counter stepped by clock pulses determines the duration of the call. The information on the call duration is transferred to the call store which has the A and B numbers. These call details are then transferred and recorded on a magnetic tape in the tape recorder which is also part of the TTm2. The magnetic tapes from the AMR centers are taken to the bill processing center where the tapes are processed into subscriber bills.

The costs of the ANI equipment are in the range of $6-$12 (average $9.5) 1/ per line, depending on the number of registers, which in turn is a function of traffic. The costs of components to be added to the TAX equipment is a function of the number of incoming trunks and registers, and averages about $98 per incoming trunk line. The cost of the TTm2 is about $300,000 for the smallest TAX (200 trunks 4500 BHC) to $380,000 for the largest (800 trunks 39800 BHD). The cost of installation of the TTm2 equipment is $116,000 each for three centers and $194,000 for the largest. The TTm2 equipment has a capacity of 4000 trunk and a corresponding number of registers and, hence, is very economical for large centers; however, in small centers the cost distributed over a small number of lines tends to become high.

Additional facilities: TTm2 is designed to provide pulse metering if necessary and this facility can also be used to control STD coin boxes. With special manual positions designed to work with TTm2, it can provide automatic toll ticketing facilities for operator assisted calls; further, TTm2 can provide call details and call charges on a teleprinter immediately after the completion of the call for being transmitted to hotels or to other customers who require this facility. Traffic information can also be obtained from the AMR unit.

The TTm2 equipment has built-in facilities and necessary software to locate faults and provide other maintenance. A comprehensive alarm system

1/ These figures are for exchange sizes of 600-10,000 lines. The cost rises to $38 per line for small exchanges of 100 lines.
alerts the maintenance staff to troubles. All important components are duplicated and extensive facilities verify the validity of the data transferred and provide fail-safe operation to ensure that the data is not destroyed in the event of power failure, etc.

Nippon Electric Company of Japan (NEC)

The architecture of the AMA system in the NEC proposal also follows closely that envisaged in the specifications. The ANI facilities are obtained by some additions to the local exchange equipment (90% of the costs of ANI) and minor modifications to the common control equipment in these exchanges. The AMR is type 300C AMRS and is added on to the TAX where the call details are to be recorded. The NEC type C-80 TAX does not require any modification. The interwiring between the AMR and TAX consists of 136 lead per register and 3 leads per incoming trunk to the TAX. The NEC type 300C AMR can be used with other TAXs provided the necessary interface points for these leads are accessible in the associated TAXs.

The type 300C AMR comprises two major parts, DASE and AMRE. DASE is built with relays and its main functions are to convert various types of information from the TAX equipment to the predetermined recording formats and to provide access to the AMRE for transfer of the collected information to the latter. The AMRE, built with electronic components, comprises the record control unit (RCU) and price control unit (PRU) (an optional item). RCU comprises sub-units: master system time (MST) and record control processor (RCP). The main function of MST is to generate the time information for indicating the beginning and end time of conversation. The main functions to RCP are to assemble call details and record them on magnetic tape. The call data from the magnetic tapes from all the AMR centers can be transmitted to a central data collection center (CDCC) by means of data transmission sets together with circuits from the AMR centers to the CDCC.

The operating sequences are similar to those described in the LME proposal for identification of transfer of A and B numbers from the local to the trunk exchange and for identifying the beginning and end of conversations.

The cost of ANI facilities in NEC type C400 local exchanges ranges from $14 to $17 per line for exchange sizes from 1,000 to 20,000 lines. As stated earlier, no changes are required to the TAXs of NEC type C-80. The cost of AMR type 300C ranges from $220,000 to $270,000, including installation, for traffic ranging from 4500 BHC to 40000 BHC (200 to 1000 trunks). This AMR is economical for large TAXs but not particularly so for small TAXs.

Additional facilities: Type 300C equipment can provide pulse metering for control of coin boxes with the addition of optional equipment. With special manual positions designed to work with type 300C equipment, it can provide toll ticketing for operator-assisted calls and also for charging the calls to a C number or to a credit card. Again, through use of an optional PRU unit, type 300C equipment can provide call details and call charges on a teleprinter immediately after completion of the call for transmittal to hotel or other subscribers. Traffic information can also be obtained from this unit.
As in the case of LME, NEC AMR equipment is duplicated in respect of all important units. The equipment has also facilities for routine maintenance and checks, for fault localization and for providing alarms. The system has built in fail-safe features and is designed to ensure that the data is not destroyed in the event of power failure, etc.

Bell Telephone Manufacturing Co. of Belgium (BTM)

As in LME and NEC proposals, ANI equipment is located at, and works in close association with, the local exchanges. The calling subscriber number from the ANI unit and the called subscriber number from the originating register are sent to the TAX during the set up of the call. Also, as in LME and NEC proposals, the TAX equipment recognizes the beginning and end of conversations. However, unlike the LME and NEC proposals, the AMR equipment is located at the bill processing center and receives the call details from the TAX through use of MF senders - designated CATT in the proposal - at the TAX and MF receivers at the AMR. 1/ BTM proposals did not preclude any of the equipment at the TAX, which was left to the manufacturers of the TAXs. The BTM offer was for the ANI equipment to work with BTM type local exchanges and for the AMR at the bill processing center. In the event, TOT placed orders for the ANI equipment only to interwork with the LME and NEC TAXs and AMRs at the tertiary centers.

The ANI equipment comprises an identification unit, identification or A number sender units associated with the normal MF signalling senders of the local exchange, a 20 Kc generator and two condensers per line connected to the sleeve wire (C wire) of each of the incoming lines at the Intermediate Distribution Frame (IDF). To identify the A number, the identification unit applies the 20 Kc tone to the C wire of the calling line via the register which handles the call in the local exchange. The tone passes from the C wire through the two condensers to four sets (one for each digit) of two magnetic cores arranged on a '2 out 5' code in the identification circuit. The identification process is initiated by a request for the A number from the distant TAX and the A number information is sent from the identification unit to the TAX by the identification sender using MF signalling.

The cost of the ANI equipment works out to about $35 per line, essentially because of the indivisibility of the minimum equipment for each of the small exchanges included in the proposal. However, this cost drops

1/ The call details are sent in three sequences as they become available in the TAX. The A and B numbers are sent to the AMR in the first transmission, B party reply in the second and end of call in the third. These are assembled, collated and recorded in the AMR.
to about $10 per line when the exchanges expand to their fully planned capacity, which is again well below the handling capacity of the ANI equipment. 1/ AMR equipment at the bill processing center is designed for processing and recording large volumes of call data and the costs including the installation is about $1.8 million. This figure does not include the cost of TAX changes, if any, and if the CATT senders at the TAXs. The BTM offer provides for details of call charges to be made available on a teleprinter at the bill processing center immediately after completion of the call for being passed on to a subscriber, if required.

Conrac Corporation of USA (Alston division)

The AMA system architecture of the Conrac proposal is totally different from those of LME, NEC and BTM. The AMA system comprises two units, a Call Processing Unit (CPU) at each of the local exchanges and a Call Detail Data Recorder (CDDR) located at the processing center. All the call details (A and B numbers, time of beginning and end of conversation) are collected at the local exchange in the CPU which also assembles and collates the data on a call-by-call format. The call details can be made available locally in a display unit, through a teleprinter printout, or sent to a CDDR at the bill processing center using data transmission for being recorded on tape. At regular intervals the CDDR polls each of the CPUs in the local exchanges using data transmission sets operating over dedicated four-wire party lines. The CPUs send the stored information to the CDDR where the data is recorded on tape. The entire equipment, with the exception of a few test relays, are solid state using LSI chips, microprocessors and memories. The system is designed with high redundancy to ensure high reliability.

The Call Processing Unit (CPU) comprises:

(a) an input chassis unit which contains line units on a one-for-one basis and is jumpered to the tip and ring wires of each line in the local exchange. Each of the line units has a unique number associated with it;

(b) call detail monitors which address the input circuits and accept the tip and ring voltages from associated input chassis. The voltage levels are compared to recognize on-hook, off-hook and reverse polarity from an examination of the tip and ring conditions in the subscriber loop. 2/ The detected signals are

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1/ Except for the line condensers, the minimum equipment required for an exchange is the same for up to 10,000 lines and only very little more for exchanges up to 20,000 lines. If the BTM system of ANI is used for exchanges of 10,000 to 20,000 lines, the unit costs will be quite low.

2/ In Thailand no reversal occurs to signify B answer or end of call events. Conrac later offered an alternative design at an extra cost of about $3 per line to receive MF signals for recognizing B answer and end of call events.
connected to digital filters which analyze the amplitude, polarity and duration of signals to eliminate transients and to confirm that the detected signals are of proper amplitude and duration. The number of call detail monitors required depends on traffic and one is provided for 500 input lines plus one standby unit. The output of call detail monitors is routed to the Call Detail Collator and the information consists of:

(i) input chassis identification number,
(ii) off-hook,
(iii) dialed number,
(iv) on-hook, and
(v) battery reversal.

These outputs are selected on a call by call basis by the input circuit number of the associated input chassis.

(c) The Call Detail Collator (one working and one S/B for every 5,000 lines) is microprocessor controlled. It scans up to ten (plus a spare) Call Detail Monitors and accepts the details developed. It then sorts the calls into different categories of charging, viz. in the Thai proposals calls in the same primary office area to be charged to one unit, calls in the same secondary area to be charged in units depending on both the number and duration of calls, the calls outside the secondary area of the originating exchange for which full call details are required. The calls within the primary and secondary zones are recorded in two separate counters in a memory unit and retained for being transferred to the central CDDR at the billing center. The call details developed in the collator unit for the third category of calls and similarly retained in a memory consist of:

(i) calling party's identification by chassis and circuit number (office will also be identified for each datum transmitted),

(ii) called party's number,

(iii) day of year,

(iv) starting time of call in tenths of a minute, the point in time at which "battery reversal" is detected and "off-hook" condition occurs, 1/

1/ See footnote on page 6.
(v) ending time of call, that point in time at which "battery reversal" is lost or "on-hook" occurs. 1/

When the Call Detail Collator has messages containing charge information stored for being sent to the Central CDDR, it will set a flag and await a command from the latter, whereupon it will send the information using associated data modems (duplicated for reliability) and line bridging circuits. The CPUs and CDDRs have a number of features and programs to check the validity and accuracy of transfer of all data from one point to another and also for checking the proper working of the system at all times. Malfunctions are signalled through alarms and the faults are located through built-in features and programs.

Communication Links. The data from the Call Detail Collator in the CPU is transferred to the central CDDR using data transmission operating at a speed of 1200 bands asynchronous or information on calls at a rate of more than 200 a minute. All CPUs at the local exchanges are connected on a party line basis (four-wire working) to the central CDDR with a duplicated party line on a different routing in the telephone network to minimize the possibility of a simultaneous failure. The data transmission is self-checking to detect errors and to request retransmission as required.

The CDDR (duplicated for reliability) polls each Call Detail Collator in the CPUs attached to the local exchanges, verifies correct data reception and receives the call charging information, which is then recorded on a magnetic tape.

Typically, all Call Detail Collators are polled every ten minutes for getting data on calls for destinations outside the secondary area and once every day for other calls. The Call Detail Collators in the CPU have adequate storage capacity (active and passive) to permit such polling intervals. If a polled office does not respond, it is polled again on the next sequence of polls. If it does not respond after three polls, an alarm indication is given. The data is recorded in IBM (and industry) compatible format on half-inch nine-track tapes.

The cost of the input chassis unit and the call detail monitor (including redundant unit of security) works out at between $14 to $16 a line for exchanges larger than 1,000 and up to $40 a line for small exchanges of 200 line capacity. The cost of one set with a standby unit of Call Detail Collators and Data Modems runs from about $12,000 for a small exchange to about $17,000 for an exchange of 5,000 lines. The cost of a CDDR system with fully duplicated redundant systems capable of handling and storing on tape all the call details in the country is about $80,000.

1/ See footnote on page 6.
The Conrac AMA system provides for a variety of charging methods including pulse periodic metering system. Further, if records all information for local toll and STD calls on magnetic tape so that all the call charges are handled directly on a computer. The information collected provides comprehensive traffic and quality data on all calls (outgoing and incoming local and STD calls) including time taken to answer holding time, etc. On the other hand, it does not provide for control of coinboxes, for toll ticketing of operator assisted calls or for providing immediate information on call charges to special (e.g., hotel) customers - the last facility can be provided at the premises of the subscriber by an independent installation along with a teleprinter output. An important attraction is that the system can be attached to any type of local or trunk exchange with only the tip and ring wires of the lines to be jumpered to the AMA system. 1/ Also, since the line units are on a per line basis, toll ticketing can be applied economically to only a selected number of subscribers such as for International Subscriber Dialing.

1/ In the case of Thailand, the existing exchanges do not provide for reversal of the originating subscriber loop when the called party answers. This is an unusual arrangement. Conrac offered to provide for monitoring of the MF signals to recognize the called party answer signal to complete the call data though at an additional cost.