CONSIDERATIONS AND REQUIREMENTS OF AN OFF-TRACK BETTING SYSTEM  
S. BROAD / D. ROLLS

AUTHORS:
S.W. Broad  B.Sc (Hons) Project Leader, Control Data New Zealand Pty. Limited.
D.S. Rolls  B.Sc (Hons) Systems Analyst, Control Data New Zealand Pty. Limited.

This paper describes the general requirements for a computerised off-track betting system with specific reference to the system implemented for the New Zealand Totalisator Agency Board.

The general design considerations are discussed with regard to the special requirements of hardware and software. Terminal response times, database integrity, fail safe hardware configuration and re-startable recording techniques are among the design criteria to be highlighted. The paper concludes with a brief look at possible needs for off-track betting systems of the future.

Key Words and Phrases: Betting System, Online, Fall-back and Recovery, Reliability, Communications Systems, Terminals, Distributed Processing, Throughput, Hardware Backup.
CR Categories: 3.80, 3.81, 4.32, 6.20

1. INTRODUCTION

The decisions of local governments over the past years to tap the lucrative illegal betting markets have led to the formation of government controlled totalisator boards. The effort and cost involved in conducting such business manually has caused many of these boards to look for ways to automate their operations thus producing a new application for computer systems.

Such systems have been in operation in Australia for some years and systems also exist in Europe, Asia and North America and more recently in New Zealand. It is the purpose of this paper to discuss the general requirements of these systems and the methods used to solve the unique problems inherent in them. The discussion will centre around the system installed for the New Zealand Totalisator Agency Board.

2. APPLICATION

The two primary applications of computers in the betting industry are on-track and off-track systems. An on-track system carries out the functions that are performed by the mechanical totalisators that have been operational on race courses for many years. These systems sell tickets and calculate dividends on the meeting running at the course where the system is located, with no carry over of results, pools etc. from race to race or from one day to the next.

On the other hand, an off-track system services a much wider area, ranging from a metropolitan region to a nationwide system. This requires a much more sophisticated communications network with a corresponding increase in complexity of the design of the system. In addition, the system usually has to handle more than one kind of bet input.

The two most common are cash and telephone betting. Cash betting provides facilities for punters to place bets and payout on winning tickets at offices located throughout the area being automated. Telebetting provides the punter with the facility to place bets against an established credit by calling them over a phone to an operator who then keys the bets on a terminal.

The system installed for the New Zealand Totalisator Board has an initial requirement to provide telephone and cash betting in Auckland, Wellington and Christchurch. A central computer complex is installed in Wellington and services terminals in all the areas.

At cash betting offices bets are keyed into a terminal and transmitted to Wellington to be validated by the computer. A ticket is then printed showing the bet details and the value of the bet. Winning bets are paid out by re-entering the details from the ticket. If the bet has a dividend payable on it, a ticket is printed showing the amount of the dividend.

Telebetting is accepted at a central auditorium in each area. These auditoriums contain a number of telephone betting displays and bets are taken over the phone by an operator who then keys the bets into the display. Each bet is transmitted to the computer site where it is validated and recorded. The punter's account is debited by the value of the bet. A response showing the bet value is then generated and returned to the operator. After a result has been entered, all winning telephone bets are automatically credited against their respective accounts. Deposits and withdrawals for accounts are entered through cash terminals and the ticket that is printed serves as the punter's receipt.
CONSIDERATIONS AND REQUIREMENTS OF AN OFF-TRACK BETTING SYSTEM  
S. BROAD / D. ROLLS

3. DESIGN CONSIDERATIONS

The implementation of a nationwide betting system presents quite a challenge. Added to the problems inherent in any communications system are those unique to the off-track betting industry.

The most important aspect of a TAB system is its reliability - Hell hath no fury like a punter who cannot place his bet before race close time!

Complementary to the reliability factor is the need to maintain the accuracy and integrity of the data held by the system. This data includes individual bets, collation totals for events, telebetting account balances, terminal operator totals and the audit trails. This information must not be corrupted even if there are failures of peripherals, terminals, the communication network or the computer mainframes.

The requirement for reliability frequently necessitates the use of backed up hardware at all levels from the communications equipment down to the basic CPU. This backup can be fully automatic, manual or any combination thereof. The main factor governing the method for bringing the backup equipment into service is the time taken to manually switch in the equipment. The designer must determine whether the several minutes required for an operator to switch in an equipment is critical enough to necessitate the added expense and complexity with the use of software controlled switches and parallel operation of the backup CPU.

Associated with the concept of backed up hardware is the requirement for the software to be able to detect and recover from equipment failure. Usually more than one level of recovery is required with the first level being provided by a restart capability from information held on mass storage. This type of restart should only take a matter of seconds to perform and should result in no gain or loss of information.

The second level is reverted to when the system's mass storage files are corrupted and requires the reconstruction of the mass storage information from the audit trail. This type of restart could take up to a half-hour and for this reason the designer should look for ways of keeping as much of the system as possible running in a degraded mode while this type of restart is being performed.

Some sort of manual procedure for the acceptance of data may also be necessary to handle catastrophic failures in the system or communications network. TAB systems have a requirement for a large number of terminals spread over the entire area of operation.

For example, in New Zealand, the initial requirement was to service over 450 cash selling positions, and 66 telebetting positions located in Auckland, Wellington and Christchurch.

Coupled with this is the need to provide a relatively constant response time. The system has to handle peaks in bet throughput while still maintaining a satisfactory response time at the terminals. It is at these peak periods that the longest queues are formed in cash betting offices and the telephones are busiest in the telebetting centres. If the system is to provide acceptable service, the terminal response time must not drop over these peak periods.

Any computer system designed for off-track betting should be sufficiently flexible so that most changes in legislation and rules can be handled fairly easily. This is not only for portability of software from one organisation to another, but also because an off-track betting installation can never be considered static.

For example, the types of betting that the system must support may (and probably will) change in the life of the system. The designer should also consider growth in the number of terminals connected to the system so that the number of selling points can be increased in a reasonable manner rather than having to cater for a maximum configuration initially. To these ends the system must make optimum use of modular design, table driven code and parameterisation of constants so that such modifications can be effected with minimum changes to existing code.

4. HARDWARE CONFIGURATION

Because of the need for continuous computer processing, off-track betting configurations already installed have tended to make use of dual mainframe configurations with one machine acting as backup. This, coupled with the duplication of peripherals, ensures that a malfunction in a single equipment does not cause the entire system to be closed down.

This concept of having a large centralised computer with a fully duplicated mainframe and peripherals provides a suitable level of backup in the case of failures, but also represents a large amount of computer power that is not usable.
CONSIDERATIONS AND REQUIREMENTS OF AN OFF-TRACK BETTING SYSTEM  S. BROAD / D. ROLLS

An interesting trend in the industry is the concept of distributed computing power in the implementation of communications systems.

Under this philosophy, rather than having one large backed-up central processor handling the entire application, the work load is shared among a number of smaller processors.

This eliminates the need to have full backup of the processing units since failure of one machine will still leave an operational system. The work load of the failed CPU would be distributed among the remaining machines. To illustrate these different approaches to the provision of processor backup it is worthwhile examining current TAB systems.

The NSW TAB system consists of two large central computers one of which monitors and provides backup for the other when running in real time. These machines are “front ended” by a number of smaller computers which service the communications lines. To each of the central computers is connected disk mass storage for the recording of bets and associated tapes and unit record equipment.

The system currently being developed for the Queensland TAB uses a distributed computer concept. The central site consists of a number of smaller interconnected computers. These are used as bet concentrators for cash and telebetting terminals and are cascaded through two or more levels of processing. Each terminal has more than one path through the network so that under a single machine failure, all terminals remain operational. The system installed for the Victorian TAB in Melbourne incorporates a little of each philosophy. The race-day control functions and the processing of telephone betting are carried out by a single backed up processor while the processing of cash betting is handled by a number of smaller computers. The hardware configuration installed for the New Zealand TAB is very similar. (See figure 1, page 9).

The control of the system resides in the online 3100 computer and it is designated as the master control processor (MCP) for the race-day. It requests cash betting totals from the 1700’s and notifies them of scratchings, race close, postponed meetings, etc. The other 3100 computer is used for offline processing but is switched into the communications system if an online machine fails. Both drum mass storage devices are connected to the online machine and all information is recorded in parallel on both drums.

The communications equipment can be switched to either machine via a manual switch as can the magnetic tapes, printers, and console displays. The card reader is used only for offline processing and it usually switched to the standby machine.

The smaller 1700 computer systems act as ticket issuing processors (TIP) and service up to 236 cash betting positions. They communicate with the central MCP computer via 150 bps communications lines. A drum is used to store totals for cash bets sold by the system and these totals are transmitted to the MCP upon request. An audit trail of cash bets is maintained on a magnetic tape.

Terminals in each cash betting office are spread over all TIP systems and telephone betting terminals in each centre are routed via different multiplexors to the MCP. This coupled with the backup of all critical equipment, provides uninterrupted service in the case of component failure.

5. TERMINALS

The specifications of the terminal will affect the way in which the system operates.

An off-track betting system is generally configured so that each selling position is serviced by a terminal. The characteristics of the terminal depend on the type of betting that is being carried out; cash betting terminals are different from those used for telebetting and both are different on-course terminals.

The basic requirements for a cash betting terminal are for a keyboard to enter bets and a printer to record the bets in hard copy form for the punter.

In the NZTAB system, cash betting is handled with dual-ticket issuing machines (D-TIMS). The D-TIM services two selling positions by having two keyboards sharing a common printer and electronics unit. The TIM is a polled device and sends a message to the TIP containing the bet details from the keyboard. A ticket is printed for each bet that is keyed.

As well as operating in selling mode, the keyboard can operate in a number of other modes.

These include:

- pay mode which is used to payout winning tickets,
- test mode which is used during online operation for operator training or terminal maintenance, and
- account mode which is used for depositing and withdrawing funds from telebetting account.
CONSIDERATIONS AND REQUIREMENTS OF AN OFF-TRACK BETTING SYSTEM  S. BROAD / D. ROLLS

For a telebetting terminal there is no requirement for hard copy, bets generally being displayed on a CRT screen. The telephone betting terminal (TELET) designed for NZTAB is controlled by a firmware program.

This program processes messages to and from the terminal and drives the two display heads (24 lines of 48 characters), and two keyboards (thus providing two operator positions) which go to make up the terminal. Provision is made for screen control, message formatting, reply message overlay, and the sending of terminal status to the MCP. Screen control characters provide such functions as page roll up before or after display of message. The line to which the message is directed can also be communicated to the terminal. The message formatting feature enables messages to the terminal to be transmitted with blanks omitted. With the facility of message overlay, such information as bet value and punter’s current balance can be appended to the bet details being displayed.

The status from the terminal provides details such as "last message corrupted" or "awaiting response". This provides the MCP with information necessary to recover from line errors and is also used to restart the terminal in the event of system failure.

6. SYSTEM DESCRIPTION

The processing of bets and indeed all other messages must be carefully implemented so that it is possible to fully restart the system after a failure at any stage of processing.

The TIP and MCP systems use different concepts due to the different architecture of the machines and derivatives of the software.

Programs in the MCP fall into four categories; processors, control routines, I/O drivers and the system executive. Working storage is allocated in blocks of 4 to 512 words (24 bits) and these are called bins. The processors perform the application-oriented functions of the system. They receive control from the system executive and continue executing until I/O is required or the processing chain for the data is complete.

Critical function processors are core resident while those less frequently used are overlayed on mass storage. Control routines are entered on a time basis. These perform time oriented functions such as recovery from non-completion of I/O (i.e. lost interrupts) or the initiation of a processing chain (e.g. update of race-day information being displayed on the VDU).

The, I/O drivers perform all the peripheral and terminal input and output and maintain the queues of waiting requests. Data to and from external devices is, in general, executed from bins. When the I/O is complete, it is the responsibility of the driver to dispatch the input or output data for further processing. The executive uses a simple bin scanning technique to control the flow of data through the system. An activity bit is used to determine if a bin is to be passed (floated) to a processor and the executive continuously scans the bin area looking for active bins. When one is found, the number of the next processor is extracted from the bin and the processor is entered. The main functions of the MCP are:

- the validation and recording of telephone bets,
- the processing of telebetting deposits and withdrawals,
- the closing of races and printing of collation totals,
- the processing of results,
- the recording of serial numbers for cash betting,
- the processing of scratchings messages,
- the entry of race-day schedules,
- the carryover of betting and schedule information to subsequent race-days.

Telephone bets are entered from the terminal one at a time and the reply, containing bet value and updated account balance, is sent to the terminal before the next bet is transmitted. Once an account has been set active by a betting sequence on one terminal it may not be accessed by another terminal. The bet details are checked for validity and the punter's account balance is checked to determine that there are sufficient funds to cover the bet.

A journal record is constructed and written to tape and the bet details are recorded on drum. The running account balance is kept in core for the duration of a betting sequence and is updated on drum when the bet sequence is terminated.

Deposit and withdrawal requests for telebetting accounts originate from cash betting terminals and TIP's interrogate the MCP to determine whether the transaction can be performed. Any resulting account updates are passed to the MCP.
CONSIDERATIONS AND REQUIREMENTS OF AN OFF-TRACK BETTING SYSTEM  S. BROAD / D. ROLLS

An associated function is the establishment of a new account and in this case, the TIP requests an account number and punter's code. The MCP responds with these details and generates a record for the account which is written to the account file. The TIP completes the transaction by printing a receipt on the TIM.

Races are closed and collation totals automatically generated at times determined from the race-day schedule. When race close time for an event is reached, the event's collation state is updated and no further betting activity is permitted on the collation. Requests are sent to all TIP's requesting collation totals and these are combined with the telephone betting totals and output to the line printer.

The state of each bet sold by a TIP is maintained within the MCP. The TIP requests status of tickets before paying out on them and rejects all tickets that have already been cashed. When a ticket is paid out, the MCP is notified that the ticket has been paid.

The availability of this information within the MCP provides any TIP with the facility to payout on a ticket regardless of which TIP sold the bet. Results of events are entered via the VDU and these details are passed to the TIPs. The collation chain containing telephone bets for the event is then examined and any winning bets have the dividends calculated and these are credited to the betting accounts.

Scratchings information is entered via the VDU and a message is generated and transmitted to each TIP connected to the system. The collation tables are then updated to reflect the adjusted field sizes.

For a pre-sales meeting, scratching information is carried forward to the day on which the meeting is held.

Before the system is shut down it is necessary to enter a schedule for the next day's racing. This schedule has a record for every meeting on which the TAB will be operating. These records contain details of field sizes, race start times, along with types of betting associated with each race (e.g. win/place, quinella or leg of a double). This schedule is carried forward to the next race-day and the collation tables initialised from it. Any bets already sold for a future meeting are also carried forward.

On the TIP, the monitor is based on standard real time executive available on the 1700 computer; this executive provides multiprogramming facilities with up to 16 levels of priority. The TIP uses this priority scheme extensively with bet processing being carried out at low priority, servicing of the character multiplexer and message assembly/disassembly being carried out with medium priority and peripheral drivers operating at high priority.

The routines for processing sell or pay requests and deposit/withdrawal transactions are all located in core storage. Data is received from or sent to the D-TIM terminals one character at a time and the software assembles or disassembles the TIM messages. When a complete 14-character message is received from a TIM, it is placed on a thread for the bet validation routine. This routine carries out preliminary validation of the message and then routes the message to the appropriate processor according to transaction type, i.e. sell, pay, deposit/withdrawal, test, etc.

For a sell bet, the race/horse/meeting combination specified in the message is validated against the race-day tables and rejected if an invalid detail is found. For a valid bet, the appropriate collation total is updated and the message details logged on the audit tape.

For pay transactions, two lines from a ticket are sent to the TIP. The TIP checks the bet details against a file containing a list of all winning combinations at meetings held within the last four weeks. Tickets that are more than four weeks old - about 2% of winning tickets - are manually checked and paid out.

If the ticket presented for payout represents a winning combination, a message is sent to the MCP to check that the ticket has not been previously paid out. When the TIP receives an acknowledge from the MCP, it prints a ticket indicating the value of the dividend.

In addition to bet processing routines, there are several processors that handle race-day control functions within the TIP. These processors are overlayed on drum and are given control when a message is received from the MCP notifying the TIP of a change in race-day status. These messages are logged on the audit tape and the processing is arranged so that the same message can be processed more than once without causing race-day tables to be incorrectly updated. After actioning a message, the TIP sends an acknowledge to the MCP.
7. RELIABILITY

For a betting system to be of any use whatsoever it must be reliable. The provision of hardware backup has already been discussed. Some of the techniques employed in the software to maintain reliability will now be described.

The MCP prints computer collation totals on the line printer. These figures are extremely important, since it is from these that the TAB liability to the oncourse totalisator is calculated.

To guard against the corruption of a printed character producing incorrect totals, all output is duplicated. A visual check is made that both copies are identical before any of the figures are used.

The two drums connected to the MCP are the most important peripheral devices on the system. If one of the drums becomes inoperative, the files can be accessed from the other.

A facility used to reduce the likelihood of total data loss is track shifting. If the data on a track cannot be accessed on one drum, another track is logically substituted. The information on the duplicate drum is then copied to the new track and the data on the bad track remains available from either drum.

Both the TIP and the MCP have extensive validation checks incorporated in the software to rigorously check for out of range conditions. These tests are applied to any parameters passed to a program and the system stops if inconsistencies are found.

By testing that data is within the correct limits, software and hardware errors can be detected before vital system tables and files are corrupted. Since most software errors encountered in a "debugged" online system are to do with timing, a restart will general overcome the problem and the system can carry on processing.

8. FALBACK AND RECOVERY

The fall-back and recovery procedures for an off-track betting system can take place at different levels of operation.

At the top, the failure of a terminal, communications line or peripheral should not cause the whole system to fail and should only result in degraded performance without any interruption to processing. The system should operate in such a way that when an equipment fails, the software declares it down and transfers operation to the backup device if one exists.

At the next level of recovery, the failure of a mainframe or major system component means that the betting system is "off the air". The recovery from this kind of failure requires the actioning of a restart program to "tidy up" the system files after the failure and to recommence normal operation.

The MCP has two levels of recovery in the case of a malfunction.

The first level that is reverted to is a drum restart. The second which is performed only if a drum restart fails (i.e. drum files have been corrupted) is a journal tape restart.

Before discussing the drum restart, the methods of recording data must be examined.

All critical data (i.e. that which cannot be reconstructed from other files) is written using failsafe writes. A failsafe and marker record are written before the file update is performed. The failsafe record contains an exact copy of the data to be written while the marker signifies that the failsafe is complete. When a restart is performed, the failsafe and marker records are examined and from them, any partially written update is completed. This also provides a method of synchronising the content of the two drums.

The marker records contain sequence numbers and by an examination of these, the restart routines can ensure that both drums contain exactly the same information. The corruption of the data base by one update taking place without a related update to another file must also be guarded against over a restart. To prohibit this, a "flight plan" technique is used. Before a transaction is processed, a record containing what file updates are to be performed is written to drum.

These are used at restart time to ensure that all updates associated with the transaction are completed.

The first step in a drum restart is to use the failsafe records to reconstruct any data being written to the drums at the time of failure. The flight plan records are then examined and all drum and journal tape updates contained in them are re-initiated.
CONSIDERATIONS AND REQUIREMENTS OF AN OFF-TRACK BETTING SYSTEM  S. BROAD / D. ROLLS

At this point, all files within the system contain valid information and the online system can recommence operation.

All TELET’s are then polled to determine if the terminal had a message being processed at the time of failure. If it did, the message is re-transmitted. The system compares the input with that contained in the terminals flight plan record and if different, the input is processed.

Using this mechanism, the terminal is restarted without any special operator action and without any loss or duplication of betting information. In the case where the files on drum have become corrupted, a restart must be performed from information on the journal tape.

This can be quite a lengthy process as it entails repassing all of the day’s transactions. Collation chains are rebuilt, results information is processed and account details are updated to reflect the balances at the time of failure.

The operation of the TIP restart program is also very dependent on the procedures that are used to record the bet details.

When processing a sell bet, the first action that is carried out is to access the collation total. An entry is then made in the restart record for the TIM consisting of the current bet details, the updated collation value and the updated seller’s balance details. The restart records for all TIM’s are held in core with a dedicated area for each keyboard. This entire area is written to mass storage at ½ second intervals.

In this way, the overheads of writing terminal restart records are minimised although information for terminals that may not be active is also written to mass storage. Once the bet details have been stored in the core restart record, the updated collation total is placed on a temporary string in core. The entries on this string are written back to the collation area when the restart record has been successfully written to drum.

Thus, a collation total is not updated until the bet details and collation value have been logged on drum. To complete the recording of the bet, an audit record is formatted; audit records are blocked in core based buffers and are written to magnetic tape at one-second intervals. The writing of the records is arranged so that any bets logged on the audit tape will have a restart record on the drum.

When a failure occurs on a TIP module, attempts are made to restart the system using drum restart which determines if the last transaction on each TIM was completed. For TIM’s that have partially processed transactions, the restart program deletes the incomplete transaction from the system.

The TIP does not complete partial transactions since it is not a backed-up configuration and the transaction would probably have been re-entered on a TIM connected to a different TIP module. The drum restart program carries out validation checks on the system tables and if the failure has corrupted these files, the TIP can be restarted from the audit tape. The audit tape restart program reads the individual records from tape and sends them back through the system to update collation totals and tables. After reading the audit tape, the system is brought back to the stage it was at prior to the failure.

9. SYSTEM TESTING AND TUNING

Off-track betting systems should have provisions for monitoring the use of systems resources.

The simplest way of doing this is to use counters that are updated according to the number of drum accesses, amount of working core storage used, length of queues and so on. A program can be activated to “snapshot” these counters at various intervals during online operation. This enables system performance to be regularly monitored.

The MCP has a comprehensive status report that is printed every 15 minutes. This report contains details such as number of bets processed, core and drum usage, and a summary of communications line errors.

A status report is also produced by the TIP giving details of drum accesses, and the numbers of pay, sell and deposit/withdrawal transactions.

As well as reporting these statistics, it is important to have the facility to accurately measure the throughput of the system under full load. This situation is difficult to create using actual operator input since in the test phase, the system usually does not have its full complement of terminals. Even with the necessary terminals such tests are difficult to co-ordinate.
The approach taken for the NZTAB system was the adoption of software “stimulators” to produce these load conditions.

The MCP load stimulation uses the facility of looping back out-going messages at the data set adaptors. The sequence is initiated by the "start of day" message to the terminals. This message cycles back into the MCP and is trapped and replaced by a simulated bet message which is processed by the system. Subsequent bet reply messages continue the process.

This not only tests the CPU under load, but also the facility of the communications interface to cope with the traffic. Using this "flood test" the MCP system was tuned to obtain a throughput of 78,000 bets per hour.

On the TIP, this loopback type of stimulation was not as simple to implement as TIM output messages are twice as long as input messages. The TIP stimulation package takes messages from tape, unpacks and passes them to the online system a character at a time simulating TIM input. The package controls system timing and inhibits the clock while performing such functions as reading bets from tape. Using this simulator package the throughput for a single TIP module has been measured at 220,000 bets per hour.

10. FUTURE TRENDS

The systems that are currently running on the TIP and MCP system, reflect the current state of the art for real time betting systems.

In the three to four years since the NZTAB system was designed, many changes have already occurred in computer and in off-track betting systems and this trend will continue.

The range of bet types to be supported will expand from the current three to four types per system to include exotic bets such as seven-race jackpots, "superfecta", "super-yankee", all up betting and so on that may require more than one iteration of computer processing on a single-bet ticket.

Rather than the simple "sell a ticket - payout on winners" transaction sequence, some forms of betting willrequire that after each race, another ticket has to be issued representing the punter's selection for the next stage of the bet. It is also possible that off-track betting systems will expand their operations to include on-track operations or perhaps different kinds of gambling such as lotteries or football pools.

Another significant factor in the industry today is the revolution in mini computer technology.

These machines are offering more power for less money, and, this has made feasible the use of mini computers in "intelligent terminals". Such terminals have greater flexibility than conventional hardware or firmware terminals. It is to these that we will look to provide the capability for handling a greater range of functions with the additional benefit of lowering line costs. Mini computers are already being used as remote concentrators in existing communications networks.

This trend is particularly applicable to countries like New Zealand where population centres tend to be distributed over a wide area. The future will see a growing use of mini computers not only as intelligent terminals and concentrators but as a substitute for the large central processors currently being used to control communications networks. These trends will (and already have been) manifested in TAB systems of the future.

ACKNOWLEDGEMENTS

Our thanks are extended to the management of New Zealand TAB who allowed this paper to be published.
CONSIDERATIONS AND REQUIREMENTS OF AN OFF-TRACK BETTING SYSTEM

S. BROAD / D. ROLLS

Figure 1

Figure 1 configuration - Figure 1