General Information Manual

IBM 7750 Programmed Transmission Control

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Preface

The 230,000,000 miles of telephone and telegraph wire and cable that crisscross the United States are indispensable to our livelihood and way of life. This communication network enables us to communicate easily with each other, even when we are hundreds of miles apart. Our decisions don't have to wait until tomorrow; they can be made now.

Many companies, large and small, are decentralizing their operations, and the need for rapid communication between central and branch offices becomes greater and greater. Important decisions must be made with a confidence born of thorough awareness of company operations.

IBM Tele-Processing® systems are designed to bridge today's communication gap. These systems link widely separated data gathering points with a data processing center via telephone, telegraph, radio, or microwave links. Data, transmitted the moment they originate, may be received at a central location in time to be an important influence on operational decisions. In short, an IBM Tele-Processing system supplies information where it is needed, when it is needed, over communication channels. One unit of Tele-Processing equipment is the IBM 7750 Programmed Transmission Control described in this manual.

Address comments concerning this manual to:
IBM Corporation
Customer Manuals, Dept. 298
P.O. Box 390
Poughkeepsie, N. Y.

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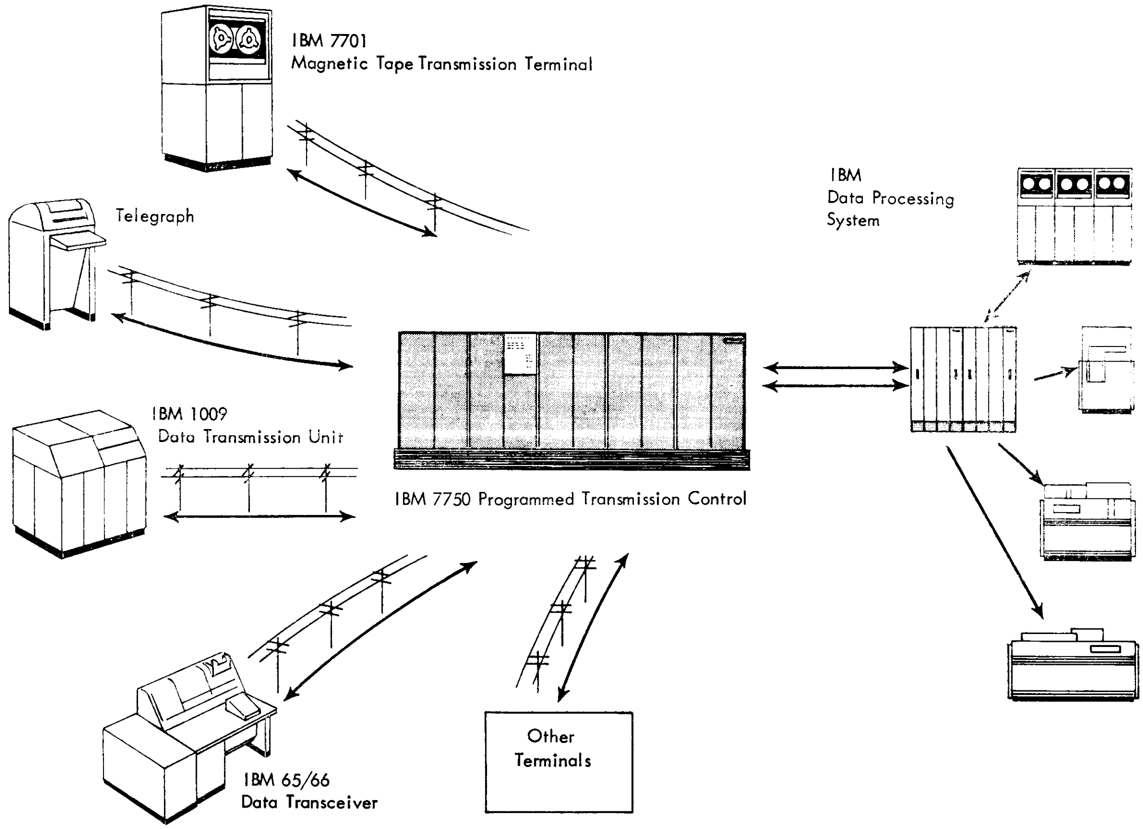

Figure 1. Communication-Based Data Processing System

The IBM 7750 Programmed Transmission Control is a Tele-Processing® system component that links a central computer with remote terminals. Telecommunications equipment such as telegraph machines, IBM 65/66 Data Transceivers (with IBM 67 Telegraph Signal Unit) or IBM 7701 Magnetic Tape Transmission Terminals may be connected to the 7750 through appropriate channel adapters. On the other end, the 7750 is connected to an IBM Data Processing System through a standard connection. The 7750 thus enables computer users to combine the data processing capabilities of their computers with the high-speed transmission capacity of many telecommunication devices.

The IBM 7750 is a stored program unit that serves as a buffer control device, directing and controlling the flow of information between the computer and its communication network. This communication network may have a variety of standard or specially designed terminals, each operating independently but linked directly to the system (Figure 1). The terminals may have different transmission speeds. The 7750 accepts signals simultaneously from a number of communication lines, converts these signals into bits, then into characters, then into records and, finally, relays these records at high speed to the computer for processing (Figure 2).

A primary function of the 7750 is to connect the diverse elements of the communication network to an associated computer such as the IBM 1410, 7040, 7044, 7070, 7074, 7080, or 7090 Data Processing System. Tele-Processing systems using the 7750 may be employed for airline reservations, data routing, centralized data processing, production control, or other applications. The system planner can choose the computer and be assured that the communication problem will not be a factor in determining his choice.

Within a Tele-Processing system, the 7750 performs five basic functions:

Data Assembly (and Distribution) proceed automatically with only occasional supervision from the stored program. Data assembly begins with the derivation of bits from the incoming communication circuit to the channel adapter. The process continues to the point where characters are assembled into complete data messages in the process storage section of the 7750. Data distribution is the sending of data from the

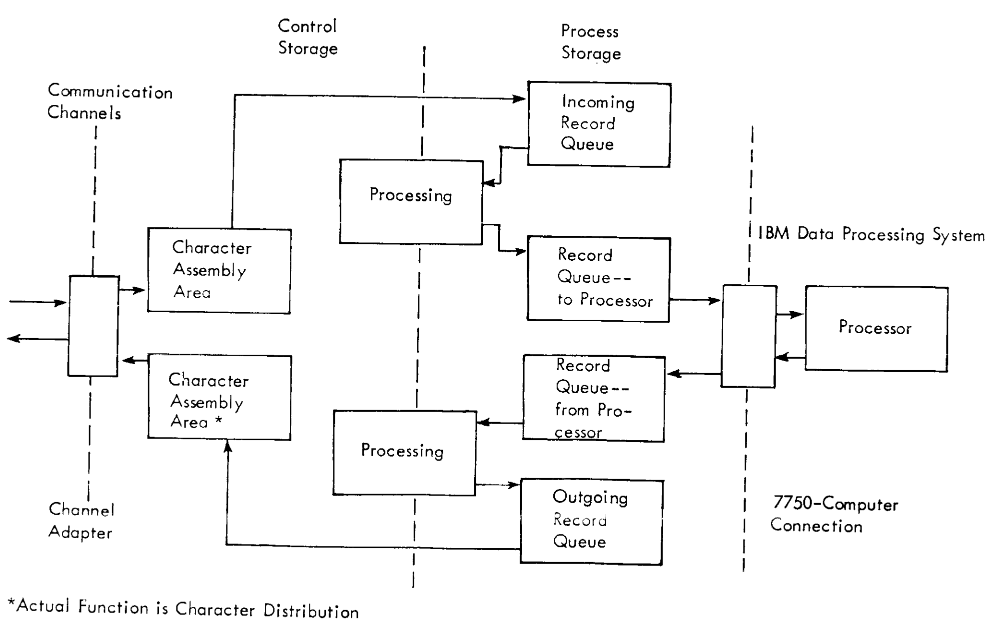

Figure 2. Data Flow

process storage of the 7750 to the communication channels.

Information Conversion from or to the form required by the computer may include changes to both the code and format of the message. Conversion is controlled by the 7750 stored program.

Editing involves omitting and adding special characters—and, sometimes, format changes—under program control.

Monitoring and Supervision check incoming traffic to indicate the status of terminals and oversee the data flow in a network. The stored program controls these functions.

Data Transfer supplies data to and accepts data from the computer, on a demand and response basis, through linkage connecting the 7750 and the computer.

The 7750 has no arithmetic unit. Computation, shift operations, and comparisons of data, therefore, must be made by lookup in prestored tables.

The 7750 is made of five standard IBM modules:

The Communications Line Terminator Module aids the customer in isolating troubles in his communication network. The module contains patch panels, signal generation circuitry, and equipment used to run diagnostic programs in the 7750.

The Channel Adapter Module holds different types and combinations of channel adapters. The channel adapters perform various functions, such as time multiplexing a number of low-speed communications channels into one high-speed output and recovering bit timings from synchronous communicated data.

The Process Control Module contains the registers and instruction control circuitry of the 7750. All processing is controlled by this module.

The Core Storage Module contains two magnetic core storage units: process storage and control storage. Process storage is available in three sizes: 4,096, 8,192, and 16,384 words of 48 bits per word. Control storage contains 128 words of 48 bits per word. The data registers for these storage units are in the process control module.

The Power Supply Module contains all power supplies for the 7750.

In addition to these five modules, a separate sixth module may be obtained as an optional feature. This module contains equipment to convert IBM signal levels to certain telegraph signal levels.

Data Flow

The five basic functions of the 7750 Programmed Transmission Control are performed by circuitry within the 7750 and by the 7750 stored program. Consider the 7750 as consisting of two functional units:

The first part performs the basic function of data assembly and distribution. This part is electrically and functionally compatible with the communication channel and assembles bits into characters under proper control.

The second part performs the other four basic functions of the 7750 (information conversion, editing, monitoring and supervision, and data transfer). This part contains the stored program, which controls the transfer of data to and from the communication channels and the computer, and performs certain processing concerned with the messages (data) passing through the 7750.

Data enter the 7750 serially (bit-by-bit) from the communication channels. Channel adapters allow the 7750 to accept bits at low-speed rates (45 to 200 bits per second) or at high-speed rates (up to 1,200 bits per second).

The channel adapters attach the communication channels to one or several of the 16 possible half duplex scan points of the process control module. Half duplex high-speed channels are attached on a one-for-one basis, through appropriate adapters, to the scan points. Low-speed lines are attached through low-speed line adapter sets to a multiplexing channel adapter (low-speed group feature), which in turn is attached through a low-speed base feature to one or more process control module scan points. Up to 28 low-speed channels may enter the 7750 from each multiplexing channel adapter (MCA).

The adapters gather incoming data, bit-by-bit, and transfer these data—one bit at a time—to the process control module, where the bits are assembled into characters in and under the control of the control storage. The control storage consists of 128 words of 48 bits each. A few of these words are used as operational registers for the 7750; others are used with the communication channels. Each half duplex communication channel has at least one control storage word, called the channel word, associated with it.

The channel word contains an 11-bit character assembly area and a number of control fields and bits that control the operation of the channel. The control bits are initially placed in the appropriate channel word by the 7750 stored program. Thereafter, these bits are modified according to channel and subsequent program operation.

When character assembly is completed in a channel word, the character is automatically placed in process storage, under control of an address in the channel word. This action is a character interrupt cycle. When thirty-one characters have been assembled in process storage, the 7750 program is interrupted and the 7750 goes to a special program routine that assigns a new block of storage for incoming data and also changes the address in the channel word. Such blocks, connected in an orderly manner and manipulated as a unit, are called a chain.

Data distribution (sending data from the 7750 to the communication terminals) is the reverse of the data assembly process.

Once data are within process storage, data processing in preparation for transfer of the data to the computer follows usual stored program principles. The 7750 has built into it, however, a number of capabilities that make it particularly adaptable to operations in real time. Among these facilities are six program mode levels, which have predetermined priorities according to the relative inportance of the operation required. A mode may be entered either automatically or by the 7750 stored program, and reversion to a lower priority routine is automatic. In addition, there are unique programming facilities for indirect addressing, table lookup, and other programming techniques.

The transfer of data and programs between the 7750 and the computer takes place through an appropriate data channel. Information transfer is under program control. Either the computer or the 7750 may request service from the other.

7750 Systems Operation

Interrupt System

In usual data processing applications, the computer program controls all aspects of the operation. Magnetic tape is read or written when the program calls for it; cards are read or punched under control of the program. It is relatively easy for the programmer to assure that all computer functions are executed in the correct sequence.

In real-time data processing, events are often independent, not only of the computer, but also of each other. Thus, the 7750 works in an essentially uncontrolled environment. In many applications, the 7750 cannot dictate when messages will occur on the communication network or what the length of the message will be. Communications from the associated computer may take place at random intervals. For these reasons, the 7750 is equipped with a flexible interrupt system so that it may quickly and automatically switch from one program to another when various conditions require immediate attention.

This interrupt system has several levels. An interrupt may interrupt an interrupt; priorities are assigned to various modes so that the machine can decide which interrupt to execute.

There are six levels (modes) of program priority in the IBM 7750. The choice of mode is made by a wired-in selection system that recognizes the mode that is requesting service. Each mode, except copy mode, has a unique program designed to execute the required function when the given mode is selected. The six operating modes of the 7750, classified in declining priority, are:

1. Service Mode
2. Channel Service Mode
3. Copy Mode
4. OUT Mode
5. IN Mode
6. Normal Mode

Service Mode has highest priority. In most cases, the program for this mode is used to detect environmental errors, and the request of this mode is automatic through channel words if the check switch on the operator's panel is set to SERVICE MODE instead of to STOP. In addition, the service mode program may be used to:

1. Isolate or remove mistakes from a program (debugging).
2. Locate a faulty component (diagnosing).
3. Obtain a programmed output of error messages when a machine malfunction occurs. Service mode may be entered manually from the operator's panel, automatically on the occurrence of an error condition, or by the stored program. The 7750 program must enable the machine to leave this mode.

Channel Service Mode has second priority. The process storage is divided into blocks of eight words (32 characters). Each communication channel has access to only one block at a time. When a message is being received by the 7750 and the assigned block is filled, channel service is requested. The channel service mode program keeps an inventory of available storage blocks and can assign an additional block to the channel requesting storage. In the case of an outgoing message, after the transmission of each block, control returns to the channel service mode program. This program provides the address of the next block of the message and at the same time adds the already transmitted block to the inventory of available buffer storage space.

Copy Mode has third priority and is requested by the mode program of some other mode. When this mode is operative, data are automatically moved to or from the associated computer from or to the 7750. Copy mode is not a program executing mode but is given a mode position because its function ranks in priority above all but service mode and channel service mode.

OUT Mode has fourth priority. It allows a program to execute the necessary instructions to set up the copy mode process word and prepare the 7750 to transmit data to the computer. The OUT mode request bit is normally turned on by the program of the associated computer and is turned off by the IBM 7750 program. This mode may also be requested by the 7750 program.

IN Mode has fifth priority. It is usually requested by action of the associated computer when the computer wants the 7750 to accept data from it. The program written for this mode locates space for the data, sets up copy mode process word to read the data into this area, and requests copy mode. The IN mode request bit is normally turned on by the program of the associated computer and is turned off by the IBM 7750 program.

Normal Mode has lowest priority. It causes the execution of the normal program, which performs error checking, code translation, recognition of functional codes, monitoring, queuing, and so on. All 7750 functions not specifically delegated to other modes are executed by the normal program.

Mode Selector Operation

The mode selector system enables the 7750 to change modes automatically. This system consists of a mode request register and a mode status register. Both registers have five bit positions. Each bit position in the registers represents a specific mode. Normal mode is indicated when there are no bits appearing in either register. A 1 bit in the service mode position of the mode status register (MSR) indicates that the 7750 is in service mode; a 1 bit in the IN mode bit position of the MSR indicates that the 7750 is in IN mode. If more than one bit appears in the mode request register at the same time—indicating that more than one mode is requested—the 7750 always services the mode with the highest priority. This occurs because only the bit associated with the highest mode of the requested modes will appear in the mode status register.

Loading the IBM 7750 from the Computer

To begin 7750 operation, the main 7750 program and the necessary tables and constants are loaded into the associated computer from cards, magnetic tape, or disk storage. The associated computer then transfers the program with tables and constants to the process storage of the 7750.

The loading of data into control storage is accomplished by the 7750 program after programs and data have been loaded into process storage from the computer.

Detailed Description

Control and Process Storage

To buffer and control the data flow between a computer and a communication network, the 7750 is organized around two magnetic core storages. One of these storages, control storage, controls the communication network and assists in executing the programs. The other storage, process storage, holds message queues and programs.

Control Storage

Control storage is a 128-word storage that contains most of the operational registers (all instruction counters and the registers most frequently used for data manipulation and address modification). The contents of a word in control storage may be arranged in several ways depending on its intended use (Figure 3). These word formats are:

Channel Word (CWD): Each channel word is the control word assigned to a communication channel. Bits received from a channel adapter are assembled into a character within an eleven-bit field—the assembly area—of this word. A character obtained from process storage is transmitted, bit-by-bit, from the same area to a channel adapter. The remaining bit positions contain all information necessary for controlling and checking the transmission of one character at a time. This control and check procedure varies, depending on the type of character transmission (start-stop or synchronous). High-speed communication channels require the assignment of three or four words of control storage: one as a channel word and the other two or three for additional control functions based on the specific service being used.

Process Word (PWD): The IBM 7750 has six process words, one for each mode. Modes of operation of the 7750 are changed by using a different process word. An instruction counter in each PWD, except copy mode PWD, controls the sequence of operation in the respective mode.

The control storage, operating with two standard features, enables the 7750 to insert delays in the outgoing data stream and to wait for an answer in a specified time period. When the IBM 7750 is preparing a message for transmission, the program may examine the record to locate carriage return characters or other formating marks placed there by the computer. Between each formating mark and a data character, the 7750 may insert the sending delay character (SDC), followed by the amount of delay required. The maximum delay is equal to 2,045 bit times. (A bit time is the time needed by the 7750 to send one bit at a particular channel speed.) When this delay sequence later passes through the channel word, the required delays are automatically inserted. For example, an SDC specifying 750 bit times on a 75-bit-per-second channel would insert a 10-second delay.

The other feature is the automatic line reversing mark. At the end of a transmitted message, the 7750 program automatically inserts a status change character followed by a delay count equal to the desired delay in binary bit times. This status change character (SCC) is inserted at the end of a transmission when it is desired that the line be immediately switched to receive status at the 7750 to listen for an expected response. Like SDC, the maximum delay of the SCC is 2,045 bit times.

Process Storage

Process storage is available in three sizes: 4,096, 8,192, and 16,384 words. A word in process storage may be arranged in three ways, depending on its use: data

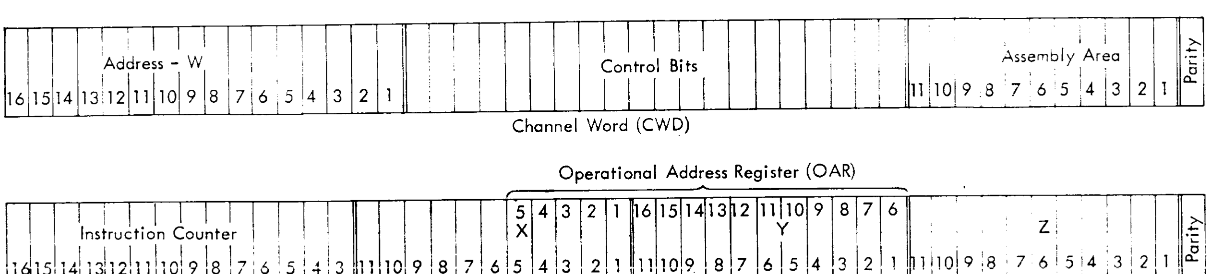

Figure 3. Control Storage Word Format

word, instruction word, and limit word (Figure 4).

Data Word (DWD): A data word contains four 11-bit fields. Each of these fields may contain a variable length character of up to eleven bits. If a character has fewer than eleven bits, it is stored in the low-order positions of the field, and the remaining bit positions are set to zero.

Instruction Word (IWD): Each machine instruction is stored in a separate instruction word. This word contains an operation code (op code), an address field, two flag bits, and four fields for specifying registers and field sizes for address modification and data manipulation. The instruction word tells the 7750 what operations it is to do and where to get the data needed for the operation.

Limit Word (LWD): This is the control word for a chain of storage locations. This word contains the address of the character that begins the chain and the address of the character that ends the chain. The limit word also contains an eleven-bit field that may be used as a counter for the number of blocks in the chain or for other purposes.

Timing

The basic machine cycle of the 7750 is 28 microseconds. Most 7750 instructions are one-cycle instructions. Two-cycle instructions, which require 56 microseconds for execution, are the instructions using indirect addressing and those used for storage-to-storage data manipulations.

For control storage operations, the basic machine cycle is divided into two storage cycles, scan and process, which are 11 microseconds and 17 microseconds long, respectively. During 7750 operation, the control storage goes through alternate cycles during which it:

1. Services one of the channels, assembling bits until a character has been accumulated.
2. Provides the operational registers for the process storage to execute the instructions.

For process storage operations, the basic machine cycle is also divided into two cycles, the instruction cycle and the execute cycle. These two cycles alternate and are 12 and 16 microseconds long, respectively. During an instruction cycle, the 7750 obtains an instruction; during the execute cycle, it executes the instruction.

The control storage and the process storage cycles overlap, allowing the information of either cycle of either storage to influence the operation of the other storage. In one machine cycle, the process storage goes through an instruction cycle and an execute cycle while the control storage goes through a scan cycle and a process cycle. The process cycle of the control storage, being 17 microseconds long, overlaps the instruction and execute cycles of process storage (Figure 5).

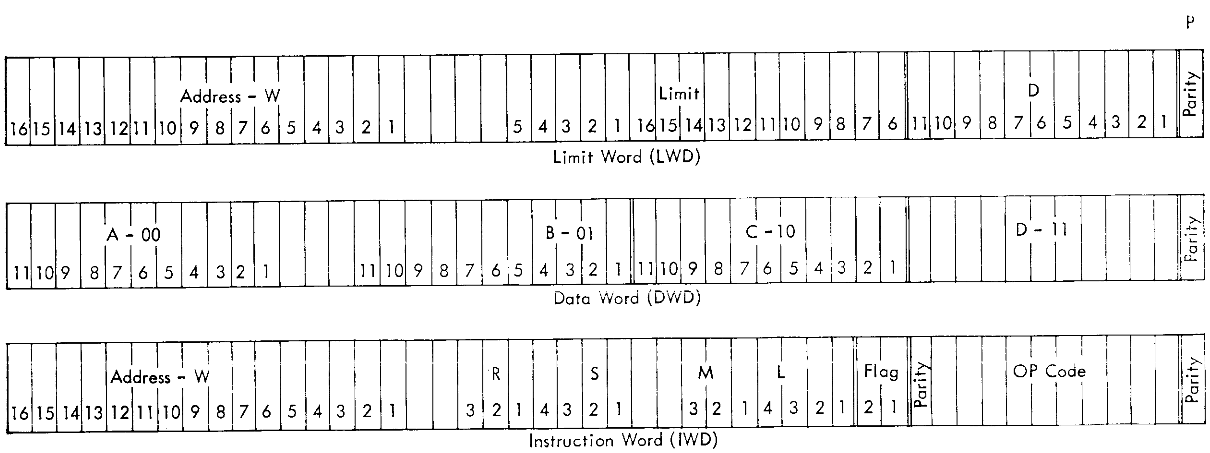

Figure 4. Process Storage Word Format

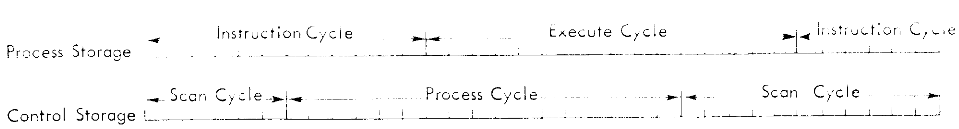

Figure 5. Storage Cycle Timing

Registers

The 7750 has both addressable and nonaddressable registers. Addressable registers can be addressed by the stored program (loaded, set, or requested by the programmer). Nonaddressable registers cannot be addressed by the stored program; they are set and reset automatically at the proper time.

Addressable Registers

The Channel Service Register enables a channel requiring assignment of new storage space to identify itself to the channel service program. This register has seven bit positions to hold the channel address. When channel service is obtained during a character interrupt or a scan cycle, the channel service register is automatically set with the channel address. During execution of storage-to-storage instructions while in the channel service mode, the 7750 transfers the contents of the channel service register to the control storage address register to address control storage. This transfer is automatically done on the second process cycle of a two-cycle instruction that refers to the control storage while the 7750 is in channel service mode.

The Interface Data Register is a nine-bit register (eight bits plus one parity bit) that enables the 7750 to communicate with a computer or data processing machine through an appropriate data channel for input-output operation. This register may be loaded or its content stored under program control. It may also be loaded or its content automatically stored when data are transferred to or from the associated computer.

The Interface Control Register is an eight-bit register that controls the data flow between the IBM 7750 and the associated computer. This register may be loaded and its content stored or modified under program control. The control, sense, stop, and end response bits are not addressable; these bits are set or reset automatically when the 7750 is transferring data to or from the associated computer.

The Mode Request Register is a five-bit register that holds requests for priority program service. The 7750 requests a mode by setting to a logical 1 the bit associated with that mode in the mode request register. The priority of a mode depends on the position of its associated bit in the mode request register. If more than one mode is requested in the mode request register, the 7750 always selects first the mode having highest priority. If no mode is requested in the mode request register, the 7750 executes the normal mode program.

Nonaddressable Registers

The Instruction Register is a 26-bit register that holds the instruction being executed (except the address). The first ten bit positions contain the operation code, the next two bit positions contain the flag bits, and the last 14 bit positions contain the R, S, M, and L fields.

The Mode Status Register is a five-bit register. Before execution of each instruction, this register selects the bit associated with the highest priority mode from the priority requests contained in the mode request register. At any one time, the mode status register may contain only one bit (a logical 1) to indicate the highest priority mode selected. If this register contains no logical 1, the 7750 selects the normal mode through wired-in logic.

The Process Storage Address Register 1 (PSAR 1) contains the current address for addressing the process storage. Address modification occurs as the address is set into this register from process storage address register 2 (PSAR 2). This register can hold 16 bits; 14 bits are used to address the correct location in storage, and two bits are used to specify a particular character (0, 1, 2, or 3) within a four-character word.

The Process Storage Address Register 2 (PSAR 2) temporarily stores a 16-bit address from the process storage data register. The address is transferred to the PSAR 1 when it is used to address the process storage.

The Control Storage Address Register (CSAR) contains the current address for addressing a channel word or process word in control storage.

The Process Storage Data Register (PSDR) is a 48-bit register that holds the word read out from, or to be written into, process storage. This register can conform to any one of the three word formats in the process storage (data word format, process word format, or instruction word format).

The Control Storage Data Register (CSDR) is a 48-bit register that holds the word read out of, or to be written into, the control storage. This register can conform to any one of the four formats of the control storage (channel word format, two process word formats, and copy mode process word format).

Instructions

All 7750 instructions belong to one of four types:
- Character Manipulating (CH) Instructions
- Address and Limit Moving (AL) Instructions
- Storage-to-Storage Data Transfer (SS) Instructions
- Control (CT) Instructions

The 7750 is a single address machine, and each instruction contains one address for addressing storage. The addressing format includes, however, address modification and indirect addressing. Address modification is done by replacement; up to eleven low-order bits of the address may be replaced by bits from another register.

All 7750 instructions contain a 16-bit address (W field) in bit positions 47 to 32 of the instruction word (Figure 4). For direct, unmodified character manipulating instructions (CH), W is the location in process storage of one of the characters to be manipulated. In the execution of the other three types of direct, unmodified instructions, the 14 high-order bits (47-34) address the word to be used in the execution of the instruction.

In character moving instructions both the word and the character must be specified. Therefore, the complete 16-bit address must be used, with the 14 high-order bits specifying the word and the two low-order bits specifying the character within the word.

Except for all branch instructions other than branch indirect, the address W of any instruction may be modified by specifying a nonzero value for the L field of the instruction word. If L is zero, no modification takes place. If L is nonzero, the M field (bits 20-18) specifies the register containing the modifier to be used, counting from the low-order end of the specified register. L cannot have a value larger than eleven.

In executing directly addressed instructions, W is the location of one of the operands. When an instruction is executed indirectly, the operand is located at W*, where W* is the address (bits 47 through 32) contained in the word addressed by W.

All character manipulating instructions deal with two character locations, one in process storage specified by W or W*, and the other a register specified by R (bits 29-27). S (bits 26-23) is a binary number specifying the size of the character to be operated on, counting from the low-order bit of the register specified by R. In character manipulating instructions, S cannot have a value larger than eleven.

Address and limit moving instructions must specify the operational address register (OAR) as one of the operands, because the other registers are not big enough to accommodate the 16-bit address or limit. The OAR is composed of the Y register and the five low-order bits of the X register. When an address or limit is moved into the OAR, the five low-order bits of the address or limit go to the five low-order bit positions of the X register, and the 11 high-order bits of the address or limit go to the Y register.

Storage-to-storage instructions deal with two word locations: one in process storage, specified by W or W*, and one in control storage, specified by R and S in all modes except channel service. In channel service mode, storage-to-storage instructions are executed using the contents of the channel service register to address control storage.

Error Checking

The error control procedures of the IBM 7750 may range from operator's messages to elaborate forward-error-correction techniques for handling data. Within the 7750, the following checks are made:

Parity Check: Process storage and control storage have a parity bit associated with each word. Before a word is written into storage, the parity bit is generated so that each word has odd parity. The 7750 makes an odd parity check after a word is read out from either storage.

Full Word Transfer Check: When full words are transferred between the control storage data register and the process storage data register, a parity bit is also transferred and an odd parity check is made on the word in each data register.

Instruction Register Parity Check: An odd parity check is made on the operation code and flag data (bits 1 through 13) of the instruction register. The instruction word that contains the parity bit for the operation code and the flags is read into the process storage data register first; then the 26 significant bits (with the exception of bits in the address field) are moved into the instruction register for decoding. The 26 bits are composed of the ten-bit operation code, the two flag bits, and 14 bits for naming the two registers and size defining fields. Though the parity bit is not moved into the instruction register, the parity check for the operation code actually occurs when the information is in the instruction register.

Clock Check: The clock in the 7750 is checked for multiple pulses, no pulse, and failure to advance properly.

Channel Check: The 7750 has 16 channel check lights. Each light is associated by number with a high-speed communication channel or an MCA. When an error occurs on a high-speed communication channel, the channel check light corresponding to that channel goes on. When an error occurs on a low-speed communication channel, the channel check light corresponding to the MCA that handles this low-speed communication channel goes on.

Error Procedure

Either a parity error in the operation code and flag data bits of the instruction register or a clock error causes the 7750 clock to stop. Except for a clock error, the error condition remains in the register where it occurred. Whenever an error occurs, a check indication appears on the operator's panel.

The manual check switch may be set to SERVICE MODE or STOP. Setting this switch to SERVICE MODE status causes the IBM 7750 to go into service mode instead of stopping when an error, other than a clock or operation code error, occurs. If a clock or an operation code error occurs, the machine operation stops, regardless of the setting of the manual check switch.

Communication Channels and Scan Points

The process control module has 16 scan points. By use of adapters, different types of communication channels may be attached to each scan point. For example, a high-speed channel adapter (HSA) permits one high-speed telephone-grade line to be attached to one scan point. With a multiplexing channel adapter (MCA), one scan point can handle as many as 28 low-speed communication channels (45 to 200 bits per second).

Different combinations of low-speed and high-speed communication channels may be connected to the 7750. The design of the machine and the stored program enable it to have a flexible communication capability (Figure 6), depending on system considerations such as line utilization, peak traffic loads, core storage requirements and the like.

Figure 7 shows one possible communication network configuration employing one multiplexing channel adapter and one high-speed channel adapter.

Channel Adapters

A communication system may perform many services using varied equipment. There are the remote terminals previously mentioned. Data sets made by several companies are used. These devices may employ different modulation methods or bit rates, but all must be integrated into IBM Tele-Processing systems. (NOTE: Data set is a general term applied to any common carrier equipment connecting an IBM Data Processing System to a common carrier communication system.)

Channel adapters are used so that the IBM 7750 may fit into many communication systems. These channel adapters—the multiplexing channel adapter (MCA) and the high-speed channel adapter type 2 (HSA2) perform many functions. Some channel adapters control data sets; others time-multiplex a number of low-speed communication channels into one or more scan points.

Multiplexing Channel Adapter (MCA)

The multiplexing channel adapter is a channel concentrator and a speed changing device. It extracts data from a number of incoming channels by a scanning and sampling operation and transfers the data to the 7750 through one to four scan points.

A maximum bit rate on a communication channel connected to the MCA depends on the number of low-speed channels going into the MCA, the number of scan points the MCA connects to (one, two, three, or four), and the number of scan points a 7750 has. Figure 8 shows the maximum bit rate for low-speed communication channels operating on a given set of conditions.

If the 7750 has 14 scan points, for example, and the highest bit rate on any channel going into the MCA is 150 bits per second, the MCA can be connected to a single 7750 scan point, and 17 low-speed communication channels operating at 150 bits per second can be accommodated. Similarly, the MCA can be connected to two of the 14 scan points, and 27 communication channels operating at 188 bits per second can be accommodated. If the 7750 has only seven scan points, however, the MCA requires connection only to a single scan point to accommodate 27 communication channels operating at 188 bits per second or less.

The MCA operates with both the control storage of the 7750 and the communication channels on a bit-by-bit basis. It sequentially scans the communication channels, obtains bits one at a time from each channel, stores them in a buffer, and transfers them at the proper time to control storage. On output, the MCA takes bits one at a time from control storage, stores them in a buffer and, at the proper scan time for a particular channel, transmits the bits one at a time to the proper terminals. The transfer of bits between the MCA and control storage is by demand from the MCA.

An MCA can handle communication channels operating at different bit rates. Seven bit rates are possible

Communication Capability (Maximum Number of Channels)	
Low Speed (200 Bits per Second Maximum)	High Speed (1,200 Bits per Second)
0	16
1 - 56	8
57 - 84	4
85 - 112	4

Figure 6. 7750 Communication Capability

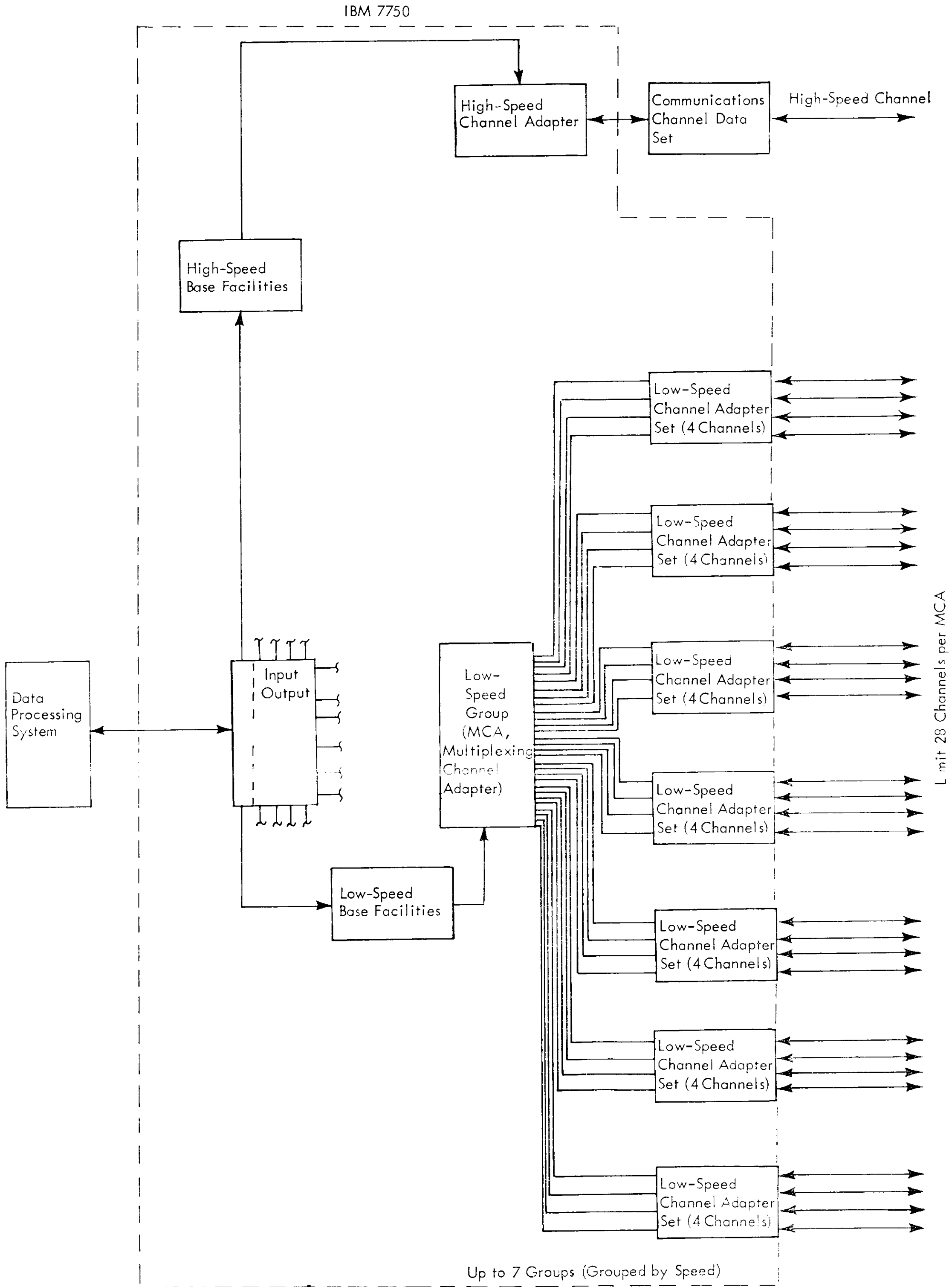

Figure 7. 7750 Communication Channels Configuration

in the configuration of low-speed channels, but the standard design recognizes only the three most widely used: 45, 56, and 75 bits per second. Other bit rates are available at the customer's request on an RPQ* basis.

High-Speed Channel Adapter Type 2 (HSA2)

The high-speed channel adapter type 2 connects a data set capable of handling up to 1,200 bits per second to one scan point, enabling the IBM 7701 Magnetic Tape Transmission Terminal to be connected to one scan point. An important feature of the high-speed channel adapter type 2 is that it may be connected to any IBM Synchronous Transmitter-Receiver (STR) device. That means that, using the STR, the 7750 may be connected to any data transmission equipment, such as an IBM 1009 Data Transmission Unit, operating at 150 characters per second.

In operation, the HSA2 accepts bits from the process control module and sends them to a data set at the proper time, serially by bit. It also samples the incoming data from the data set at a given time and transfers the bit serially to the process control module on demand by the process control module.

Data may be transferred by the HSA2 in one direction at a time (half duplex) or in both directions at a time (full duplex). In addition to data transfer operations, the HSA2 also performs the necessary control functions for proper operation of the data set, senses for certain error conditions, and indicates these errors to the 7750 when they occur. The HSA2 operates at transmission speeds of 600 or 1,200 bits per second.

* Request for Price Quotation.

Channel Operation

The communication channels of the IBM 7750 may be half duplex or full duplex. On half-duplex lines, information can flow in both directions, but only in one direction at a time (the channel may either send or receive data, but not simultaneously). Full-duplex operation requires a pair of communication channels operating concurrently, with one channel sending and the other receiving.

Communication channels may be shared by a number of terminals for greater system capacity and efficiency. In multiple terminal operation, some procedure must be used to determine when each terminal may have access to the channel. One method of controlling terminal access to a channel is called polling. With this method, a terminal may not use the channel until it gets permission to do so. The IBM 7750 grants this permission by sending the terminal a short control message. Each terminal and the 7750 use the channel in a programmed pattern. If an overload threatens, the 7750 can decrease the input rate and increase the output rate by modifying the polling pattern. Both half-duplex and full-duplex channels may be polled.

I =	15 10 5	12 6	14 7	16 8	9	10	11	12	13	14	15	16
N=	3 2 1	2 1	2 1	2 1	1	1	1	1	1	1	1	1
i=	5	6	7	8	9	10	11	12	13	14	15	16
n	b/s	b/s	b/s	b/s	b/s	b/s	b/s	b/s	b/s	b/s	b/s	b/s
17	420	348	298	261	232	209	190	174	160	150	139	130
19	376	311	267	233	207	187	170	155	143	133	124	116
21	340	--	--	211	--	169	153	--	130	--	--	105
23	310	257	220	193	171	154	140	128	118	110	103	96
25	--	236	203	177	157	--	129	118	109	101	--	88
27	264	--	188	164	--	131	119	--	101	94	--	82
29	246	204	175	153	136	122	111	102	94	87	81	76

-- Indicates invalid combination
I = Number of process control module scan points
N= Number of scan points to which an MCA is connected
i= I/N = Number of 7750 scan cycles between consecutive scans of a particular MCA
n= Number of low-speed channels connected to MCA
b/s= Bits per second maximum on low-speed channel with I, N, i, and n.

Figure 8. Multiplexing Channel Adapter Scanning Capabilities

The IBM 7750 Programmed Transmission Control must fit into a variety of IBM Tele-Processing system applications. For this reason, directing the 7750 to perform its communication control function in a Tele-Processing system involves special programming techniques. Some techniques used in programming are:

1. Techniques for table lookup.
2. Techniques for control and assignment of storage space.

Table Lookup

In the 7750, table lookup is the basic method for computation and data manipulation (addition, subtraction, code conversion, and so on). In table lookup operations, the desired outputs are arranged in tabular form and stored in the process storage. By using a combination of table lookup operations (using the output of one table lookup operation as input for a second lookup operation, and so on), the 7750 can execute relatively complex processes.

The 7750 can use table lookup for code conversion, error checking, arithmetic operations (addition, subtraction, counting, and so on), and branching.

One straightforward example of the table lookup technique is in code conversion. Suppose it is desired to convert data from the six-bit alphameric code (IBM 705 code) to the four-of-eight code used by the IBM 65/66 Data Transceiver. The first step is to select 64 consecutive character positions in process storage. The character address of the first character position must have zeros in the low-order six bits, for example, 002700_8. This area becomes the code translation table, and the location corresponding to each IBM six-bit character is obtained by substituting that character into the low-order six bits of the initial address of the table (Figure 9). Each line of the table is an IBM 7750 word.

The contents of each table location represent, in four-of-eight code, the character whose six-bit alphameric representation is the address of that location. Thus, when the character Q, with alphameric representation 101000 (BA8421) is used to address the table, the contents of the specified location 002750_8 are found to be 10 010 101 (1248RNX), which is the four-of-eight representation for that character.

Storage Allocation Control

In telecommunications, random and unpredictable data flow into and out of the central processor creates a need for flexible buffering. The 7750 Programmed Transmission Control is specifically designed to solve this problem. By proper programming of the 7750, the best buffering techniques for a specific telecommunications system can be worked out.

Blocks and Chains

In the IBM 7750, part of the process storage is used to store programs, tables, constants, and the like. The rest is used for buffering and the assembly and distribution of records being sent or received over the communication channels. The programmer determines how process storage is partitioned and used.

To partition the buffer space for the various channels, process storage is sectioned into blocks. In the 7750, a block contains 32 characters; the last character position is the block control character. The complete block of 32 characters is contained in eight sequential

Address First Character (Octal)	Contents of Storage Word			
	Low-Order Digit of Character Address			
	0/4	1/5	2/6	3/7
002700	/ 00 000 000	1 / 10 000 111	2 / 01 000 111	3 / 11 001 100
002704	4 / 00 100 111	5 / 10 101 100	6 / 01 101 100	7 / 00 010 111
002710	8 / 10 011 100	9 / 01 011 100	0 / 00 110 110	# / 10 001 110
002714	@ / 10 111 000	/ 00 000 000	/ 00 000 000	/ 00 000 000
002720	b / 00 111 100	/ 10 000 110	S / 01 001 110	T / 11 000 110
002724	U / 00 101 110	V / 10 100 110	W / 01 100 100	X / 00 011 110
002730	Y / 10 010 110	Z / 01 010 110	= / 11 111 111	' / 11 010 010
002734	% / 10 100 010	/ 00 000 000	/ 00 000 000	/ 00 000 000
002740	- / 00 110 101	J / 10 001 101	K 01 001 101	L / 11 000 101
002744	M / 00 101 101	N / 10 100 101	O / 01 100 101	P / 00 011 101
002750	Q / 10 010 101	R / 01 010 101	0 / 00 001 111	$ / 11 010 001
002754	* / 10 110 001	/ 00 000 000	/ 00 000 000	/ 00 000 000
002760	& / 00 110 011	A / 10 001 011	B / 01 001 011	C / 11 000 011
002764	D / 00 101 011	E / 10 100 011	F / 01 100 011	G / 00 011 011
002770	H / 10 010 011	I / 01 010 011	+0 / 01 110 010	. / 11 010 100
002774	/ 10 110 100	/ 00 000 000	/ 00 000 000	/ 11 111 111

Figure 9. Code Conversion by Table Lookup

words. Each character in the block has a 16-bit address. The address of the characters runs from 0 to 31; the 32nd character is actually character position 31.

Each character address is divided into three parts. The eleven high-order positions represent the block address, which is identical for each 32 characters of the block. The next three bit positions represent the word address (the address of one of the eight words within a block), and the low-order two bit positions contain the address of the character within each word.

Blocks may be located anywhere in storage as long as the first character begins in a character location whose address has all zeros in the low-order five bits. The end location, unlike the first thirty-one, does not contain a data character; it contains the address of the next block to be chained (block control character).

BLOCK RECOGNITION

When the 7750 is storing a character from a communication channel into process storage, or reading out a character from process storage into a communication channel, the address in the channel word is incremented on every character-interrupt cycle. This insures that successive characters are stored into or read out from successive character locations in process storage. The 7750 will continue to store or read out characters without interrupting the program until the address in the channel word is incremented to a number containing all ones in the low-order five bits; this is the location of a block control character and data from the communication channels cannot be stored in this location.

When the end of a block is reached, the 7750 requests channel service by putting the address of the channel word in the channel service register and setting the channel service mode request bit. When the request for channel service program is recognized as highest in priority among the requested modes, the channel service mode program is executed and assigns a new input block to that channel by changing the address of the channel word. If the channel is receiving data, the space is an empty block; if the channel is transmitting, the block contains the data next in sequence. The channel service program must cause the 7750 to leave channel service mode. The 7750 will then automatically, without further program guidance, move 31 characters in succession. Then, it will call for channel service to be told where to go next.

Similarly, the copy mode process word also automatically recognizes blocks. It will move characters to or from the central processing unit. Each character-moving operation increments the address by one until the low-order five bit positions contain all ones. At this point, it automatically transfers the contents of the block control character from the process storage to the high-order eleven bits of the address of the copy mode process word, and sets the low-order five bits to zero. Regardless of the direction of data flow, therefore, the copy mode process word must refer to an existing chain.

The normal mode also has the ability to recognize the beginning or end of a block during data processing operations. In this case, however, the recognition is not automatic as in the previous two modes; it must be programmed by a character-moving instruction that includes a skip. If the indirect address of the instruction executed has all ones in its low-order five bits, the program executes the next instruction in sequence. If the low-order five bits are not all ones, the second instruction in sequence is executed. Thus, when processing full blocks, 31 skips are effected and on every 32nd time, the next instruction is executed.

CHAINS

To process messages of arbitrary length, some method must be provided for assigning portions of storage to records. Furthermore, because this assignment must be made as the message is stored, the blocks of storage put together to make a single arbitrarily long record do not come from adjacent locations in storage. These blocks are connected in an orderly manner, however, and may be manipulated as a unit. Such a unit of data is called a chain.

In the 7750, the procedure for connecting the blocks uses the block control character to designate the next block in sequence. Each block is assigned a unique number that consists of the eleven high-order bits in the 16-bit address location of the characters in the block. The address of the next block in the chain is contained in the last character position of the previous block.

Figure 10 illustrates how blocks are chained together for record storage. Suppose the first part of a message is being stored in block 123. When a channel reaches the end of this block, it requests channel service in order to obtain an empty block for further storage of the message. The channel service program finds that block 671 is available and directs the channel to begin loading into this block. Finally, it chains block 671 to 123 by inserting, in the control character location of block 123, the number 671. Later, after the characters in block 123 are processed, the program looks in the control character to find that 671 is the next block in sequence. It then processes that block. A chain may be as long as there are blocks in storage.

If the chain is to be a message storage area, it is not sufficient to know only how to go from one block

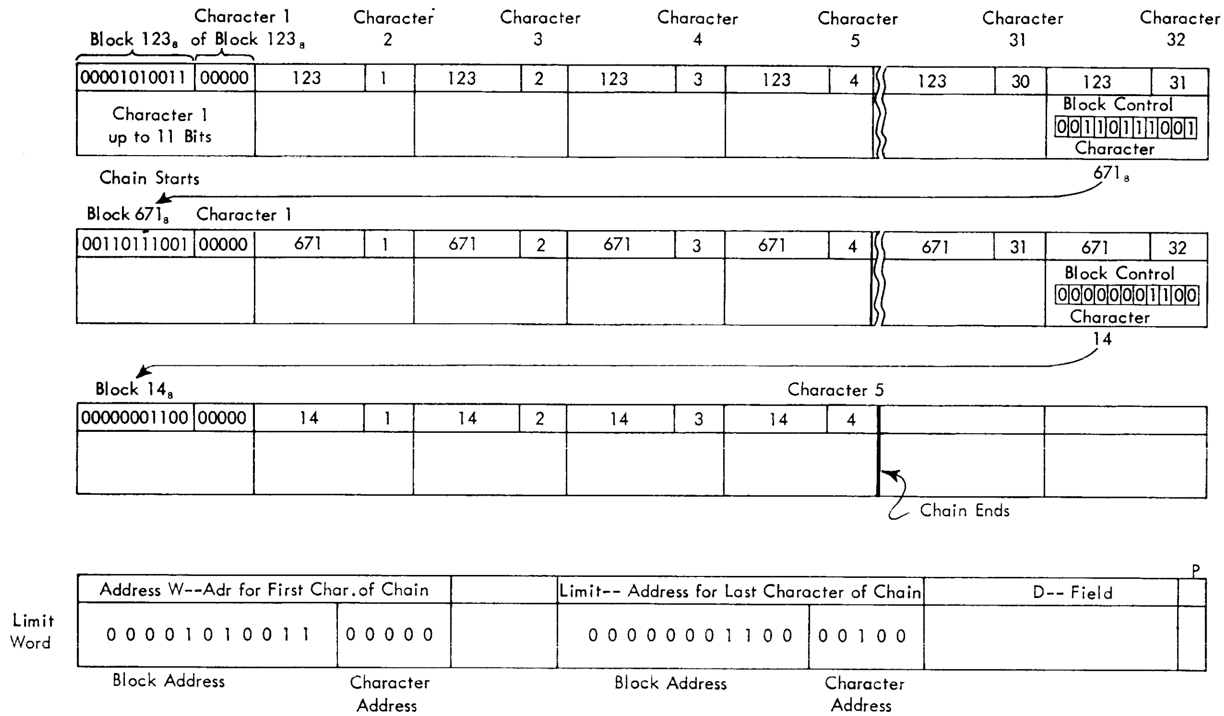

Figure 10. Block and Chain Control

to the next in the chain. One must know exactly where each chain begins and where it ends. A chain usually begins at the beginning of a block but does not necessarily end at the end of a block. For this reason, the beginning and the end of chains must be specifically identified. This is done by the limit word, which is the control word for a chain.

The limit word has both an address field and a limit field and may be stored in any word in the 7750 process storage. The address field designates the first character of the chain and the limit field designates the last character of the chain. The chain controlled by the limit field may be located anywhere in storage.

The limit word is usually stored in a location corresponding to the function of the chain as a storage element. For example, the limit word for controlling the chain for storing unprocessed data from channel 3 might be stored in word address 3; the word controlling the chain for processed but incomplete data for that channel might be stored in word address 103; and the word controlling the chain of outgoing data for that channel might be in 203.

To understand the use of chains and limits in the IBM 7750, look at the fundamental processes in the 7750 as shown in Figure 11. Message storage areas are shown as rectangles, and the data flow through them

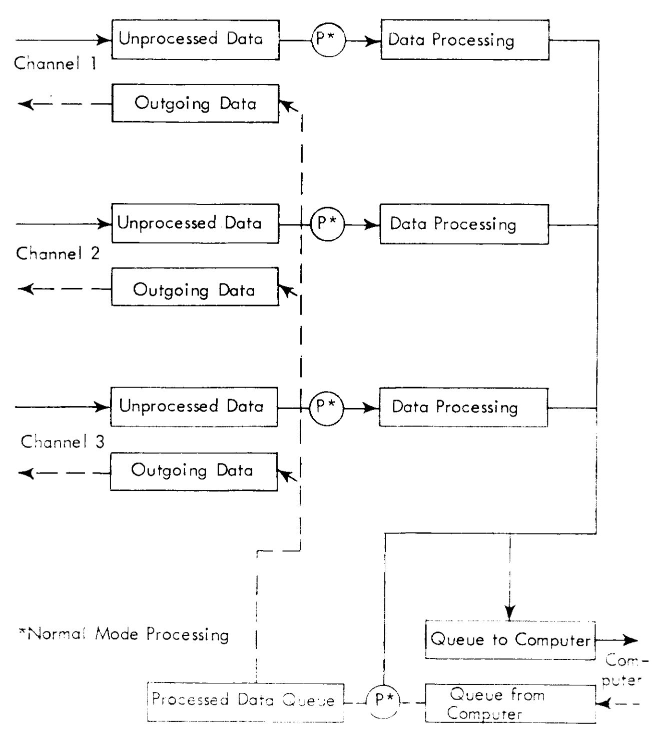

Figure 11. Queuing

is shown by arrows. Channel 1 feeds unprocessed data into a storage area; the data wait here until the normal program process (P) comes around and processes each character—in sequential order—by testing it for errors and for a functional code, translating it, and so on.

As each character is processed, it is placed in another storage area where it waits until a complete message is received. When a complete message is received, it is transferred to a queue of messages waiting to go to the computer. The programmed process moves from one channel to another, processing all received data. It then finally processes all data from the computer, transferring processed, complete messages to the outgoing queues for the appropriate channel.

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International Business Machines Corporation
Data Processing Division
112 East Post Road, White Plains, New York

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