# Reservations Communications Utilizing a General Purpose Digital Computer

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THIS paper describes a communications system developed for the purpose of establishing communications between a general purpose digital computer and a large number of employees whose work requires frequent and immediate access to the services of the computer. The communications system is, to a degree, "general purpose" in nature; however, in the specific application to be described, the system will be used by airline employees in communicating with a computer which is engaged primarily in processing airline reservations data.

An over-all view of the system may be obtained by reference to Fig. 1. The rectangular area at the top of the drawing represents the common location of those portions of the system symbolized there, including the central computer. In the lower right-hand portion of the drawing, a smaller area represents a typical location remote from the computer. The remaining portion of the drawing contains a brief legend for later reference; it may be disregarded at this time.

Referring again to the upper portion of the drawing, the group of small circles to the left represents a large quantity of units called "agent sets." The agent set is the primary communications device through which the individual employee transmits and receives information. This device will be described quite completely later. At this point, it is only important to note that messages to be transmitted are formed by a combination of actions including the pressing of buttons and the operation of other controls. Messages received by the agent set are displayed in the form of illuminated signs or signals.

To the right of the agent sets, the block labeled HSPS represents a group of units called high-speed programmer scanners, which perform the following functions.

1) They provide service, sequentially, to agent sets which have complete messages ready for transmission.
2) They establish the sequence in which the characters of the message are transmitted and cooperate in the transmission of messages at the rate of 200 characters per second.
3) They receive reply messages from the computer and translate the replies into selective illumination of signs or signals on the agent set, causing the illumination to persist until retired by a specific manual operation at the agent set. This latter activity does not totally occupy the programmer scanner which proceeds immediately to serve the next agent set after translating the reply for the first.
4) They perform parity check and character count check on received messages. Upon recognition of error, the programmer scanner causes repetition of the reply. If the second reply is error-free, normal operation is resumed. If the error persists, the programmer scanner will cause an appropriate sign to be illuminated on the agent set. Depending upon the nature of the input message, the agent set will display a sign reading ERROR or a sign reading RESET.

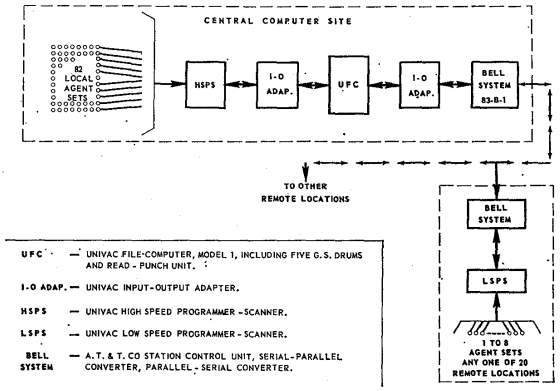


Fig. 1.

Continuing to the right on the diagram, the next box represents a unit called "input-output adapter." This unit relays messages between the high-speed programmer scanners and a section of the computer which we shall call the "message box." The loading and unloading of the "message box" by the input-output adapter is independent of the processing functions of the computer.

The input-output adapter loads the message box and then notifies the computer to that effect. The computer subsequently processes the message, deposits a reply in the message box, and notifies the input-output adapter. The adapter immediately relays the reply back down the line to the agent set.

The input-output adapter also checks parity and character count, notifying the computer when an error is observed. Error notification to the computer is used to make appropriate modification to the program.

The entire communications process just described occupies a period of time ranging from 90 to 125 msec depending upon the nature of the input message. This figure does not include processing time in the computer which will range from about 100 msec to slightly more than one

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second. Most input messages will be processed by the file computer in less than 250 msec.

Referring again to Fig. 1, the large box labeled UFC is, of course, a representation of the Univac file computer. Although only one box is shown on the diagram, the computer system will be composed of approximately a dozen large equipment cabinets. The system will include five magnetic drums having a storage capacity of 900,000 alpha-numeric characters. The storage system is capable of expansion to thirty-three drums having a storage capacity of nearly 6,000,000 characters.

At this point it is appropriate to call attention to the fact that so far we have been referring to a communications system which is wholly contained on our premises. The greatest distance intervening between an agent set and the file computer is not likely to exceed 300 feet. Let us now direct our attention to the communications system which serves agent sets at remote locations.

Referring now to the lower right-hand portion of Fig. 1 we note that the area represents "any one of 20 remote locations." These locations may be as far distant from the computer location as one chooses to think, whether it be one mile, a hundred miles, a thousand miles, or more. The only requirement is that the remote location be capable of being connected to the computer location by a dependable telegraph circuit.

The limit of twenty remote locations is established by choice. Up to forty remote locations may be served by one telegraph network of the type referred to herein.

If we follow the path between the remote agent sets and the Univac File Computer we note that the labels in two of the boxes are somewhat familiar. At the top end of the path next to the computer we find an input-output adapter. This unit performs essentially the same functions as the other unit of the same name. The essential difference is that it contains a few relays which are required to compensate for the lower speed of communication.

At the other end of the path, we see a box labeled LSPS which represents one unit named "low-speed programmer scanner." This unit performs essentially the same function as the high-speed programmer scanner including parity checks and character count. In the case of this unit there is not only a difference in speed of operation but, as the diagram indicates, one unit serves a maximum of eight agent sets. Although the unit is capable of operating speeds up to 20 characters per second, it is limited by the speed of the telegraphic equipment which is, in this case, 10 characters per second.

A feature of the low-speed programmer scanner is the ability to operate two such units as a single unit with a capacity to serve as many as sixteen agent sets. Doubling of units in this manner does not change the appearance to the telegraph network.

As indicated on the diagram, the telegraph network is leased from the Bell System. The Bell System in this case is represented by the A.T.&T. Company which operates most of the intercity circuits of the Bell System. The basic system is called "83-B-1 Selective Calling System;" in this application it is modified for use with the Univac File Computer.

A complete description of this system is beyond the scope of this paper. However, the principal characteristics of its operation will be evident in the following description of a cycle of operation.

The elements of the 83-B-1 system in this application are a "control station" located at the central computer site and a number of "station control units"—one at each remote location.

The "control station" initiates a continuous series of events by transmitting a particular set of two characters which are received by all of the station control units. This set of two characters is referred to as a "start pattern." One, and only one, of the station control units recognizes this particular set of two characters and responds in one of two ways. If the associated low-speed programmer scanner has *not* indicated a need for service, the station control unit transmits one particular character which when received at the "control station" causes that station to transmit a different set of two characters; *i.e.*, a different start pattern, thus directing a different remote station to respond.

If the low-speed programmer scanner *has* indicated a need for service, the station control unit transmits characters submitted to it by the low-speed programmer scanner. The characters submitted by the LSPS are, of course, those which are represented by the position of the controls on the particular agent set which is then being served. Should the "control station" fail to receive a reply of either type, audible and visual alarms will be set off at the control station location.

At the completion of this transmission the telegraph network becomes idle until the control section of the File Computer tells the input-output adapter that a reply message is ready in the "message box." The control station transmits the characters submitted to it by the input-output adapter, thus completing the two-day communication.

If a second agent set at the remote location is awaiting service at this time, its message will be transmitted after a delay ranging from roughly 50 to 150 msec. The amount of the delay is determined primarily by the relative positions of the two agent sets in the fixed service sequence. As the number of sets requiring service increases, this delay decreases.

When each of the active agent sets at a particular location has been served once, the low-speed programmer scanner submits for transmission a particular set of two characters, which are then transmitted by the station control unit. The control station at the central computer location responds by transmitting a start pattern for a different remote station.

When all of the remote stations have been served, the control station begins a new cycle without delay and the process continues without interruption until the hour arrives for the start of daily maintenance procedures at the computer center.

The telegraph system in this application will be operated at the nominal speed of 100 words per minute or approximately 10 characters per second. The system includes protective features which supply visual and/or audible alarms in the event of various types of failures which may occur.

Having completed the general description of the communications system, attention may now be directed to a more detailed examination of a most remarkable piece of communications equipment—the agent set.

Fig. 2 is a photograph of an agent set. The predominant feature of this unit is a photographic projection system in which a light beam is passed through a single frame of a conventional 35-mm film projecting the image of the film on a viewing screen on the upper panel of the agent set. Each frame of film is precisely mounted in a holder two inches square. A cartridge containing thirty holders, *i.e.*, thirty pictures, fits loosely in a tunnel, the opening of which is visible at the lower right-hand corner of the agent set.

A rack of teeth along the edge of the film cartridge engages a pinion gear controlled by a knurled wheel visible along the right edge of the lower panel. The top of the film cartridge contains an index which is visible to the operator of the set.

Therefore, a selection of thirty images is immediately available to the operator. Additional groups of thirty images may be referred to quickly by removing one film cartridge and inserting another.

The cartridges incorporate a simple locking mechanism which prevents accidental removal of individual film holders. The potential difficulty associated with spilling and subsequent faulty rearrangement of the file is thus avoided.

On each individual film, a narrow strip along the right edge and a narrow strip along the top are reserved for digital coding in a five-channel code. These strip areas are appropriately divided into three discrete areas each of which in turn is divided into five areas. Each of the five areas is made black or clear white to represent binary "1" or binary "0." Thus, there is created the means for specifically identifying any one of a thousand images, assuming the identification system is based on the decimal system.

After a film slide has been selected by reference to the index and by operation of the knurled wheel, a slide lever is moved to the left, causing the projection lamp to be lighted and the selected film to intersect the resultant light beam. In addition to the image which appears on the screen, a pattern of light described by the coding along two edges of the film is impressed on fifteen light-sensitive elements located behind the upper panel bordering the viewing screen. The condition of these elements is subsequently sensed by the programmer scanner to transmit a specific set of three digits to the computer.

All other information transmitted from the agent set is obtained by sensing the five contacts of the buttons which have been depressed. Each button is one of a particular set; the button supplies the decimal information in

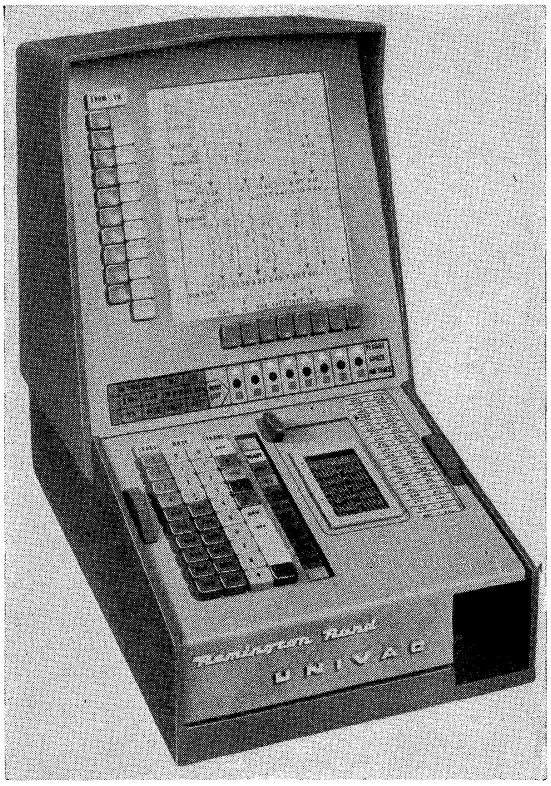


Fig. 2.

five-level code while the identity of the set of buttons is retained by virtue of the position of the digit in the total message. Mechanical interlocks prevent the selection of more than one button of a set.

A system of electrical interlocks prevents the agent set from attempting to establish communication if any of the required elements of a message have not been entered.

Before referring to the next illustration, note that there are two sets of buttons along the left edge of the viewing screen and one set of buttons along the lower edge.

Refer now to Fig. 3, which is an example of an image which might appear on the screen of the agent set in our application of airline reservations.

An employee wishing to inquire about the availability of two reservations from New York to Houston would have selected this slide. The employee would then enter the set of buttons meaning FROM and push the particular button to the left of the words NEW YORK, and next, the TO button opposite the word HOUSTON and other buttons specifying month, day, number of seats, and type of transaction.

No further manual operation is required to code this message, gain access to the communications circuit, transmit the message, consult the records, prepare a reply, transmit the reply, receive it, decode it, and display the answer in front of the agent. Yet the entire operation takes place in less time than it takes to describe it.

The answer to an inquiry of the type illustrated covers the availability of all flights represented in the horizontal

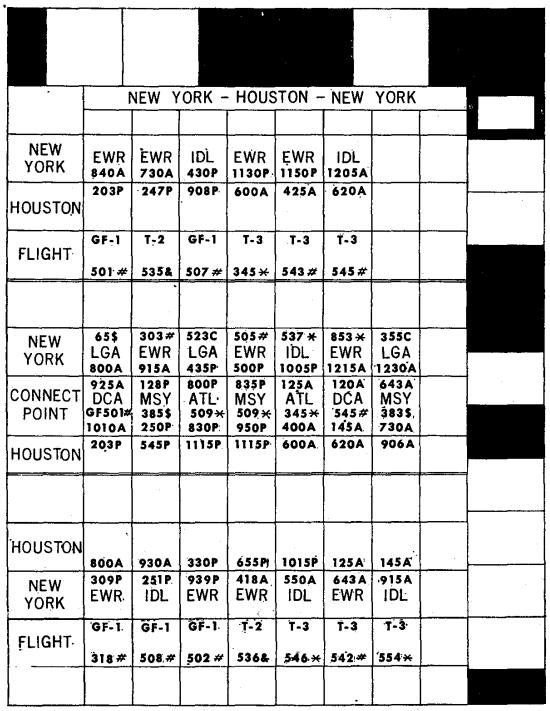


Fig. 3.

columns corresponding to the FROM, TO buttons selected.

Referring back now to our picture of the agent set, Fig. 2, attention should be directed to a long rectangular area near the bottom edge of the upper panel. In this area are located the twenty-eight individual signs or signals which may be illuminated to provide a direct answer or to signify an answer to an inquiry.

The twelve lamps to the left, arranged in three rows and four columns, are individually controlled and provide back illumination to words or phrases which, in the airline application, constitute the range of replies to inquiries concerning estimated time of arrival or departure of the flight specified in the input message.

The sixteen lamps to the right are arranged in eight pairs, each pair corresponding with one of the buttons immediately above it and thus corresponding with the flight which appears in that column on the viewing panel. Each pair of lights may have one of three acceptable conditions of illumination which represent one of three conditions of availability; *i.e.,* available, not available but expected to become available, not available and not expected to become available. The fourth possible condition, which is both lights not lighted, is not an acceptable condition and is interpreted as evidence of malfunction.

Near the center of the bottom panel, just to the right of the four columns of buttons, nine lamps provide back illumination for an equal number of words or phrases which supply verification or instructions to the operator.

In addition to the words ERROR and RESET previously referred to, there is one other instruction word, WAIT. Illumination of the WAIT sign informs the operator that transmission has started. This sign remains on until a reply is received.

The set is used by the airline employee to adjust the central inventory when reservations are made or cancelled or an auxiliary inventory may be adjusted to reflect unsatisfied demand. Each such transaction is verified by illumination of an appropriate sign in this bank.

Unfortunately, time does not permit description of the intended expansion of the system. Much of it can be deduced from the communications capabilities described. Widely separated File Computers can communicate with one another through their "message boxes" and much simpler teletype networks than the 83-B-1.

An accessory now under development will establish an interlocking relationship between a specific punched card record and a specific agent set transaction.

An accessory available immediately will provide discrete identification of the agent set, thus opening the door to measurement of employee effectiveness and other useful benefits.

Credit for the development of this system is due to the many individuals in Remington Rand Univac, A.T.&.T. Company, and Eastern Air Lines, Inc. who cooperated with one another so magnificently to convert ideas to reality.

## Discussion

**Mr. Johnson** (Adalia Limited): What is your specification on error rate, and how much redundancy have you found it necessary to add to achieve this specification over leased communications lines? What error correction and detection facilities are provided in the remote agent set system?

**Answer:** The agent set and its associated programmer scanner cooperate to reject attempted transactions which omit needed data. For example, if an agent should attempt to book space on a flight without specifying the number of seats, an indicator on the agent set would be lighted reading RE-ENTER. The message would not proceed further than the associated programmer scanner, thus avoiding waste of valuable communications and data-processing time.

We use a five-channel code in transmitting input and output messages between the agent sets and the input-output adapters. The four low-order channels are used to form an "excess-three" binary code which is identical with the four low-order channels of the Univac seven-level code. The fifth level is a checking level in which a binary "1" is stored or not stored so as to form a character having an odd number of bits. A parity check is performed on the receiving end of each interunit communication.

Upon recognition of a parity error, appropriate action is taken depending upon the stage at which the error becomes apparent. Generally, the agent set signals RE-ENTER when no inventory adjustment was likely, or ERROR when there was a possibility of inventory adjustment.

**Question:** If error is indicated on the agent set in a remote area, is the agent able to determine from the nature of the error indication whether the error occurred in the equipment in his remote area or in the central computer?

**Answer:** The agent set has two back-illuminated signs reading RE-ENTER and ERROR, respectively. In normal operation, the agent's entry of a transaction is fol-

lowed by illumination of a sign reading WAIT. This informs the agent that his message has been transmitted from the programmer scanner on to the next stage of communication, whatever that might be. However, if the agent omits some necessary portion of the message, the WAIT sign does not light; instead, the RE-ENTER light comes on immediately and thus the agent knows that he has erred. A RE-ENTER light following a WAIT light is indication to the agent that one of several conditions has occurred; the system has detected a parity error at some stage of the process which cannot cause erroneous adjustment of inventory, or the agent has attempted some nonvalid operation such as entering the date JUNE 31, FEBRUARY 30, entering a date November 21 while using a film slide for a flight schedule which expires November 15, etc. An ERROR sign will be lighted only when the following conditions coincide: the transaction involved is one which is intended to adjust inventory and the message has reached the computer; the reply reaching the programmer scanner contains either a parity error or an insufficient number of characters, and this is the second erroneous reply received at the programmer scanner (it having requested a repeat when it received the first such reply).

Communications circuits provided by the communications companies will be equipped with alarms and signals which will provide information regarding cetrain types of circuit failure. These alarms and signals will be available to the agent or, in the case of large installations, to the supervisory personnel.

**Question:** In the midst of all this wonderful development, is there some way to get Eastern and other airlines to answer their telephone when one calls for a reservation?

**Answer:** We believe that he development and application of equipment here under discussion is one way to come more near the fulfillment of the objective of the management and employees of Eastern; that is, to serve our actual and potential customers to their complete satisfaction. It may be of interest to you to know that this objective is continually presented to all employees because every paycheck has clearly printed on it, in very large red letters, "The customer pays our wages."

**Question:** When a cancellation is received on a flight which had been filled, what is done to insure that the seat is first made available to those on the waiting list rather than to the next agent who happens to request the fight?

**Answer:** This question, and the answer, exemplify one of the reasons we chose to employ a general purpose computer. The computer will store not only an inventory of seats, it will also store the number of unfilled requests for seats, *i.e.,* the waiting list. As each cancellation is received, the computer determines whether there are any unfilled requests; if there are unfilled requests, the cancelled space is reported out immediately on a punched card which is then routed to the position where the waiting list is held.

**Question:** Is there some provision for using the file computer on other problems during the night or at times when the computer is not ordinarily busy?

**Answer:** At the present time we are not planning such use during the busier hours of the day because we have yet to learn how much spare time will be available. However, assuming available computer time, there is no reason why such use should not be made. The equipment is capable of such operation. We plan to use it at night in slack hours to develop statistical data from the inventory during the same hours when it is still serving agent sets.

**Question:** If a flight leg can occur on several different routings, does the agent have to check several plates?

Is not the agent set itself able to store information received? Also information requested?

**Answer:** Some definition of terms is necessary to avoid misunderstanding. A "leg" is defined as that portion of a flight from take-off to the next point of landing. A "segment" is defined as that portion of a flight which lies between the boarding point and the deplanting point of a particular passenger. A "flight" is the operation of an aircraft from the point where it is identified by a particular flight number to the point where it is no longer identified by that same number. Within these definitions, the question is best answered by stating that the agent never has to check more than one film slide to obtain the desired information on any flight leg or on any flight segment. If a passenger's itinerary involves more than one flight, it may be necessary to refer to a maximum of one slide per flight.

So long as the keys on an agent set are depressed, the information so represented is available to the programmer scanner. And, of course, the film slides store a great quantity of information. When an answer has been displayed on an agent set, that answer is continuously available until the agent "clears" the transaction key or operates the lever to restore the film slide in the magazine.

**Question:** How long does it take for the two-character start pattern to reach a remote station?

And, can a busy remote station's agent sets be served more than once in a given recognition cycle?

**Answer:** The time will be dependent upon the traffic situation at any given time. Under a "no traffic" condition each remote station will be polled once every five seconds, making the average access time two and one-half seconds. This answer refers to the 83-B-1 ten-character per second system, with twelve remote stations.

The agent sets at a given remote station can be served only once during a given "recognition cycle." When more than one set is served on the same poll, the average access time is correspondingly reduced.

**Question:** Is the information from the local agent sets transferred to UFC through the HSPS and IO adapt in a serial or parallel mode?

And, where are the messages from the remote agent sets buffered? What is the capacity of the buffers and how many buffers are there?

**Answer:** In serial.

For the purpose of this question, the remote agent sets should be considered to be grouped so that all agent sets served by particular input-output adapter are in a common group. Within such a group, agent sets are served sequentially; thus, each agent set stores its own message until it is served. Each input-output adapter stores the message it is then handling on to a portion of one track of the high-speed drum in the UFC. When the UFC tests the input-output adapter and receives a reply that there is a message waiting, the UFC processes the message, stores the reply in an unused portion of the same track, instructs the input-output adapter to take the reply and begins testing other units to see if there is work waiting to be processed. At the outset, we will be using two input-output adapters (therefore, two buffers) for agent set work. Other tracks on the high-speed drum will act as input-output buffers for the electric typewriters and the read-punch unit.

**Question:** Is there any provision for expanding the system to handle reservation names as input—printed output—ticketing, et cetera?

And, how many agent sets, total, can one system handle and still provide satisfactory service?

**Answer:** Initially, we plan to have the read-punch unit produce punched cards containing the reservation details. These cards will be matched with similar cards first written by the agent and then keypunched. This process will detect errors of many kinds. Although there has been considerable reflection and discussion regarding extending into the ticketing area, it would be an exaggeration to say that such provision has been made.

The answer is entirely dependent upon the average handling time of the transactions at each of their various stages, and the speed of service which is considered "satisfactory." At the present time there is not sufficient information available regarding the "mix" (relative quantities of various types of transactions), nor is there available information of sufficient accuracy regarding the handling times. Because of this uncertainty, we have (we believe) deliberately underloaded the system for our initial application in order that we may safely collect the information necessary to plan intelligent expansion.

**Question:** What developments are there for storing passenger identification for preparing lists to be checked against later ticket purchase?

**Answer:** The answer to a previous question partially answers this one; that is, the comparison of computer produced punched cards with the manually written and keypunched cards. Ticket purchases will be related to the keypunched cards (now audited for comparison with inventory) for verification. When reservations are made at the time of ticket purchase, the computer produced card (produced