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ABSTRACT

The signalling conventions to be used by AAEC network computers communicating with the IBM360 computer are detailed and discussed.

Provision is made for the temporary relinquishing of intermediate computer to computer links during such communications, and a local path command retry facility is made available.

The signalling conventions presented are recommended for general AAEC computer network use.

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The following descriptors have been selected from the INIS Thesaurus to describe the subject content of this report for information retrieval purposes. For further details please refer to IAEA–INIS–12 (INIS: Manual for Indexing) and IAEA–INIS–13 (INIS: Thesaurus) published in Vienna by the International Atomic Energy Agency.

COMPUTER CODES; DATA TRANSMISSION; IBM COMPUTERS; MAGNETIC TAPES; PDP COMPUTERS; SIGNALS

CONTENTS

1. INTRODUCTION

The AAEC computer network has been designed to enable a number of small to medium size computers, situated within a half mile radius of an IBM360/50 computer installation, to call upon the facilities of the central computer (Richardson 1971).

The computer network consists essentially of two parts:

(i) A high capacity path, or Dataway, interconnecting all computers other than the central computer (Ellis 1970),

and (ii) A broad-band link between a PDP9L computer attached to the Dataway and the IBM360 central computer (Richardson 1969).

Up to 128 different devices or destinations may be accessed by the IBM360 computer through the IBM360 – PDP9L link. The PDP9L computer controls the signalling and buffers the data transfers between the IBM360 and these destinations, all of which appear like standard IBM360 control units and attached devices to the IBM360 computer.

The Dataway is essentially a party line. Any two computers attached to the Dataway may communicate with each other. Teletypes and other one-byte buffered peripheral devices may also be attached to the Dataway, but each such attached device may only communicate with a single nominated Dataway controlling computer.

Eight bit destination addresses are used throughout the network. Network destinations accessible to the IBM360 computer each contain a 1 in their second address bit positions. Each Dataway computer is allotted a range or ranges of destination addresses to which it will respond. Usually, addresses allotted to a particular computer differ only in their low order address bit positions. The all-zero low order bits address is used to refer to the computer itself. The remaining addresses within an allotted range are used to refer to devices attached to the computer.

Devices attached directly to the Dataway are allotted addresses whose first two bit positions are zero. The same address, except for a 1 in the first bit position, is allocated to the range of Dataway addresses recognised by the device's controlling computer. These two addresses are then used by the device and controlling computer in communicating with each other. Devices attached directly to the Dataway are thus not directly accessible from the IBM360 computer.

Three distinct phases are in general associated with each transfer of data over the Dataway: an Initial Selection sequence, a Data Transfer sequence and an Ending sequence.

During an Initial Selection sequence, the originating computer or device must communicate with its desired destination, notifying the desired operation and also its own address if the destination is a computer.

Whether or not any data transfer takes place, the originator needs to know the outcome of the requested operation. If any data transfer occurred, the destination also needs to know the success or otherwise of the requested operation. This exchange of ending status information constitutes an Ending sequence.

The Initial Selection sequences and ending status conventions to be used by network computers communicating with the IBM360 computer through the PDP9L Dataway computer are given in this report.

2. NETWORK STATUS AND THE CONCEPT OF A SENSE CODE

The IBM360 computer requires all attached control units to maintain up-to-date status and sense information bytes. The IBM360-PDP9L link appears as a control unit to the IBM360 computer, and the PDP9L computer maintains status and sense information for all IBM360-PDP9L link addresses.

IBM360 device status consists of an eight bit byte with the following bit position meanings:

bit 0 : ATTENTION

1 : STATUS MODIFIER

2 : CONTROL UNIT END

3 : BUSY

4 : CHANNEL END

5 : DEVICE END

6 : UNIT CHECK

7 : UNIT EXCEPTION

For the purposes of the IBM360 operating system software, all accessible network destinations have been designated 7-track magnetic tape units. Table 1 lists all possible magnetic tape operations, their command codes, and the ending statuses expected by the IBM360 computer at the normal, successful conclusion of each operation. In some cases, such as forward space file, two separate ending statuses are expected: one as soon as the request is interpreted, and a second when the operation has been completed.

Certain exceptional conditions may arise during magnetic tape operations. Whenever an end of file or tape mark is encountered during read, read backwards, forward space record, or backward space record operations; and whenever a write or write tape mark operation is performed in an end of tape region, UNIT EXCEPTION status replaces the corresponding normal ending status. Whenever an error is detected during an operation, or if a device is unable to perform the requested operation, UNIT CHECK status replaces the normal ending status. BUSY status is returned if the addressed device is busy. STATUS MODIFIER accompanies BUSY status if the control unit itself is busy.

In addition to status information, the IBM360 computer requires control units to maintain a detailed record of the current state and capabilities of each attached device, together with the reasons for any immediately preceding UNIT CHECK indication. This information is called sense byte information, and is available for reading at any time by IBM360 sense commands. From one to 24 bytes of sense data are stored for each device, depending on the type of device. 7-track magnetic tape control units maintain six sense bytes for each attached device.

With 128 different network destinations accessible to the IBM360 computer, it would not be feasible for the PDP9L computer to store separate sense bytes for each address. A set of fifteen different six byte sense strings has been chosen to represent the major magnetic tape unit states, and pointers to these sense byte strings are maintained for each of the 128 different network destinations. A four bit sense code is used in selecting the desired sense bytes string pointer. Table 2 lists these fifteen standard sense codes and their sense bytes interpretation. Full network status may thus be represented by 12 bits of information: a four bit sense code and an eight bit status byte.

Network status is signalled during Dataway ending sequences, and is right – justified within the Dataway ending status word. It is not normally necessary for network destinations to include a sense code with the ending status, as the PDP9L can usually deduce the appropriate sense code from the status byte received and the current IBM360 command. An explicit NOT READY sense code may be specified by including at least one non-zero bit within the four bit positions adjacent to the zero four bit sense code and the eight bit status byte.

3. PDP9L COMPUTER DATAWAY INITIATIONS AND RESPONSES

The PDP9L computer may initiate any Dataway command on behalf of the IBM360 computer except the commands TEST I/O, NOP-CONTROL and SENSE. These three IBM360 commands are always processed entirely within the PDP9L computer, and are never passed on to the rest of the network.

TEST I/O is used within the Dataway to request the status of another network address. The last network status sent to the interrogating address should be re-sent if possible, otherwise an all-zero status should be returned if the destination is now in ready state. The PDP9L assumes a sense code 1 in this case. If the interrogated address wishes to appear not ready, either no response is made or UNIT CHECK alone is returned. No Data Transfer sequence occurs with a TEST I/O command.

NOP-CONTROL is used within the Dataway to send current status to another network address. No Data Transfer sequence occurs with a NOP-CONTROL command.

SENSE is reserved for future use within the Dataway.

The PDP9L computer responds to TEST I/O and NOP-CONTROL commands addressed to 40 hexadecimal from any Dataway address. Under certain conditions, the PDP9L computer will also respond to commands derived from the last PDP9L command issued to the currently requesting address. The PDP9L computer will also respond to WRITE (5) commands addressed to 40 hexadecimal. An immediate illegal command response: UNIT CHECK with a sense code F, is returned to every other command addressed to the PDP9L computer. The PDP9L computer device addresses 41 to 47 always appear not ready. Immediate UNIT CHECK ending status is returned to every Initial Selection sequence addressed to these devices.

A network computer may request IBM360 facilities by issuing a WRITE (5) command addressed to the PDP9L computer on address 40 hexadecimal, followed by a transfer of up to 24 bytes of indicative data to the PDP9L. The PDP9L then passes this indicative data, together with the requestor's address, to the IBM360 computer which may then initiate appropriate read and write sequences to the network.

Three responses may be made by the PDP9L to a WRITE (5) request. CHANNEL END, DEVICE END at the conclusion of the indicative data transfer is the normal response. UNIT CHECK signalled after the data transfer implies a DATAWAY error, and no further action is taken by the PDP9L. The requesting computer must re-issue the WRITE (5) request. A BUSY response means that a previous WRITE (5) request from the same originating computer has not yet been transferred to the IBM360 computer. Three courses of action are open to the originating computer. CHANNEL END, DEVICE END status returned to the PDP9L computer will allow the previous WRITE (5) request to continue. ATTENTION status returned to the PDP9L computer will re-activate the previous WRITE (5) request. UNIT CHECK status returned will cancel the previous request. A STATUS MODIFIER, BUSY response means that the PDP9L cannot currently accept the WRITE (5) request. The PDP9L computer will issue a TEST I/O to the requesting computer when free to accept WRITE (5) commands.

When an IBM360 command is issued to a network computer through the PDP9L, the required data may not be immediately available. Although the IBM360 selector channel must remain occupied until the conclusion of the requested data transfer, it is not necessary to retain the Dataway connection during the whole of this waiting period. A Dataway time-out would occur if this were attempted.

When data is not immediately available to satisfy an IBM360 request, CONTROL UNIT END status alone is returned to the PDP9L computer by the network computer. The PDP9L will then drop the Dataway connection, whilst retaining the IBM360 channel connection. When the required data becomes available, the network computer may re-establish connection with the PDP9L computer by addressing an 8 bit command to the PDP9L computer derived by inverting the low

order two bits of the original IBM360 command, and proceeding with the original data transfer request. The PDP9L computers allow approximately 15 seconds for this re-connection before signalling an error termination to the IBM360 computer.

In general, CONTROL UNIT END suspensions may be used both before and after any data transfers, and with both read and write IBM360 commands. To re-establish connection without further data transfer, a NOP-CONTROL command is used by the network computer.

The PDP9L computer also provides a local error re-try facility during IBM360 initiated commands. If an error is detected by either the network computer involved or the PDP9L computer during a data transfer or an ending status exchange, the computer detecting the error may return STATUS MODIFIER, UNIT CHECK status to the other computer. The PDP9L computer will then re-try, or expect a re-try, of the data transfer or status sending. A NOP-CONTROL command will be, or should be, used if the error applied only to the ending status sent. The PDP9L computer will allow one re-try for both the data transfer and the ending status before signalling UNIT CHECK to both the network computer and the IBM360.

The local error re-try facility may be bypassed by signalling UNIT CHECK status without STATUS MODIFIER to the PDP9L computer.

A zero ending status and sense code word is the normal network computer response following a successful data transfer. The PDP9L computer returns CHANNEL END, DEVICE END to the IBM360 in this case, and sets an appropriate sense code within the PDP9L. It is sometimes desirable to send CHANNEL END alone to the IBM360, to be followed at some later stage by DEVICE END. An explicit CHANNEL END status and BUSY sense code must be returned to the PDP9L to achieve this. If the BUSY sense code is omitted, the PDP9L will return the CHANNEL END status to the IBM360 computer, and immediately follow this with a separate DEVICE END status presentation to the IBM360.

4. EXAMPLES OF AAEC NETWORK TRANSFERS

The following steps are involved in writing a record to a magnetic tape unit attached to a network computer.

(i) The IBM360 computer addresses a START I/O command to the required device.

(ii) The PDP9L responds to this initial selection.
If UNIT CHECK is returned, this will complete the operation.
The IBM360 will then almost certainly issue a SENSE command to ascertain the reasons for this abnormal termination.

(iii) If initial zero status is returned to the IBM360, the command can proceed.

(iv) The PDP9L reads the data bytes from the IBM360, and requests a Dataway write to the required destination.

If the Dataway is busy, the PDP9L will re-attempt connection when the Dataway becomes free.

No status is returned to the IBM360 at this time, unless repeated attempts fail to establish a Dataway connection. BUSY status would be returned in this event.

(v) The destination computer receives the write request.

If the destination computer does not wish to proceed at all with the operation, UNIT CHECK status is returned immediately. If no sense code accompanies this status, the destination computer is marked NOT READY within the PDP9L,

and UNIT CHECK status is returned to the IBM360, completing the operation. If a non-zero sense code accompanies the UNIT CHECK indication, this sense code is used by the PDP9L in establishing the required stored sense byte information.

If the destination computer wishes to defer proceeding with the operation, CONTROL UNIT END alone is returned immediately. In this case, the PDP9L will expect the destination computer to re-establish connection later with either a NOP-CONTROL command, or with a derived command obtained from the original command by inverting the last two bit positions of the command. NOP-CONTROL would only be used if immediate termination were to follow the delayed request. If no re-connection is attempted, the PDP9L will return UNIT CHECK to the IBM360 computer after about 15 seconds.

(vi) The destination computer reads the required data from the PDP9L computer.

If, after reading the data, the destination computer does not wish to proceed further with the operation, UNIT CHECK status may be returned at this stage. If no sense code accompanies the UNIT CHECK status, an ERROR, WRITE STATUS sense code is assumed.

If the destination computer wishes to accept the data as 'error-free', without waiting until the outcome of its attempts to write this data on its own magnetic tape, it may return CHANNEL END, DEVICE END at this stage. In the absence of a sense code, the PDP9L computer will assume a WRITE STATUS sense code, and return the CHANNEL END, DEVICE END to the IBM360 computer.

The normal destination computer response to a successful data read, would be CONTROL UNIT END alone. This frees the Dataway, but allows the PDP9L to retain control of the IBM360 channel. The destination computer would then seek to write this data onto its own magnetic tape. When the final outcome of its writing onto magnetic tape is known, the destination computer would use the NOP-CONTROL command to notify the PDP9L of the outcome. If UNIT EXCEPTION status was returned, a WRITE STATUS, END TAPE REGION sense code would be assumed. CHANNEL END, DEVICE END would be the normal status response. If desired, two NOP-CONTROL commands could be used, to return CHANNEL END and DEVICE END statuses separately.

If the destination computer wishes to free the IBM360 channel immediately upon receipt of the data bytes, it would return CHANNEL END status with a BUSY sense code. DEVICE END, UNIT CHECK, or UNIT EXCEPTION status would then be returned by the NOP-CONTROL command.

5. CONCLUSION

The signalling conventions described in this report allows network computers to communicate readily and easily with the IBM360 central computer.

6. REFERENCES

Ellis, P.J. (1970). – A multiplexed computer-computer, computer-device data link. AAEC/E206

Richardson, D.J. (1969). – A generalized computer to computer link for an IBM360 computer. Aust. Computer Journal, 1 (5): 273. Also issued as AAEC/TM485.

Richardson, D.J. (1971). – The AAEC computer network design. Aust. Computer Journal, 3 (2): 55.

TABLE 1

MAGNETIC TAPE OPERATIONS AND ENDING STATUSES

Operation	Command	Normal Ending Status
READ	MMMMMM10	C
WRITE	MMMMMM01	C
TEST I/O*	0	D
NOP-CONTROL*	11	C
SENSE	100	C
READ BACKWARDS	1100	C
MODE SET†	MMMMM011	C
REWIND	111	8,4
REWIND & UNLOAD	1111	8,6
ERASE GAP	10111	8,4
WRITE TAPE MARK	11111	8,4
BACKSPACE RECORD	100111	8,4
BACKSPACE FILE	101111	8,4
FORWARD SPACE RECORD	110111	8,4
FORWARD SPACE FILE	111111	8,4

M denotes a possible modifier bit or zero

* These IBM360 operations are always processed solely by the PDP9L computer, and are never passed on to the network.

† Not all modifier bits may be zero.

TABLE 2

NETWORK SENSE CODES

Hexadecimal Sense Code	Sense Bytes Interpretation
0	NOT READY
1	READ STATUS
2	READ STATUS, EOF DETECTED
3	BACKWARD READ STATUS
4	BACKWARD READ STATUS, EOF DETECTED
5	BACKWARD READ STATUS, LOAD POINT
6	BACKWARD READ STATUS, LOAD POINT, ERROR
7	READ STATUS, ERROR
8	BACKWARD READ STATUS, ERROR
9	WRITE STATUS
A	WRITE STATUS, END OF TAPE
B	WRITE STATUS, ERROR
C	WRITE STATUS, END OF TAPE, ERROR
D	SPARE
E	BUSY
F	ILLEGAL COMMAND