

COMPANY CONFIDENTIAL

PROJECT STRETCH

November 15, 1956

EXCHANGE MEMO NO. 11

DELTA COMPUTER MEMO NO. 16

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A meeting was held on November 12, 1956 concerning the communications between the Exchange and the Delta Computer. Those in attendance were:

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The subjects covered in this meeting included:

1. The instructions and their format.
2. The necessary signals from the Computer to the Exchange to order and identify an operation to be performed.
3. The necessary signals from the Exchange to the Computer to present information to the Indicator Registers to allow break-in operation.

The following memo contains the results of our discussion and specifies the method of communication between the Exchange and the Computer.

DEFINITION OF COMMUNICATION LINES, DELTA COMPUTER TO EXCHANGE

1. Read/Write (1 line) - Signals the Exchange to read from an input unit or write to an output unit. A read operation is differentiated from a write operation because input units have odd addresses and output units have even addresses.
2. Interrogate I/O Unit Status - Signals the Exchange to send the status of an I/O unit to the Computer.
3. Copy Control Word - Signals the Exchange to send an I/O unit's control word to main memory.

4. Control I/O Unit - Signals the Exchange to send control data to an I/O unit. This control data will be interpreted by the I/O units as a control instruction.
5. Control Word Address is Data - Signals the Exchange that the control word address lines represent control data.
6. I/O Unit Address (10 Lines) - Specifies the I/O unit involved in an operation.
7. Control Word Address (20 Lines) - (a) When the computer signals a read/write operation, these 20 lines indicate the main memory address of the control word, (b) When the Computer signals a control I/O units operation and does not signal that the control word address is data; these lines indicate the main memory address of the word containing the control data, (c) When the Computer signals a control I/O unit operation and also signals that the control word address is data; the control word address lines represent the actual control data (instruction) which is to be sent to the I/O unit.

To summarize (b) and (c), when the control data (instruction) is 20 bits or less, the data is sent to the Exchange on the control word address lines. When the control data is more than 20 bits, the main memory address of the control data is sent to the Exchange on the control word address lines.

DEFINITION OF COMMUNICATION LINES EXCHANGE TO DELTA COMPUTER

1. Exchange Busy (1 Line) - Signals the Computer that the Exchange is busy. This implies that the same instruction should be sent at a later time if execution is still desired. It permits the program to accept the execution refusal and work on other problems for the moment or to go into a tight loop until this instruction is executed by the Exchange.
2. Exchange Not Busy (1 Line) - Indicates to the Computer than the execution of the instruction will be attempted. One of the above two signals is always sent back to the Computer as an immediate response to an instruction from the Computer.
3. Instruction Response (1 Line) - Signals the Computer that the status of the I/O unit has been interrogated and that the I/O unit's status is such that the instruction can be executed. An Instruction Response is not generated for a "copy control word" instruction or a "control (I/O unit" instruction; an "Interrogate Response is generated instead. The Computer has the option to matter-of-factly accept an Instruction Response condition and be alerted for break-in on Interrogation Response and Instruction Reject signals.

4. **Instruction Reject (1 Line)** - Signals the Computer that the status of the I/O unit has been interrogated and that the I/O unit's status is such that the instruction should not be executed. The I/O unit's status is sent to the Computer Indicator Register along with the Instruction Reject signal.
5. **Interrogation Response (1 Line)** - This signal is generated in response to an "interrogate I/O unit status" operation or a "copy control word" operation. In the former case, it indicates to the Computer that the status of the I/O unit has been sent to the Computer. In the latter case it indicates that the I/O unit's control word is in main memory. An Interrogation Instruction resets the status conditions in the control word, the copy control word instruction will not.
6. **Operation Request (1 Line)** - This signal is sent to the Computer Indicator Register to signify that an I/O unit is requesting to be selected to read data into the Exchange. This is a normal type operation for certain low-speed interrogation devices. The Exchange sends to the Computer at the same time 10 bits of unit address information so that the Computer can identify the device requesting operation.
7. The following seven lines represent the status of the I/O unit and are sent to the Computer when an instruction is rejected because an error condition exists, I/O units in use or not available, end of File and read-write operation is specified, or in response to an interrogate I/O unit status instruction.
 - a. **I/O Unit Not Ready** - Indicates that the unit is not mechanically ready.
 - b. **I/O Unit Busy** - Indicates that the I/O unit is still busy as the result of a previous instruction.
 - c. **I/O Unit at End of File** - Indicates that the I/O unit has reached the end of tape, etc.
 - d. **I/O Unit R/W Error** - Indicates the I/O unit had made a read or write error.
 - e. **I/O Data Transmission Error** - Indicates a data error was detected between the input unit and the input register or between the output register and the output unit.
 - f. **Exchange Data Handling Error** - Indicates the 64 bit data word is incorrect in the Exchange.

- g. **Control Circuits Error - Indicates errors such as no "service request" from the I/O unit, etc. (anything attributable to malfunction of control equipment).**

SUMMARY: DELTA TO EXCHANGE COMMUNICATION LINES

Exchange Computer Communications

Signal lines from Delta Computer to the Exchange.

NAME		R	W	C	I
Read/Write Operation	1 line	X	X		
Interrogate Operation	1 line				X
Copy Control Word	1 line			X	
Control I/O	1 line			X	
Control; address is data *	1 line			X	

Data lines from Delta Computer to the Exchange

NAME		R	W	C	I
I/O Unit Address	10 lines	X	X	X	X
Control Word Address	20 lines	X	X	X*	

Note: Column Headings Read: R - Read Operation
 W - Write Operation
 C - Control Operation
 I - Interrogation Operation
 A - Any Time Phenomina is Determined
 IR - Indicator Register

* Sometimes, depends if # is present, if # is present, then * is control data, if # is not present, then * is control word address.

SUMMARY: EXCHANGE TO DELTA COMMUNICATION LINES

Signal lines from Exchange to Delta control system and/or Indicator Register

NAME		R	W	C	I	IR
Instruction Reject	1 line	X	X	X		X
Exchange Busy	1 line	X	X	X	X	X
Interrogation Response	1 line				X	X
Instruction Response	1 line	X	X	X		X
Exchange not busy	1 line	X	X	X	X	X
Operate Request	1 line					X

Status and data lines from Exchange to Delta Computer Indicator Register when;

1. An interrogation instruction is executed.
2. Any instruction is attempted when an error condition is identified.
3. Any instruction is rejected for execution by the Exchange.

Recorded Status Conditions

I/O Unit End of File	1 line
I/O Unit Not Ready	1 line
I/O Unit Busy	1 line
I/O Unit R/W error	1 line
I/O Data Transmission Error	1 line
Exchange Data Handling Error	1 line
Control Circuit Error	1 line
Undefined	1 line
Undefined	1 line
I/O Unit Address	10 lines *

* Does not go to Indicator Register - goes to specially designated register.

INSTRUCTION WORD FORMAT FOR EXCHANGE OPERATIONS

The instruction word format for instructions pertaining to the Exchange will vary depending on the particular operation. The format for each operation is given below.

Read/Write Operation

Read/Write	1 bit
Control Word Address	20 bits
I/O Unit Address	10 bits

INTERROGATE I/O UNIT STATUS OPERATION

Interrogate I/O Unit Status	1 bit
I/O Unit Address	10 bits

COPY CONTROL WORD OPERATION

Copy Control Word	1 bit
Control Word address	20 bits
I/O Unit Address	10 bits

CONTROL I/O UNIT OPERATION

If the control data (instruction) is 20 bits or less, the format is as follows:

Control I/O Unit	1 bit
Control Word Address is Data	1 bit
I/O Unit Address	10 bits
Control Data (instruction)	20 bits

If the control data is more than 20 bits, the format is as follows:

Control I/O Unit	1 bit
Control Word Address *	20 bits
I/O Unit Address	10 bits

* Specifies the address in main memory where the control data is to be found.

ILLUSTRATIVE CASES

Case A - An instruction is fully executed - no abnormal conditions.

1. Computer to Exchange - Read/write operation or (interrogate operation, or copy operation, or control I/O and perhaps control address) line.
2. Exchange to Computer - Exchange Not Busy signal.
3. Resulting from Step 2, Case A, Computer continues with its program.
4. Exchange to Computer Indicator Register - Instruction response, or (Interrogation response if 1 had been an interrogation instruction).
5. Computer can respond or not to the response signal recorded in the Indicator Register signifying successful initiation of execution of the instruction assigned in Step 1.

Case A-1 - An instruction is fully executed as per Case A, however, an error is detected sometime after Step 5, Case A.

6. Exchange detects an error, the indication of which it holds until the Control Word Cycle of the Exchange, then,
7. The information is recorded in the status word associated with the data word; and
8. The address of the I/O unit is combined with the status information and immediately sent to the Computer (to the I/O Address Register and to the Indicator Register). The status information is retained with the data word; and
9. The I/O operation continues to completion.

Case B - An instruction is accepted initially, then due to some existing condition is rejected by the Exchange rather than being executed.

1. Computer to Exchange - Read/Write operation or (control operation)
2. Exchange to Computer - Exchange Not Busy signal.
3. Resulting from Step 2, Case B, the Computer continues with its program.

4. Resulting from Steps 1 and 2, Case B, the Exchange, in preparation for execution discovers a condition which is defined to prevent execution (e. g. I/O unit busy, I/O End of File, etc.), and causes Step 5 to be performed.
5. The Instruction reject signal is sent to the Computer Indicator Register along with the status information from the control word in the Exchange. The address of the unit associated with this operation is sent by the Exchange to the designated register in the Computer.
6. The status conditions portion of the data word in the Exchange is not reset, the set of particular conditions is returned to the status memory. Certain items of indication are responsible for the statements made here, they include the indications which may represent dynamic or continuous conditions such as I/O unit busy and perhaps I/O unit not ready as opposed to conditions indicating an error had been made in data handling, etc.
7. The Computer may or may not respond to the Instruction Reject indication and the status information sent it by the Exchange depending upon the program being run.

Case B-1 - Instruction is accepted initially, then rejected before execution, due to an error condition indicated which had undoubtedly been detected earlier. Therefore following Step 3, Case B, we have:

4. Resulting from Steps 1 and 2, Case B, the Exchange in preparation for execution discovers record of a previously identified error condition (e. g. I/O error, etc.) which is defined to prevent execution.
5. The Instruction Reject signal is sent to the Computer Indicator Register along with the status information from the control word in the Exchange. The address of the unit associated with this operation is sent by the Exchange to the designated register in the computer.
6. The status conditions portion of the data word in the Exchange is reset, and not returned to the status memory. This particular philosophy of operation was adopted to prevent a computer program from being unnecessarily committed to remove an obstacle by special programming and at the same time preventing the program from executing an operation without at least two warnings of an error condition. The first warning is sent to the Computer when the error condition was encountered, the second warning when the particular unit associated with the error was attempted to be operated without first having an interrogation operation (which also resets the status memory data) or otherwise correcting the situation.

7. The Computer may or may not respond to the Instruction Reject indication and the status information sent it by the Exchange depending upon the program being run.

Case C - An instruction is not accepted.

1. Computer to Exchange - Read/Write operation (or interrogation operation etc.).
2. Exchange to Computer - Exchange Busy signal.
3. The computer continues its program execution knowing that the I/O operation attempted failed to be executed by the presence of the Exchange Busy bit in the Indicator Register.