

INTERDEPARTMENTAL

MASSACHUSETTS INSTITUTE OF TECHNOLOGY CAMBRIDGE, MASS. 02139

from the office of

April 30, 1970

MEMORANDUM

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FROM: J. H. Saltzer

Enclosed is a draft memo outlining a proposed statement of the M.I.T. Terminal behavior standards. This statement is slightly more flexible than the current standard on 2741's, and should be viewed as a proposed statement, not interpreted as current policy. Your comments on the memo are solicited.

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MEMORANDUM

From: J. H. Saltzer

Subject: Background on Terminal Behavior Standards for the
M.I.T. Dataswitch Terminal Network

DRAFT III

September 30, 1970

There are a number of standards which apply to all typewriter-like terminals proposed for attachment to the M.I.T. dataswitch for use with computers of the M.I.T. Information Processing Center. The implications of adherence (or non-adherence) to these standards is frequently debated; this note is intended to supply some background information as to the nature, origin, and purpose of the standards.

In broad outline, the standards recognize two distinctly different kinds of terminal interface behavior, and require that all proposed terminals provide one of these two types of interface behavior. These two behavior types can be briefly and operationally described as:

1. Terminals behaving as a Teletype Model 37.
2. Terminals behaving as an IBM 2741, as modified at M.I.T.

Other standards, such as for rapid printing or soft-copy terminals, are under discussion but are not yet in force.

The motivation for settling on a small number of interface behavior standards is the recognition that there are several different computer systems in use at M.I.T., each evolving at its own rate to adapt to new hardware and operating system releases. As these systems evolve it is important to assure that they continue working with all M.I.T. terminals.

The smaller the number of interfaces involved the easier it is to meet this goal, and the more quickly can new systems be put into service.

There are two other potential standards which have been deliberately excluded from recognition. These are

1. Terminals behaving as a Teletype model 33 or 35.
2. Terminals behaving as a standard IBM 2741.

These two exclusions demand some discussion, since they represent what are probably the two most widely available Terminal types outside M.I.T.

The model 33 and 35 Teletype Terminals have been excluded fundamentally for the reason that they have an inadequate character set; there are not separate upper and lower alphabetic cases. Since both of the standard terminal types have a fuller character set including upper and lower case letters, inclusion of an upper-case-only device would tend to dilute the usefulness of the full character set. This would follow since subsystem programmers attempting to meet the widest possible audience for their facilities would restrict their use of characters to those available on the most restricted terminal. Since in announcing new terminals, current suppliers seem to be generally moving toward full character set devices, it seems inappropriate to effectively narrow the M.I.T. use of time-shared computers to what happens historically to be a popular standard. A second problem with the model 33 Teletype in particular is that it is designed for intermittent communications service. It also works fairly well under the reasonably light load imposed by some FORTRAN and BASIC time-sharing services. On the other hand, the nature of programs and other time-sharing services provided by CTSS and Multics, the two most widely used M.I.T. services, is

much more severe; experience suggests that the Model 33 Teletype does not stand up well under the intense traffic. Finally, there is substantial additional cost to each of the computer systems in providing ports which operate at the 110 bit per second rate of these Teletypes.

The unmodified IBM model 2741 has been excluded from the M.I.T. standard because it is fundamentally not possible to implement read-ahead, a feature which is essential to close man-machine coupling. Also, the standard 2741 is not suited for attachment to a console-computer interconnection network involving concentration. Both of these limitations are explained in detail in the description below of the modified 2741 terminal.

The 2741 Interface

The 2741-like standard interface has several interesting aspects. The M.I.T. 2741 standard requires two normally optional features to be installed, and also requires five additional special engineering (RPQ) features on the IBM 2741. Some other 2741-like terminals have different lists of which these are standard options and which require special engineering. We will discuss the reasons why each of these features is required.

1. "Dialup" feature. This feature permits attachment of the 2741 terminal to a Bell System type 103A dataset (or equivalent), to allow communication via switched telephone lines. A discussion of why M.I.T. uses switched telephone lines appears below, under feature no. 4.
2. Receive Interrupt feature. The 2741 terminal operates in three modes; transmit (keyboard unlocked, user typing), receive (keyboard locked, computer typing) and control (keyboard locked, terminal awaiting

further instructions about which mode to switch to.) The attention key, used to interrupt a runaway or unwanted computation on all M.I.T. time-sharing systems, is only usable on an unmodified 2741 during transmit mode. The receive interrupt features makes the attention key usable in receive mode as well. Since a common reason for pressing the attention key is to stop a program caught in an output loop, it is essential that the attention key work during receive mode as well as transmit mode.

3. Transmit Interrupt RPQ. In a standard 2741, if the computer switches the 2741 to transmit mode so the user can type, the console stays in transmit mode until the user presses return or attention. There is no way for the computer to switch the console back to receive mode, so that the system can type a message. The Transmit Interrupt RPQ allows just this operation. The implication of this feature is not immediately apparent. All M.I.T. time-sharing systems, as a matter of human engineering, permit a degree of type-ahead. That is, if the user can anticipate his next line of input, he is allowed to type it even before his program has asked for it: this strategy allows the user to overlap his thinking and typing with the queueing and processing of the computer system, and permits closer man-machine interaction. In many cases, output in response to an input is conditional; for example, output may occur only if the input line has an error; no output is required if the input line was correct. In all those cases where no output occurs, with type-ahead the user is free to begin typing his next line without waiting for his program to "catch up" to him. In the rarer cases of an error, the lines typed ahead are normally scrapped.

The importance of the transmit interrupt RPQ is now apparent. Without it, an attempt to implement type-ahead would leave the computer system powerless to reply if a conditional output situation required it; any reply would have to be delayed until the next time the return (or attention) key is depressed. As a consequence,

- a) Any reply would appear to the user to be synchronized with his next input, a misleading situation if his next input follows a long pause on his part.
- b) The user may never type return, and thus never see his message. (If the system is being shut down, for example.)
- c) In order for the user to be sure he has received his last message, he would have to wait until he was somehow sure the computation was complete, and then press return to allow printing of any output from his program.

Thus we see that the absence of the Transmit Interrupt RPQ is fundamentally incompatible with a type-ahead strategy.

4. Automatic Answerback RPQ. This feature allows the terminal, if properly addressed by the computer, to transmit to the computer a stored character sequence, which identifies both the type of terminal (e.g., 2741 or teletype M37) and also the individual terminal. This feature is needed because with use of a switched telephone network* any of a large number

* The switched telephone network is in use at M.I.T. for several purposes:

1. Switching, so that any terminal can access any M.I.T. Computer system.
2. Concentration, so that the number of computer ports need not be equal to the number of terminals. With concentration, only enough computer ports need be supplied to satisfy the maximum number of simultaneous users of the computer system. Typically, at most 1/3 of the terminals are in use at any one time; the cost savings from concentration can thus be quite significant.
3. To allow users outside M.I.T. to use M.I.T. computers, and to allow M.I.T. users access to outside computers.

of different terminals may be connected to any single computer port; the computer system has no way to determine by port number which terminal is calling, and thus what kind of terminal control, what interface behavior, or what data transmission rate is required.

One direction frequently suggested to permit knowledge of at least the terminal type and options is to have a different telephone number for each different combination of type and option. This approach directly contradicts the concentration motive. Since two users having different terminal types, but with usage at different times, cannot use the same port, the number of ports must in general be larger.

Currently, all M.I.T. systems use the multiple phone number approach to distinguish between terminals operating at different bit rates. A 20 to 40% increase in the number of ports is required to maintain this approach, which has been historically forced by a lack of computer I/O channels with program settable bit rates. It can be expected that this port breakage problem will keep up pressure to design more flexible computer ports, so that better sharing of a smaller number of ports is possible. Thus, there is and will remain in the future a need for a terminal to be self-identifying at least as to type and options.

Unique identification of each individual console is a further refinement of type identification. Probably its most important use is as a management tool to monitor the amount of usage of individual consoles. Statistics are kept by the time-sharing systems on the number of hours logged by each individual terminal, on the basis of its unique answer-back code. This information is very useful for identifying terminals

which are not being utilized enough to justify their continued rental. In addition, knowledge of the answerback code of a logged-in user allows the possibility of more easily locating him. Unfortunately, the ease of change of most answerback mechanisms as well as growing use of portable terminals degrades use of the answerback code as an additional authentication mechanism. Reliance on authentication should await availability from the switched network of the telephone number of the calling party.

5. "Auto-EOT" RPQ. This RPQ inhibits the usual 2741 action of locking the keyboard whenever a return is typed. When the RPQ is missing (or switched off) it is necessary for a computer system using a read-ahead strategy to respond and unlock the keyboard between typed input lines. In addition to whatever delay may occur while the computer is responding, the 2741 addressing protocol requires that a minimum of three signalling characters be sent back and forth, meaning that the keyboard remains locked for at least 200 milliseconds. This is just enough time to throw a touch typist off pace. It is possible for the computer to discover that this RPQ is missing by scanning the input character stream. It can then insert a rapid response to unlock the keyboard following each return. Thus, if the RPQ is missing the effect is one of degrading the human interface.
6. Red Shift RPQ. This RPQ permits user and computer controlled shifting of the ribbon color. It originally appeared in the list of required features quite by accident, as a result of an early 2741 design which required this RPQ as a prerequisite for the print inhibit RPQ, described below. The resulting general availability of this feature has led to

widespread use in many programs and subsystems implemented at M.I.T. It is possible to make this feature optional if both of the following constraints are observed:

1. The terminal must ignore the attempts of the computer to switch its ribbon color. This constraint is required so that programs (and systems) expecting that the feature is available will not have to be modified to work with a terminal missing the feature.
 2. It must be possible for the computer to determine, from the terminal identification, that the feature is missing. This constraint assures that systems which want to modify their strategies in the absence of the feature have the option of doing so.
7. "Print Inhibit" RPQ. This feature permits the user's typing at the keyboard to be transmitted to the computer without being simultaneously printed on his typewriter output. Its purpose is to permit privacy while typing the passwords required for usage of all M.I.T. systems. This feature has a very strong psychological effect in convincing the user that the system cares about his privacy. It is very handy in a public area where control of observers is awkward; it is also useful in one's own office, where one does not have to make a scene (and risk offending a guest or superior) by ripping off and hiding a piece of paper containing a printed password. An alternate way of achieving a similar effect is to have the computer print out a random collection of overstruck characters in the area of the paper where the password is to be typed. This approach requires that the computer system realize that the terminal is missing the print-inhibit feature, thus, both

of the constraints mentioned before about terminals missing ribbon shift apply here also.

In summary, the M.I.T. 2741 standard includes

1. Four required features and RPQ's to allow implementing type-ahead and use of a switched telephone network.
 - Dialup feature
 - Receive Interrupt feature
 - Transmit Interrupt RPQ
 - Automatic Answerback RPQ
2. Three optional RPQ's, one of which, if missing, is discoverable by the computer system. The other two must, if missing, be missing in a particular way.
 - Auto-EOT RPQ
 - Ribbon shift RPQ
 - Print Inhibit

It is useful to note that users outside M.I.T. who have 2741 terminals equipped for use with either IBM TSS/360 or IBM CP/67/CMS generally have those features required to implement type-ahead. If they should attempt to use an M.I.T. computer by some path other than the switched telephone network (for example, the ARPA network) then the lack of answerback is irrelevant and the console will be usable. Direct dial-up may also be temporarily possible with some M.I.T. systems which have dedicated telephone numbers for 2741's such that answerback is not required. In such cases, the system will assume that the terminal does not have either the print-inhibit or the ribbon-shift option.