Network Working Group Mark Crispin
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SUPDUP Protocol

INTRODUCTION

This document describes the SUPDUP protocol, a highly efficient display telnet protocol. It originally started as a private protocol between the ITS systems at MIT to allow a user at any one of these systems to use one of the others as a display. At the current writing, SUPDUP user programs also exist for Data Disc and Datamedia displays at SU-AI and for Datamedias at SRI-KL. The author is not aware of any SUPDUP servers other than at the four MIT ITS sites.

The advantage of the SUPDUP protocol over an individual terminal's protocol is that SUPDUP defines a "virtual" or "software" display terminal that implements relevant cursor motion operations. The protocol is not built on any particular display terminal but rather on the set of functions common to all display terminals; hence it is completely device-independent. In addition, the protocol also provides for terminals which cannot handle certain operations, such as line or character insert/delete. In fact, it is more than this. It provides for terminals which are missing any set of features, all the way down to model 33 Teletypes.

The advantage over the TELNET protocol is that SUPDUP takes advantage of the full capabilities of display terminals, although it also has the ability to run printing terminals.

It is to be noted that SUPDUP operates independently from TELNET; it is not an option to the TELNET protocol. In addition, certain assumptions are made about the server and the user programs and their capabilities. Specifically, it is assumed that the operating system on a server host provides all the display-oriented features of ITS. However, a server may elect not to do certain display operations available in SUPDUP; the SUPDUP protocol is far-reaching enough so that the protocol allows terminals to be handled as well as that host can handle terminals in general. Of course, if a host does not support display terminals in any special way, there is no point in bothering to implement a SUPDUP server since TELNET will work just as well.

A more complete description of the display facilities of SUPDUP and ITS can be found by FTP'ing the online file .INFO.;ITS TTY from ARPAnet host MIT-AI (host 206 octal, 134. decimal). For more information, the mailing address for SUPDUP is "(BUG SUPDUP) at MIT-AI". If your mail system won't allow you to use parentheses, use Bug-SUPDUP@MIT-AI.

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BACKGROUND

The SUPDUP protocol originated as the internal protocol used between parts of ITS, and between ITS and "intelligent" terminals. Over the network, a user host acts like an intelligent terminal programmed for ITS.

The way terminal output works in ITS is as follows: The user program tells the system to do various operations, such as printing characters, clearing the screen, moving the cursor, etc. These operations are formed into 8-bit characters (using the %TD codes described below) and stored into a buffer. At interrupt level, as the terminal demands output, characters are removed from the buffer and translated into terminal dependent codes. At this time padding and cursor motion optimization are also done.

In some cases, the interrupt side does not run on the same machine as the user program. SUPDUP terminals have their "interrupt side" running in the user host. When SUPDUP is run between two ITS’s, the SUPDUP user and server programs and the network simply move characters from the buffer in the server machine to the buffer in the user machine. The interrupt side then runs on the user machine just as if the characters had been generated locally.

Due to the highly interactive characteristics of both the SUPDUP protocol and the ITS system, all transactions are strictly character at a time and all echoing is remote. In addition, all padding and cursor control optimization must be done by the user.

Because this is also the internals of ITS, the right to change it any time if necessary to provide new features is reserved by MIT. In particular, the initial negotiation is probably going to be changed to transmit additional variables, and additional %TD codes may be added at any time. User programs should ignore those they don’t know about.

The following conventions are used in this document: function keys (ie, keys which represent a "function" rather than a "graphic character") are in upper case in square brackets. Prefix keys (ie, keys which generate no character but rather are held down while typing another character to modify that character) are in upper case in angle brackets. Hence "<CONTROL><META>[LINE FEED]" refers to the character generated when both the CONTROL and META keys are held down while a LINE FEED is typed. Case should be noted; <CONTROL>A refers to a different character from <CONTROL>a. Finally, all numbers which do not explicitly specify a base (ie, octal or decimal) should be read as octal unless the number is immediately followed by a period, in which case it is decimal.

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INITIALIZATION

The SUPDUP server listens on socket 137 octal. ICP proceeds in the normal way for establishing 8-bit connections. After the ICP is completed, the user side sends several parameters to the server side in the form of 36.-bit words. Each word is sent through the 8-bit connection as six 6-bit bytes, most-significant first. Each byte is in the low-order 6 bits of a character. The first word is the negative of the number of variables to follow in the high order 18. bits (the low-order 18. bits are ignored), followed by the values of the TCTYP, TTYOPT, TCMXV, TCMXH, and TTYROL terminal descriptor variables (these are the names they are known by at ITS sites). These variables are 36.-bit binary numbers and define the terminal characteristics for the virtual terminal at the REMOTE host.

The count is for future compatability. If more variables need to be sent in the future, the server should assume "reasonable" default values if the user does not specify them. PDP-10 fans will recognize the format of the count (ie, -count,,0) as being an AOBJN pointer. At the present writing there are five variables hence this word should be -5,,0.

The TCTYP variable defines the terminal type. It MUST be 7 (%TNSFW). Any other value is a violation of protocol.

The TTYOPT variable specifies what capabilities or options the user’s terminal has. A bit being true implies that the terminal has this option. This variable also includes user options which the user may wish to alter at his or her own descretion; these options are included since they may be specified along with the terminal capabilities in the initial negotiation. See below for the relevant TTYOPT bits.

The TCMXV variable specifies the screen height in number of lines.

The TCMXH variable specifies the line width in number of characters. This value is one less than the screen width (ITS indicates line overflow by outputting an exclamation point at the end of the display line before moving to the next line). Note: the terminal must not do an automatic CRLF when a character is printed in the rightmost column. If this is unavoidable, the user SUPDUP must decrement the width it sends by one.

Note: Setting either the TCMXV or TCMXH dimension greater than 128. will work, but will have some problems as coordinates are sometimes represented in only 7 bits. The main problems occur in the SUPDUP protocol when sending the cursor position after an output reset and in ITS user programs using the display position codes ^PH and ^PV.

The TTYROL variable specifies the "glitch count" when scrolling. This is the number of lines to scroll up when scrolling is required. If zero, the terminal is not capable of scrolling. 1 is the usual value, but some terminals glitch up by more than one line when they scroll.

Following the transmission of the terminal options by the user, the server should respond with an ASCII greeting message, terminated with a %TDNOP code (%TD codes are described below). All transmissions from the server after the %TDNOP are either printing characters or virtual terminal display codes.

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The user and the server now both communicate using the intelligent terminal protocol (described below) from the user and %TD codes from the server. The user has two commands in addition to these; they are escaped by sending 300 (octal). If following the escape is a 301 (octal), the server should attempt to log off the remote job (generally this is sent immediately before the user disconnects, so this logout procedure should be done regardless of the continuing integrity of the connection). If the character following the escape is a 302 (octal), all ASCII characters following up to a null (000 octal) are interpreted as "console location" which the server can handle as it pleases. No carriage return or line feed should be in the console location text. Normally this is saved away to be displayed by the "who" command when other users ask where this user is located.

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TTYOPT FUNCTION BITS

The relevant TTYOPT bits for SUPDUP usage follow. The values are given in octal, with the left and right 18-bit halves separated by ",," as in the usual PDP-10 convention.

Bit name	Value	Meaning
%TOALT	200000,,0	characters 175 and 176 are converted to altmode (033) on input.
%TOERS	40000,,0	this terminal is capable of selectively erasing its screen. That is, it supports the %TDEOL, the %TDDLF, and (optionally) the %TDEOF operations. For terminals which can only do single-character erasing, see %TOOVR.
%TOMVB	10000,,0	this terminal is capable of backspacing (ie, moving the cursor backwards).
%TOSAI	4000,,0	this terminal has the Stanford/ITS extended ASCII graphics character set.
%TOOVR	1000,,0	this terminal is capable of overprinting; if two characters are displayed in the same position, they will both be visible, rather than one replacing the other. Lack of this capability but the capability to backspace (see %TOMVB) implies that the terminal can do single character erasing by overstriking with a space. This allows terminals without the %TOERS capability to have display-style "rubout processing", as this capability depends upon either %TOERS or [%TOMVB and not %TOOVR].
%TOMVU	400,,0	this terminal is capable of moving the cursor upwards.
%TOLWR	20,,0	this terminal’s keyboard is capable of generating lowercase characters; this bit is mostly provided for programs which want to know this information.
%TOFCI	10,,0	this terminal’s keyboard is capable of generating CONTROL and META characters as described below.
%TOLID	2,,0	this terminal is capable of doing line insert/delete operations, ie, it supports %TDILP and %TDDLP.
%TOCID	1,,0	this terminal is capable of doing character insert/delete operations, ie, it supports %TDICP and %TDDCP.

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TTYOPT FUNCTION BITS (continued)

Bit name	Value	Meaning
%TPCBS	0,,40	this terminal is using the "intelligent terminal protocol". THIS BIT MUST BE ON.
%TPORS	0,,10	the server should process output resets instead of ignoring them. IT IS HIGHLY RECOMMENDED THAT THIS BIT BE ON; OTHERWISE THERE MAY BE LARGE DELAYS IN ABORTING OUTPUT.

The following bits are user option bits. They may be set or not set at the user's discretion. The bits that are labelled "normally on" are those that are normally set on when a terminal is initialized (ie, by typing [CALL] on a local terminal).

Bit name	Value	Meaning
%TOCLC	100000,,0	convert lower-case input to upper case. Many terminals have a "shift lock" key which makes this option useless. NORMALLY OFF.
%TOSA1	2000,,0	characters 001-037 should be displayed using the Stanford/ITS extended ASCII graphics character set instead of uparrow followed by 100+character. NORMALLY OFF.
%TOMOR	200,,0	the system should provide "**MORE**" processing when the cursor reaches the bottom line of the screen. **MORE** processing is described in ITS TTY. NORMALLY ON.
%TOROL	100,,0	the terminal should scroll when attempting output below the bottom line of the screen instead of wrapping around to the top. NORMALLY OFF.

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INPUT -- THE INTELLIGENT TERMINAL PROTOCOL

Note: only the parts of the intelligent terminal protocol relevant to SUPDUP are discussed here. For more information, read ITS TTY.

CHARACTER SETS

There are two character sets available for use with SUPDUP; the 7-bit character set of standard ASCII, and the 12-bit character set of extended ASCII. Extended ASCII has 5 high order or "bucky" bits on input and has graphics for octal 000-037 and 177 (see the section entitled "Stanford/ITS character set" for more details). The two character sets are identical on output since the protocol specifies that the host should never send the standard ASCII formatting characters (ie, TAB, LF, VT, FF, CR) as formatting characters; the characters whose octal values are the same as these formatting characters are never output unless the user job has these characters enabled (setting %TOSAI and %TOSA1 generally does this).

Input differs dramatically between the 7-bit and 12-bit character sets. In the 7-bit character set, all characters input whose value is 037 octal or less are assumed to be (ASCII) control characters. In the 12-bit character set, there are 5 "bucky" bits which may be attached to the character. The two most important of these are CONTROL and META, which form a 9-bit character set. TOP is used to distinguish between printing graphics in the extended character set and ASCII controls. The other two are reserved and should be ignored. Since both 7-bit and 12-bit terminals are commonly in use, 0001, 0301, and 0341 are considered to be <CONTROL>A on input by most programs, while 4001 is considered to be downwards arrow.

MAPPING BETWEEN CHARACTER SETS

Many programs and hosts do not process 12-bit input. In this case, 12-bit input is folded down to 7-bit as follows: TOP and META are discarded. If CONTROL is on, then if the 7-bit part of the character specifies a lower case alphabetic it is converted to upper case; then if the 7-bit part is between 077 and 137 the 100 bit is complemented or if the 7-bit part is 040 the 040 bit is subtracted (that’s right, <CONTROL>? is converted to [RUBOUT] and <CONTROL>[SPACE] is converted to [NULL]). In any case the CONTROL bit is discarded, and the remainder is treated as a 7-bit ASCII character. It should be noted that in this case downwards arrow is read by the program as standard ASCII <CONTROL>A.

Servers which expect 12-bit input and are told to use the 7-bit character set should do appropriate unfolding from the 7-bit character set to 12-bit. It is up to the individual server to decide upon the unfolding scheme. On ITS, user programs that use the 12-bit character set generally have an alternative method for 7-bit; this often takes the form of prefix characters indicating that the next character should be "controllified" or "metized", etc.

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INPUT -- THE INTELLIGENT TERMINAL PROTOCOL (continued)

BUCKY BITS

Under normal circumstances, characters input from the keyboard are sent to the foreign host as is. There are two exceptions; the first occurs when an octal 034 character is to be sent; it must be quoted by being sent twice, because 034 is used as an escape character for protocol commands. The second exception occurs when %TOFCI is set and a character with non-zero bucky bits is to be sent. In this case, the character, which is in the 12-bit form:

Name	Value	Description
%TXTOP	4000	This character has the [TOP] key depressed.
%TXSFL	2000	Reserved, must be zero.
%TXSFT	1000	Reserved, must be zero.
%TXMTA	400	This character has the [META] key depressed.
%TXCTL	200	This character has the [CONTROL] key depressed.
%TXASC	177	The ASCII portion of the character

is sent as three bytes. The first byte is always 034 octal (that is why 034 must be quoted). The next byte contains the "bucky bits", ie, the %TXTOP through %TXCTL bits, shifted over 7 bits (ie, %TXTOP becomes 20) with the 100 bit on. The third byte contains the %TXASC part of the character. Hence the character <CONTROL><META>[LINE FEED] is sent as 034 103 012.

OUTPUT RESETS

The intelligent terminal protocol also is involved when a network interrupt (INR/INS) is received by the user program. The user program should increment a count of received network interrupts when this happens. It should not do any output, and if possible abort any output in progress, if this count is greater than zero (NOTE: the program MUST allow for the count to go less than zero).

Since the server no longer knows where the cursor is, it suspends all output until the user informs it of the cursor position. This also gives the server an idea of how much was thrown out in case it has to have some of the aborted output displayed at a later time. The user program does this when it receives a %TDORS from the server. When this happens it should decrement the "number of received network interrupts" count described in the previous paragraph and then send 034 followed by 020, the vertical position, and the horizontal position of where the cursor currently is located on the user’s screen.
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OUTPUT -- DISPLAY PROTOCOL (%TD CODES)

Display output is somewhat simpler. Codes less than 200 octal are printing characters and are displayed on the terminal (see the section describing the "Stanford/ITS character set"). Codes greater than or equal to 200 (octal) are known as "%TD codes", so called since their names begin with %TD. The %TD codes that are relevant to SUPDUP operation are listed here. Any other code received should be ignored, although a bug report might be sent to the server's maintainers. Note that the normal ASCII formatting characters (011 - 015) do NOT have their formatting sense under SUPDUP and should not occur at all unless the Stanford/ITS extended ASCII character set is in use (ie, %TOSAI is set in the TTYOPT word).

For cursor positioning operations, the top left corner is (0,0), ie, vertical position 0, horizontal position 0.

%TD code	Value	Meaning
%TDMOV	200	General cursor position code. Followed by four bytes; the first two are the "old" vertical and horizontal positions and may be ignored. The next two are the new vertical and horizontal positions. The cursor should be moved to this position. On printing consoles (non %TOMVU), the old vertical position may differ from the true vertical position; this can occur when scrolling. In this case, the user program should set its idea of the old vertical position to what the %TDMOV says and then proceed. Hence a %TDMOV with an old vpos of 20. and a new vpos of 22. should always move the "cursor" down two lines. This is used to prevent the vertical position from becoming infinite.
%TDMV1	201	An internal cursor motion code which should not be seen; but if it is, it has two argument bytes after it and should be treated the same as %TDMV0.
%TDEOF	202	Erase to end of screen. This is an optional function since many terminals do not support this. If the terminal does not support this function, it should be treated the same as %TDEOL. %TDEOF does an erase to end of line, then erases all lines lower on the screen than the cursor. The cursor does not move.
%TDEOL	203	Erase to end of line. This erases the character position the cursor is at and all positions to the right on the same line. The cursor does not move.

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OUTPUT -- DISPLAY PROTOCOL (%TD CODES) (continued)

%TD code	Value	Meaning
%TDDLF	204	Clear the character position the cursor is on. The cursor does not move.
%TDCRL	207	If the cursor is not on the bottom line of the screen, move cursor to the beginning of the next line and clear that line. If the cursor is at the bottom line, scroll up.
%TDNOP	210	No-op; should be ignored.
%TDORS	214	Output reset. This code serves as a data mark for aborting output much as IAC DM does in the ordinary TELNET protocol.
%TDQOT	215	Quotes the following character. This is used when sending 8-bit codes which are not %TD codes, for instance when loading programs into an intelligent terminal. The following character should be passed through intact to the terminal.
%TDFS	216	Non-destructive forward space. The cursor moves right one position; this code will not be sent at the end of a line.
%TDMV0	217	General cursor position code. Followed by two bytes; the new vertical and horizontal positions.
%TDCLR	220	Erase the screen. Home the cursor to the top left hand corner of the screen.
%TDBEL	221	Generate an audio tone, bell, whatever.
%TDILP	223	Insert blank lines at the cursor; followed by a byte containing a count of the number of blank lines to insert. The cursor is unmoved. The line the cursor is on and all lines below it move down; lines moved off the bottom of the screen are lost.
%TDDLP	224	Delete lines at the cursor; followed by a count. The cursor is unmoved. The first line deleted is the one the cursor is on. Lines below those deleted move up. Newly-created lines at the bottom of the screen are blank.

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OUTPUT -- DISPLAY PROTOCOL (%TD CODES) (continued)

%TD code	Value	Meaning
%TDICP	225	Insert blank character positions at the cursor; followed by a count. The cursor is unmoved. The character the cursor is on and all characters to the right on the current line move to the right; characters moved off the end of the line are lost.
%TDDCP	226	Delete characters at the cursor; followed by a count. The cursor is unmoved. The first character deleted is the one the cursor is on. Newly-created characters at the end of the line are blank.
%TDBOW	227	Display black characters on white screen. HIGHLY OPTIONAL.
%TDRST	230	Reset %TDBOW and such any future options.

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STANFORD/ITS CHARACTER SET

This section describes the extended ASCII character set. It originated with the character set developed at SAIL but was modified for 1968 ASCII.

This character set only applies to terminals with the %TOSAI and %TOFCI bits set in its TTYOPT word. For non-%TOSAI terminals, the standard ASCII printing characters are the only available output characters. For non-%TOFCI terminals, the standard ASCII characters are the only available input characters.

PRINTING CHARACTERS

The first table describes the printing characters. For output, the 7-bit code is sent (terminal operations are performed by %TD codes). For input, the characters with values 000-037 and 177 must have the %TXTOP bit on to indicate the graphic is intended rather than a function or ASCII control.

Value	Character
4000	centered dot
4001	downward arrow
4002	alpha
4003	beta
4004	logical AND
4005	logical NOT
4006	epsilon
4007	pi
4010	lambda
4011	gamma
4012	delta
4013	uparrow
4014	plus-minus
4015	circle-plus
4016	infinity
4017	partial delta
4020	proper subset (left horseshoe)
4021	proper superset (right horseshoe)
4022	intersection (up horseshoe)
4023	union (downward horseshoe)
4024	universal quantifer
4025	existential quantifier
4026	circle-X
4027	double arrow
4030	left arrow
4031	right arrow
4032	not-equal
4033	lozenge (diamond)
4034	less-than-or-equal
4035	greater-than-or-equal
4036	equivalence
4037	logical OR
0040	first standard ASCII character (space)
..	. . .
0176	last standard ASCII character (tilde)
4177	integral

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STANFORD/ITS CHARACTER SET (continued)

FUNCTION KEYS AND SPECIAL CHARACTERS

In addition, the following special characters exist for input only. These characters are function keys rather than printing characters; however, some of these characters have some format effect or graphic which they echo as; the host, not the SUPDUP program, handles any such mappings.

Value	Character	Usual echo	Usual Function
0000	[NULL]		
0010	[BACK SPACE]		text formatting
0011	[TAB]		text formatting
0012	[LINE FEED]		text formatting
0013	[VT]		text formatting
0014	[FORM]		text formatting
0015	[RETURN]		text formatting
0032	[CALL]	uparrow-Z	escape to system
0033	[ALTMODE]	lozenge or $	special activation
0037	[BACK NEXT]	uparrow-underscore	monitor command prefix
0177	[RUBOUT]		character delete
4101	[ESCAPE]		local terminal command
4102	[BREAK]		local subsystem escape
4103	[CLEAR]		
4110	[HELP]		requests a help message

BUCKY BITS

For all input characters, the following "bucky bits" may be added to the character. Their interpretation depends entirely upon the host. <TOP> is not listed here, as it has been considered part of the character in the previous tables.

<CONTROL> is different from ASCII CTRL, however, many programs may request the operating system to map such characters to the ASCII forms (with the <TOP> bit off). In this case <META> is ignored.

Value	Key
2000	Reserved
1000	Reserved
0400	<META>
0200	<CONTROL>

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ACKNOWLEDGEMENTS

Richard M. Stallman (RMS@MIT-AI) and David A. Moon (Moon@MIT-MC) of the MIT-AI and MIT-MC systems staff wrote the source documentation and the wonderful ITS terminal support that made this protocol possible. It must be emphasized that this is a functional protocol which has been in operation for some years now.

In addition, Moon, Stallman, and Michael McMahon (MMcM@SRI-KL) provided many helpful comments and corrections to this document.

For further reference, the sources for the known currently existing SUPDUP user programs are available online as:

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[MIT-AI] SYSENG;SUPDUP >                for the ITS monitor,
[SU-AI]  SUPDUP.MID[NET,MRC]            for the SAIL monitor,
[SRI-KL] <MMcM>SD.FAI                   for the TOPS-20 monitor.
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The source for the known currently existing SUPDUP server program is:

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[MIT-AI] SYSENG;TELSER >                for the ITS monitor.
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These programs are written in the MIDAS and FAIL dialects of PDP-10 assembly language.

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