論 文

The Design of the Traffic Generator for the PAD Performance Test

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PAD 성능 측정을 위한 Traffic 발생기의 설계

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ABSTRACT

The CCITT recommendation X.3, X.28, X.29 and X.25 protocols have been efficiently used in subscriber site for the purpose of using existing C_DTE in the PSDN. The Packet Assembly/Disassembly (PAD) which covers these protocols can connect C_DTE to the PSDN. The number of C_DTE connected to the PAD is dependent on the PAD performance. The design of the Traffic Generator (TG) S/W which can measure the PAD performance is introduced in this paper.

要 約

CCITT 권고안 X.3, X.28, X.29 및 X.25를 지원하는 PAD는 가입자에게 산재된 C_DTE를 PSDN에 접속하여 패킷서비스를 제공한다. PAD에 접속될수 있는 C_DTE 갯수는 일반적으로 PAD의 성능에 따라 결정되며, 이 논고에서는 PAD의 성능을 측정하는 TG를 설계하였다.

I. Introduction

Lots of the advanced nations developed data packet exchanges in the middle of 1970 independently. There are various measurement tools for the basic protocol test and the additional performance test of the exchanges.

The Packet Assembly/Disassembly (PAD) which covers X.3, X.28, X.29 and X.25 protocols can connect C_DTE to the PSDN. The PAD performance test is important for deciding the number of C_DTE connected to the PAD. It is also helpful for providing the manufacturer of the PAD with its specification.

The TG consisted of a single H/W board and S/W, is a sort of test tool for measuring the PAD performance. This paper presents the overall design of the TG, especially related to the X.28 protocol and the method of the TG performance test using system commands.

The Central Processing Unit (CPU) of the TG is Z80 and the S/W language is Z80 assembly. The reason why the Z80 CPU is chosen is that the same H/W structure is used for the existing PAD and the TG. Therefore design of the TG H/W isn't needed because the PAD H/W is

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論文番號 : 92-14(接受1991. 9. 24)

used equally. The S/W includes H/W chip initialization part, TGEEPWR part, and application part. These S/W are loaded into PROM and EEPROM according to the feature of the program.

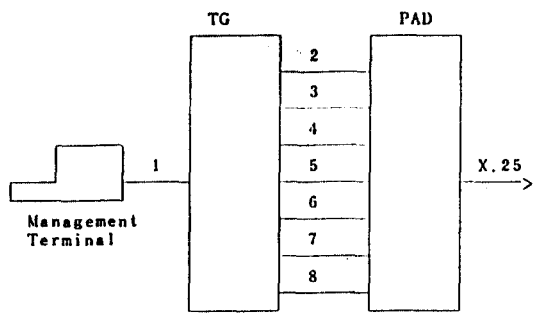
The initialization S/W which processes basic operation in power-up or system restart activates all of the concerned H/W and concentrates on the initialization of the TG S/W. The application S/W activated by receiving the operator command or the PAD service signals is described for calculating the PAD performance parameter and the operator to understand the method of the performance measurement. The TGEEPWR S/W activated by the EEPROM Tx interrupt routine or writing line context data parameter to the EEPROM protects the data which has already changed from other external damage and concentrates on the copy of EEPROM data for external damages (e.x : power off etc.). The initial data for the operation of the TG is stored in the EEPROM.

The MT requests all of the specified commands to the TG, and transmits and receives service signals to/from the PAD. There are various commands to measure the performance in the S/W and many states processing like the other protocol processing.

Ⅱ. System Configuration

The TG S/W which is connected to the MT and the PAD shown in fig.1 is activated by receiving a command from the Management Terminal (MT) or a service signal from the PAD.

The TG consists of 8 lines. One of them is connected to the MT. The other lines (line no.2-line no.8) are connected to the PAD. The Management Terminal (MT) operated by the operator makes all lines operate just like as character mode DTE to PAD.



〈Fig.1〉Connection to the management terminal and PAD.

Ⅲ. S/ W Function

3.1 Initialization S/ W

The initialization S/W processes the following functions.

- system start and restart
- maskable interrupt routine driving and non maskable interrupt processing
- line context initialization

3.2 Application S/ W

The application S/W does the performance calculation of the PAD by operator request commands.

There are four kind of the PAD performance parameters measured :

- Throughput : the number of processed characters per second
- Total calls/Time Unit (TU) : the number of processed calls per TU.
- Total successful calls/TU : the number of processed successful calls per TU.
- Failed trial number : the number of processed trial the success of the tried call.

3.3 TGEEPWR S/ W

The following functions are processed in the initialization S/W.

- EEPROM Tx interrupt processing.
- activate EEPROM write cycle.

- put the copied data on the EEPROM queue.

The following functions are processed in the EEPROM.

- line context data composition.
- composition of initial data for the Z80 Serial Communication Controller (SCC) operation.
- common data storage for every line.
- input and output memory buffer composition for every line and management buffer for line 1.

Ⅳ. S/ W Description

4.1 Initialization S/ W

The initialization S/W is activated on power_up and the serious H/W test is executed. If the verification is successful, the data table is read from EEPROM to RAM. The TG line index table is created in a data RAM, and the value of a pool RAM to store the characters received from C DTE is initialized with zero. During driving the initialization S/W of the TG, a line interface control block is read from EEPROM to check which lines are authorized for use.

4.1.1 Interrupt

There are two kind of interrupts in TG S/W. One of them is maskable interrupt and the other Non Maskable Interrupt (NMI). The maskable interrupt is initialized in the following manner.

- set up I-register
- set interrupt mode 2 : the applicable interrupt is the vectored interrupt mode. This mode allows an indirect call to the memory location of which address is defined by an 8 bit vector supplied by the peripheral interrupt device and by the I-register. This address points to an address in a vector table which contains the start address of the routine to service the interrupt.

The NMI happens and carries out as following sequence when the start address is '66H'.

- check NMI status /write alarm register.
- decide which sort of interrupt happens and proceeds correspondent interrupt and system error.

The NMI is classified into 3 kind :

- interrupt from watchdog
- interrupt from memory management error
- interrupt from memory parity error

4.1.2 Memory mapping

The memory mapping is carried out by translating from 16 bits virtual address to 18 bits real address. The most upper 2 bits are meaningful for calculating 4 Page Address Register (PAR)s the real address is based on. The PAR1 contains the upper byte for application and initial program, PAR2 application program, PAR3 RAM pools and PAR4 the data RAM. The memory mappling is read from EEPROM (PAR4) to copy EEPROM (PAR2) and copy EEPROM (PAR2) to data RAM (PAR3).

4.1.3 Line initialization

When restart or power_up happens in the TG, the data concerned with line authorities which have already been formed have to be kept by coping from EEPROM to RAM context.

4.1.4 Treat of system error

There are three kind of system errors such as watchdog error, memory management error and memory parity error in the TG. When these errors happen, the TG makes Cycle Timer Check (CTC) and SCC chips initialize.

4.2 Application S/ W

4.2.1 Interrupt

All of the interrupts are driven by the calculated interrupt vector table. Especially the Tx, Rx and Real Time Clock Interrupt (RTC_INT) drives the important actions and receiving character. RTC_INT happens every 10 msec. the process calculates the PAD performance parameter every RTC_INT.

4.2.1.1 Tx interrupt

One character has to be transmitted to drive Tx interrupt. The TG checks the condition of X.on or x.off character transmission. Number of Transmitted Character (TXNCH) is increased after transmitting a character. In case of Length of Output Buffer (LOB)=0, the TG reloads data string to the output buffer to drive Tx interrupt continuously.

4.2.1.2 Rx interrupt

A character is received every Rx interrupt and put on the input buffer. The TG checks the condition of x.on or x.off character reception. Number of Received Character (RXNCH) is increased after receiving a character.

4.2.1.3 Real Time Clock interrupt

If the number of RCT_INT equals the following Time Unit (TU), TU+1,.....,TU+7, the process carries out the inevitable things for calculating the PAD performance.

4.2.2 Flow control between the TG and PAD or MT

The TG carries out flow control with the PAD or MT using x.on or x.off character.

4.2.2.1 Memory management of the TG

The TG has three kind of buffers : Input Buffer (IB), Output Buffer (OB) and Management Buffer (MB). Every line connected to the PAD has IB and OB. The line connected to the MT has IB, OB and MB. The purpose of IB stores a character received from the PAD or the MT. The purpose of OB stores a character to be transmitted to the PAD or the MT. Input command received from the MT is stored in the IB of line 1 and transferred to the the MB. The MB is used for handling of the input command copied from IB. IB, OB and MB has 256 bytes.

Thses buffers manages to handle the difference (the length of the buffer) between the input pointer and the output pointer of the buffer. For instance, the Input Buffer Length (LIB) means the difference between the input pointer and the output pointer of IB. If a character is received, the input pointer is incremented by 1. If a character is transmitted, the output pointer is incremented by 1.

4.2.2.2 Flow control regulated by the PAD or TG

If the TG receive x.off character from the PAD or the MT in the data transmission status, the TG stops transmitting character to them. If x.on, the TG starts.

4.2.2.3 Flow control regulated by the TG

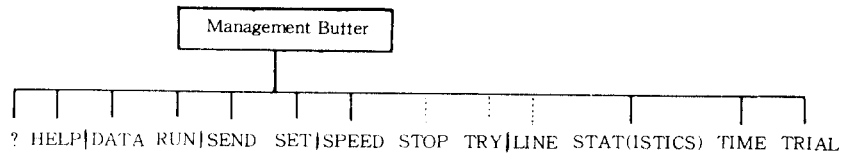
The TG regulates flow control with the PAD and MT by checking its memory status assigned to IB or OB. If the LIB of the TG equals to 128, the TG transmits x.off character to the PAD or MT. If equals to 16, x.on character to them. If equals to 256, nothing to to. If the Output Buffer Length (LOB) of the TG equals to 128, the TG transmits x.off character to the PAD or MT. If equals to 256, doesn't drive Tx interrupt.

4.2.3 Line scanning and analysis

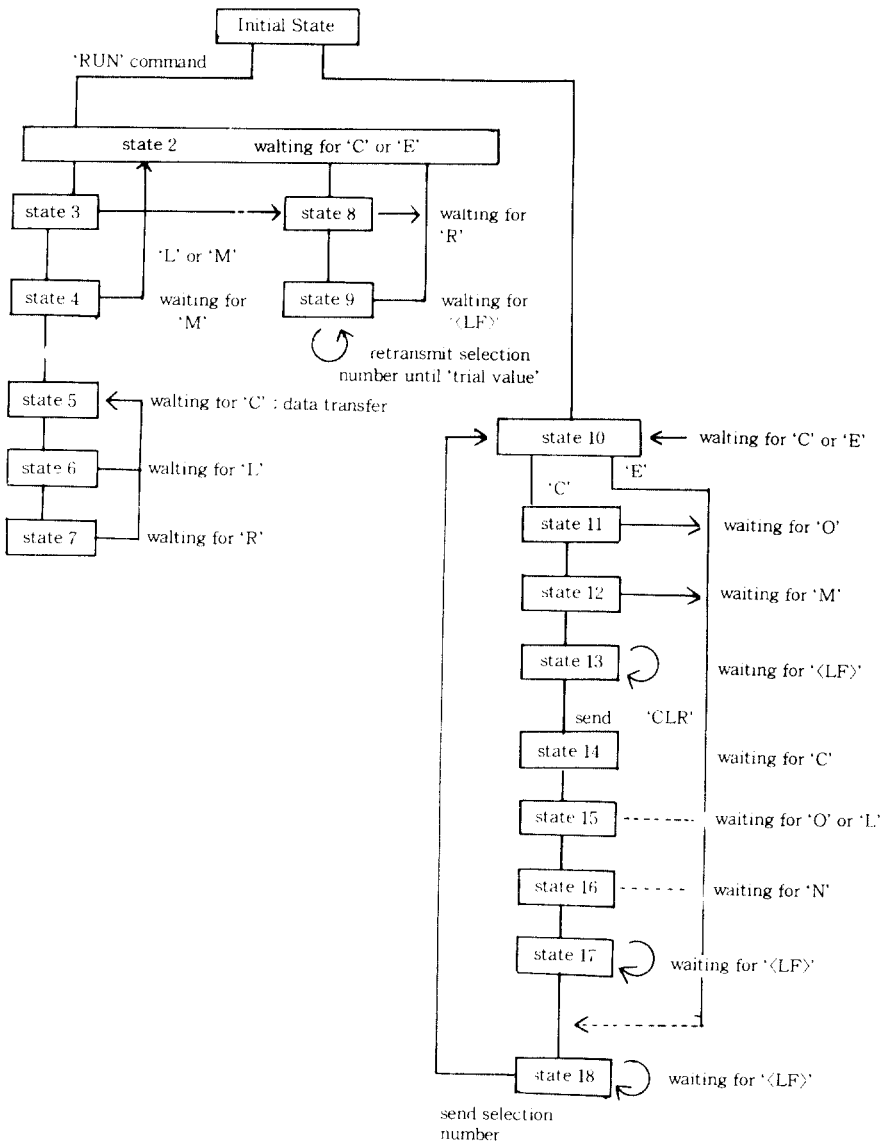
Whenever every line receives character driven by Rx interrupt routine, it sends the character to the IB and the process checks whether any character is put on or not.

4.2.3.1 Line 1 (MT line) scanning

The line 1 receives a character from the MT and checks whether line 1 carries out 'STAT (ISTICS)' command or not. During processing 'STAT(ISTICS)' command, the process jumps to the assigned address. The TG processes the assigned job according to the received character. The line 1 is used for receiving the commands from the MT and putting them on the IB. The contents of the IB are transferred to the MB. The MB checks whether the available commands are received or not. If available commands, the process activates the allocated subroutine. Otherwise the TG transmits the MT error message. Fig. 2 shows all of the commands received from



〈Fig.2〉Management buffer scanning about operator command.



〈Fig.3〉State diagram of line status with conneeted to the PAD.

the MT.

4.2.3.2 Line (no.2-no.8) scanning

The IB of every line is used for receiving character from the PAD. Every line checks whether the available character is received and activates each state routine shown in fig. 3.

The state number from 2 to 10 are used for 'RUN' command. The state number 2,3,4 are used for call set_up 'COM', 2,3,8,9 used for call release Clear Line Feeding ('CLR〈LF〉') after call set_up and 5,6,7 used for call release 'CLR' after data transfer. The state number from 10 to 18 are used for 'TRY' command. The state number 10,11,12 are used for call set_up 'COM', 10,11,13 used for call release 'CLr〈LF〉' after call set_up and 14,15, 16,17 used for call release 'CLr cON〈LF〉' after sending CLR (CLR means clear request of PAD command signal). The state number 18 is used for retransmitting selection number after receiving unsuitable character.

- initial state : in case of initializeation or receiving 'STOP' command.
- state 2 : waiting for the PAD service signal 'C'om〈LF〉 or 'E'rr.
- state 3 : waiting for the PAD service signal c 'O'm or c'L'r.
- state 4 : waiting for the PAD service signal co'M' and transmits the data to the PAD after receiving co'M' message.
- state 5 : increasing the Number of Receiving Character (RXNCH) and waiting for the PAD service signal 'C'lr.
- state 6 : increasing the RXNCH and waiting for the PAD service signal c'L'r.
- state 7 : increasing the RXNCH and waiting for the PAD service signal cl'R'.
- stat 8 : waiting for the PAD service signal cl 'R' or e'R'r.
- state 9 : waiting for the PAD service signal clr'〈LF〉' or err'〈LF〉'.
- state 10 : waiting for the PAD service signal 'C'om〈LF〉 or 'E'rr〈LF〉.
- state 11 : waiting for the PAD service signal c'O'm〈LF〉 or clr'〈LF〉'.
- state 12 : waiting for the PAD service signal co'M'〈LF〉 or clr con'〈LF〉'.
- state 13 : waiting for the PAD service signal com'〈LF〉' and then transmitting CLR to the PAD.
- state 14 : waiting for the PAD service signal 'C'lr conf〈LF〉.
- state 15 : waiting for the PAD service signal c'L'r c'O'n〈LF〉 or clr'〈LF〉'.
- state 16 : waiting for the PAD service signal clr co'N'f〈LF〉 or clr con'〈LF〉'.
- state 17 : waiting for the PAD service signal clr con'〈LF〉' and increasing the Number of Successful Calls (SUCLVA).
- state 18 : waiting for the PAD service signal '〈LF〉' and increasing the Number of Total Calls (TOCLVA).

4.3 TGEEPWR S/ W

The TGEEPWR S/W is activated by the EEPROM Tx interrupt routine or writing line context data parameter to the EEPROM to keep the data against external damage(e.x : power off ect.). When the TG writes the assigned data to the EEPROM, EEPROM Tx interrupt happens. There are three steps to transfer from 'copy EEPROM' to EEPROM. At first the TG checks whether the content of the copied EEPROM equals to the content of 'copy EEPROM' (e.g data copy has already happened). If copy had already happened, the TG would have checked next byte to transfer. Otherwise checks whether copied region has already cleared. If clearance of the region of EEPROM had already happened, the real copied data is transferred from 'copy EEPROM' to EEPROM. Otherwise clearing the region to be copied happens first, the real copy is done as the following procedure :

- EEPROM Tx interrupt : transfer the copied data from 'copy EEPROM' to EEPROM. Whenever copy is done, this interrupt happens.
- loading the data on the EEPROM queue :

data copy is transferred from RAM to 'copy EEPROM'.

- activating EEPROM write cycle : transfer the copied data from 'copy EEPROM' to EEPROM according to the given condition and allocate EEPROM copied pointer and length. If copied length is zero, the TG deactivates write cycle. Therefore EEPROM Tx interrupt stops.

V. Call phase

Call phase consists of call set up, data transfer and release.

5.1 Call set_up

Every line starts call set up after 'RUN' or 'TRY' commands. If the TG receives 'RUN' command from the MT, the TG transfers the call state to number 2. If the TG receives 'COM' message from the PAD at this time, the TG enters into data transfer state. Otherwise the TG retransmits selection number until call set up is established within the number of trial value. If call set_up fails, the TG sends 'error message' to the MT.

5.2 Data transfer

In case of existence of the data string, the TG transmits the data to the PAD, otherwise the TG can only receive a data string from the PAD.

5.3 Call release

Call release is classified into two kind : The TG transmits CLR message to the PAD after receiving 'STOP' command from the MT, the TG can receive 'CLR DTE' message from the PAD in case of invitation to clear.

VI. System Commands

6.1 Command Specification

6.1.1 Input

Input commands received from the MT consist of system commands, operation command, inquire commands and system and inquire commands as follows :

- System commands : ?, HELP
- Operation commands : DATA, RUN, STOP, SEND, SET, SPEED, TRY
- Inquire commands : LINE, STAT(TISTICS)
- System and inquire commands : TIME, TRIAL

6.1.2 Output

Output commands is originated as the response of the input commands. If the input commands enter to the TG as specified form, the TG transmits a reply message or error message. The reply messages are follows :

- MF〉 : prompt when every command finishes.
- Response of 'STAT(ISTICS)' :
  - Troughput / TU
  - Total calls / TU
  - Total successful calls / TU
  - Fail trial value
- Response of 'TIME' : Time value
- Response of 'TRIAL' : Trial value

6.2 Command analysis

6.2.1 '?', 'HELP' command

The TG sends all kind of the commands to the MT.

6.2.2 'DATA' command

The TG checks wheter the command corresponds to one or all lines. The command is classified into 3 kind : # means the line number of the TG in the command.

- DATA : the TG has nothing to do.
- DATA# : the TG source data string which has already been copied to the EEPROM.
- DATA#〈data string〉 : 〈data string〉 means that the MT requests the TG to change original data string to the new typed data string. The new typed data string is copied to the EEPROM.

The data copied in the EEPROM is transmitted during data transfer.

6.2.3 'RUN' command

The TG checks whether the TG has already received TRY command from the MT in advance. If so, the TG transfers the call state to number 10 and tries to process TRY command. Otherwise the TG transfers the call state to number 2 and tries to process RUN command.

6.2.4 'SEND' command

The TG checks whether the command corresponds to one or all lines. The command is classified into 3 kind : # means the line number of the TG in the command.

- SEND : the TG has nothing to do.
- SEND# : the TG source selection number string which has already been copied to the EEPROM.
- SEND#〈selection number string〉 : 〈selection number string〉 means that the MT requests the TG to change original selection number string to the new typed selection number string. The new typed selection number string is copied to the EEPROM.

The new typed selection number is transmitted in processing the RUN or TRY command.

6.2.5 'SET' command

Al of the information about PAD profile parameter received from the MT has to be transmitted to the PAD. The line number needn't at this command. So to speak, such a command (SET X : Y〈CR〉) is enough.

6.2.6 'SPEED' command

This command doesn't affect on the state which has already been run ('SPEED' command after 'RUN'). The changed speed information is copied to EEPROM and changes initial H/W structure to cope with the changed speed.

6.2.7 'STOP' command

The TG makes the state initialize, sends CLR message to the PAD and resets all the concerned data structure.

6.2.8 'TRY' command

This command is applied in the existence of the selection number. This command doesn't affect on the state which has already been run ('TRY' command after 'RUN').

6.2.8 'STAT(ISTICS)' command

This command is possible for 'STAT' or 'STATISTICS'. There are lots of things to do after receiving this command because there are too much data to be transmitted to the MT.

6.2.9 'TIME' command

'TIME' command is used for two kind of purposes. At first the operator wants to know the time value in case of hitting directly 〈CR〉 after the command. At second the operator wants to change the time value in case of the requested value after the command. At this case the information is copied to EEPROM.

6.2.10 'TRIAL' command

'TRIAL' command is used for two kind of purposes : At first the operator wants to know the trial value in case of hitting directly 〈CR〉 after the command. At second the operator wants to change the trial value in case of the requested value after the command. The information is copied to EEPROM at this case.

Ⅶ. Results

The H/W of the TG and the PAD is identical and their processors and Z80. The measurement of SUCLVA of the PAD is carried out according to the subsequent action of the call establishment and clearance. The measurement of the PAD throughput is carried out during data transfer.

The PAD performance mainly depends not on total number of links connected to the PAD but on total data speed of the each link, simultaneously used, connected to the PAD. The maximum throughput of the PAD using 8 bit CPU is about 20 packets per second and the call handing capacity is 5 calls per second.

Ⅷ. Conclusions

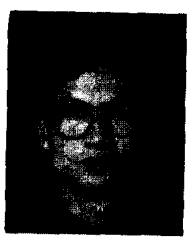
The PAD performance using 8 bit processor is measured. The throughput of the PAD is affected by the total output data speed of each link simultaneously used. The measurement of the performance in the packet switching of ISDN environment will be needed. The concept designing the TG will provide valuable aid for those who are interested in the test tool of the packet switching in the ISDN environment.

References

1. CCITT Rec. X.28, Blue Book
2. CCITT Rec. X.3, Blue Book
3. H. Van de Wielle, "H/W Description of the Protocol Converter and Concentrator", ITT 145 61106.

Abbreviation

CDTE (Character Mode Data Terminal Equipment)
CLR (Clear Request)
CLR CON(F) (Clear Confirmation)
COM (Call Confirmation)
CR (Carriage Return)
EEPROM (Electrically Erasable PROM)
ERR (Error)
IB (Input Buffer)
ISDN (Integrated Service Digital Network)
LF (Line Feeding)
LIB (Input Buffer Length)
LOB(Output Buffer Length)
MB (Management Buffer)
OB (Output Buffer)
PAD (Packet Assembly/Disassembly)
PSDN (Public Switched Data Network)
RTCINT (Real Time Clock Interrupt)
RXNCH (Number of Received Character)
SUCLVA (Number of Successful Calls)
TG (Traffic Generator)
TOCLVA (Number of Total Calls)
TXNCH (Number fo Trasmitted Character)



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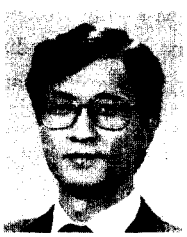

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