



# The Local Computer Network in Tohoku District, Japan

Masunaga, Y.

IIASA Working Paper

WP-75-102

1975



Masunaga, Y. (1975) The Local Computer Network in Tohoku District, Japan. IIASA Working Paper. WP-75-102 Copyright © 1975 by the author(s). <http://pure.iiasa.ac.at/326/>

**Working Papers** on work of the International Institute for Applied Systems Analysis receive only limited review. Views or opinions expressed herein do not necessarily represent those of the Institute, its National Member Organizations, or other organizations supporting the work. All rights reserved. Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage. All copies must bear this notice and the full citation on the first page. For other purposes, to republish, to post on servers or to redistribute to lists, permission must be sought by contacting [repository@iiasa.ac.at](mailto:repository@iiasa.ac.at)

The Local Computer Network in  
Tohoku District Japan

Yoshifumi Masunaga

August 1975

WP-75-102

Working Papers are not intended for distribution outside of IIASA, and are solely for discussion and information purposes. The views expressed are those of the author, and do not necessarily reflect those of IIASA.

PREFACE

This Working Paper gives an outline of the local computer network in the Tohoku district of Japan, in which the design and implementation I participated in during 1974 at the Research Institute of Electrical Communication, Tohoku University, Japan.

At present IIASA is planning its own inter-European computer network, which will be able to interconnect with many existing computer networks, including EIN and those existing in Eastern Europe.

This program has already commenced with the interconnection of three computer centres, IIASA, Bratislava (Czechoslovakia) and Budapest (Hungary) using a European public switched telephone line. It is planned to use:

- a line switching technique to interconnect two computer centres;
- packets as a unit of information transmission on telephone lines;
- an asynchronous serial data transmission technique;
- a half duplex communication facility, and
- 1200 baud communication speed.

I should mention here that the above techniques, computer centre facilities and the topological location of the computer centres are very similar to the computer network in the Tohoku district, and this is the reason why I am writing this paper. I will describe briefly the design of this computer network, which consists of the following five sections.

TABLE OF CONTENTS

|  |    |
|--|----|
| INTRODUCTION .....   | 4  |
| I NETWORK SCHEME .....   | 4  |
| 1.1 Six Terminal Mini-Computer Facilities .....  | 4  |
| 1.2 Topological Situation .....  | 5  |
| 1.3 Logical Network Scheme .....   | 6  |
| 1.4 Public Switched Telephone Line .....   | 6  |
| II PROTOCOLS .....   | 7  |
| 2.1 Introductory Remarks .....   | 7  |
| 2.2 Hierarchical Structure of Protocols .....  | 7  |
| 2.3 HOST-HOST Protocol .....   | 7  |
| 2.4 IMP-IMP Protocol .....   | 8  |
| 2.4.1 Using Code .....   | 8  |
| 2.4.2 Transmission Control .....   | 9  |
| 2.4.3 Header .....   | 9  |
| 2.5 Command Packet .....   | 11 |
| 2.5.1 IMP-IMP Commands .....   | 12 |
| III FLOW CONTROL .....   | 14 |
| 3.1 Communication Diagram .....  | 14 |
| 3.2 IMP-IMP, ACK and NAK Information Examples ....   | 17 |
| 3.3 Control of Public Switched Telephone Line ....   | 18 |
| 3.3.1 Flow Chart .....   | 18 |
| 3.3.2 Mutual Confirmation .....  | 19 |
| 3.3.3 Ring-off Procedures .....  | 19 |
| 3.4 Packet Analysis .....  | 22 |
| IV IMPLEMENTATION--CASE STUDY FOR THE FACOM U-200 SYSTEM                                       | 25 |
| 4.1 Introductory Remarks .....   | 25 |
| 4.2 Machine Configuration .....  | 25 |
| 4.3 DPS Interrupt .....  | 26 |
| 4.4 DPS External Interrupt Handling Flow Chart ...   | 27 |
| 4.5 Extended DPS to Accept Public Switched<br>Telephone Line Communication .....               | 29 |
| 4.6 Design of the UCB for Public Switched Telephone<br>Telephone Line Interrupt Handling ..... | 31 |
| 4.7 Network Control Program (NCP) .....  | 32 |

---

## INTRODUCTION

The Tohoku Local District Computer Network is designed to connect six mini-computers in three universities in the Tohoku district, Japan, in order to realize the concept of resource sharing using a public switched telephone line.

This is a two year plan directed by Professor J. Oizumi of the Research Centre for Applied Information Sciences, Tohoku University, Sendai, Japan. It was financially supported by the Ministry of Education in Japan to the amount of 25,000,000 Yen/year (1,400,000 AS/year) and commenced on 1 April, 1974. Up to now, we have set up so called IMP-IMP protocols and implemented the network control program realizing the protocols on each mini-computer.

### I NETWORK SCHEME

#### 1.1 Six Terminal Mini-Computer Facilities

- A. Research Institute for Electrical Communication,  
Tohoku University, Sendai  
FACOM U-200 system: 32 KB core, 26 KB drum, DOS;
- B. Large Computer Centre, Tohoku University, Sendai  
OKITAC 4300-C system: 16 KW core;
- C. Research Centre for Applied Information Sciences,  
Tohoku University, Sendai  
OKITAC 4300-C system: 24 KW core, 5.12MB disc,  
DOS;
- D. Faculty of Engineering, Tohoku University,  
Sendai  
OKITAC 4500-C system: 20 KW core, 2MB disc, DOS;

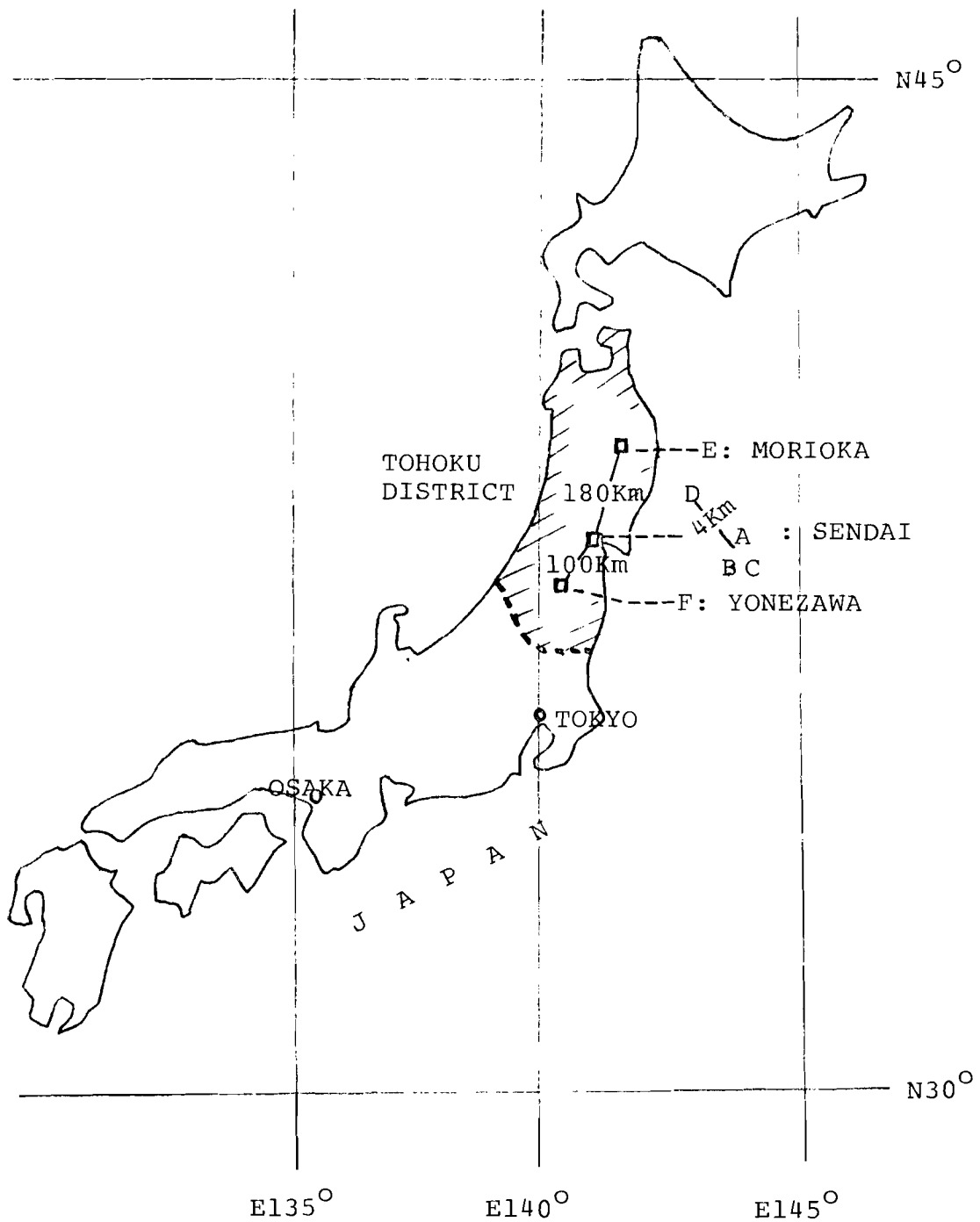
E. Faculty of Engineering, Iwate University,  
Morioka, Iwate

OKITAC 4300-S system: 8KW;

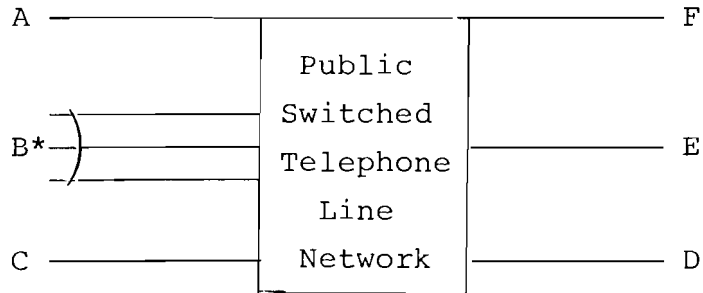
F. Faculty of Engineering, Yamagata University,  
Yonezawa, Yamagata

TOSBAC 40-A system: 48KB core, 2MB x 2 disk, DOS.

1.2 Topological Situation



1.3 Logical Network Scheme



1.4 Public Switched Telephone Line

- a) Lines are offered by the Japan Telegram and Telephone Corporation.
- b) 1200 bps, asynchronous, half duplex usage (200 or 300 bps, asynchronous, full duplex usage is also available).
- c) Line quality  
Bit error rate is announced by the Japan Telegram and Telephone Corporation to be  $10^{-5}$  under 80% connected calls.

d) Charge

Minimum charge:\*\*

7 Yen/3min. (36 Groschen/3 min.)

140 Yen (7.3 AS)/1 hour

3,360 Yen (175 AS)/1 day

100,800 Yen (5,550 AS)/1 month = 30 days

1,209,600 Yen (63,000 AS)/1 year = 365 days.

---

\*One now, three in the future.

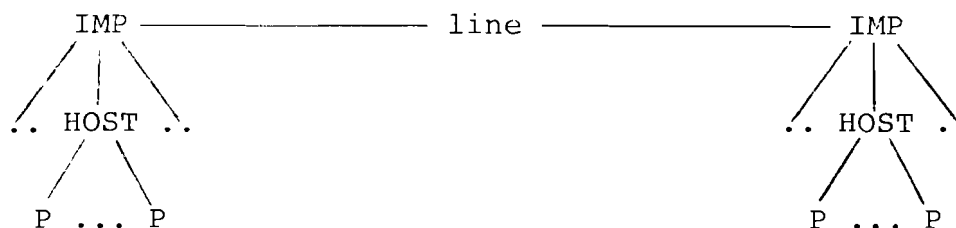
\*\*Stations A, B, C, and D can communicate with each other in this charge.



## II PROTOCOLS

### 2.1 Introductory Remarks

- a) Each terminal mini-computer will run in multi-programming mode in the near future.
- b) Because we use a public switched telephone line, communication traffic is switched in a so called "Line Switching" manner. But after the connection is established, communications are carried out using "Packets" as a unit of communication.
- c) Inter-process communication is carried out in the following hierarchical structure.



P: Process

IMP: An interface message processor which interfaces between line and HOST

HOST: Computer system with operating system.

### 2.2 Hierarchical Structure of Protocols

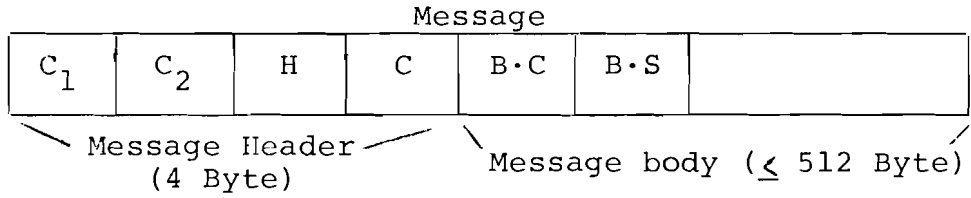
- a) IMP-IMP Protocol;
- b) IMP-HOST Protocol;
- c) HOST-HOST Protocol;
- d) User Level Protocol.

### 2.3 HOST-HOST Protocol

HOST-HOST Protocol supports inter-process communication.

Message: A unit of information (data and control elements) transmitted inter-HOST in a specified format.

Message Format



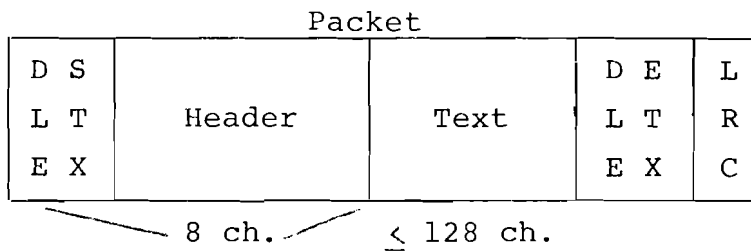
- C<sub>1</sub> : Message priority;
- C<sub>2</sub> : Kind of message;
- H : Destination Host number;
- C : Connection number;
- B·C: Byte length of message (Byte count);
- B·S: 9 (constant) (Byte size).

2.4 IMP-IMP Protocol

IMP-IMP Protocol supports inter-Host communication.

Packet: A unit of information transmitted inter-IMP in a special format.

Packet Format



- a) Regular packet: Text part is not empty;
- b) Null packet: Text part is empty.

2.4.1 Using Code

- a) JIS\* C6220 (7 bit code) + one parity bit  
(even parity);
- b) Lower order bit transmitted first.

---

\*Japan Industrial Standard.

Parity bit is the highest order.

Bit pattern on line:

start bit,  $b_1$ ,  $b_2$ , ...  $b_7$ , parity bit, stop bit —.

2.4.2 Transmission Control

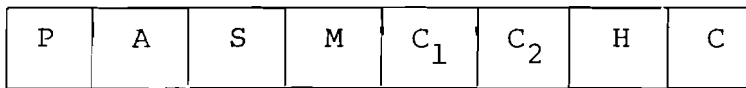
- a) D  $\begin{matrix} b_1 & & b_8 \\ \downarrow & & \downarrow \end{matrix}$   
L (00001001)  
E
- b) S  
T (01000001)  
X
- c) E  
T (11000000)  
X
- d) E  
N (10100000)  
Q

The following three combinations are permitted as transmission control codes:

|      |      |      |
|------|------|------|
| D S  | D E  | D E  |
| L T  | L T  | L N  |
| E X, | E X, | E Q. |

2.4.3 Header

Length of header is 8 characters.



Message header

P: Attribute of a packet

$b_7$ : If 1, then this packet is an IMP-IMP command;

$b_6$ : If 1, then this packet is in high priority;

$b_{5,4}$ : Not used.

$b_3$ : If 1, then this is the first packet;

$b_{2,1}$ : Packet number.

Order is 11, 10, 01, 00 in turn. But the last packet should be numbered 00.

A: Acknowledgement Information

$b_7$ : If 1, then the source IMP requests the destination IMP not to send any more regular packets\* until  $b_7$  turns off;

$b_{6,5,4,3}$ : Not used;

$b_{2,1}$ : 00 — NULL

01 — ACK

10 — NAK

11 — Not used.

S: Source place

$b_{1,2}$ : Identify HOST;

$b_{3,4,5,6,7}$ : Identify IMP.

The first HOST connected to the IMP should be numbered 01. In our case:

Station A — 00100( $b_3 \dots b_7$ )

Station B — 00010

Station C — 00001

Station D — 00011

Station E — 00101

Station F — 00110

M: Message No.

IMP gives a number for every message in ascending order for each destination.

$C_1, C_2, H, C$ : Message header.

---

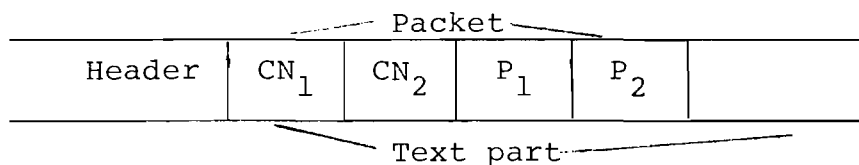
\*Except a packet with a high priority and a command packet.

Remarks

- 1) L must be doubled as L L in the Header part and  
the Text part. But the length of L L must be  
counted as 1
- 2) Any character which precedes L has no meaning.
- 3) R applies from the beginning of the Text part to  
the last (including T). But L L must be summed  
up as if it were L.
- 4) Packet with  $b_7$  of P = 1 is called a "command  
packet". In this case, any other bits except  
 $b_{7,2,1}$  of A have no meaning.  
The type of command is specified in the Text  
part. The length of command is limited to one  
packet.
- 5) Message with high priority should be sent by  
packet with  $b_6$  of P being 1.

2.5 Command Packet

Format



CN : Command name;

P : Command parameter;

CN<sub>1</sub>: Future use;

CN<sub>2</sub>: Command name

b<sub>7</sub>: command which requires reply from the destination IMP;

b<sub>6, ..., 1</sub>: command in binary form.

When the destination IMP receives command packet with b<sub>7</sub> of CN<sub>2</sub> = 1, then the destination IMP must reply to a (command) packet with b<sub>7</sub> of CN<sub>2</sub> = 0 to the source IMP.

#### 2.5.1 IMP-IMP Commands

a) Here command

Function: Information about the destination IMP.

Format: Here P<sub>1</sub>, P<sub>2</sub>.

Code:  $\begin{cases} 1000001 & \text{--- source} \\ 0000001 & \text{--- destination's reply} \end{cases}$

P<sub>1</sub> --- source IMP code

P<sub>2</sub> --- destination IMP code.

b) Terminate command

Function: A request for the destination to cut the communication line.

Format: Terminate P<sub>1</sub>.

Code:  $\begin{cases} 1000010 & \text{--- source} \\ 0000010 & \text{--- destination's reply} \end{cases}$

P<sub>1</sub> ---  $\begin{cases} 0000000 & \text{--- negative reply for cutting} \\ 0000001 & \text{--- request for cutting*} \\ 0000010 & \text{--- provisional request for cutting*} \end{cases}$

---

\*If the reply of the destination is positive, the destination must send the same code of P<sub>1</sub> to the source.

c) Status command

Function: Specify the initial status at the beginning of the connection.

Format: Status  $P_1$ .

Code:  $\begin{cases} 1000011 & \text{--- source} \\ 0000011 & \text{--- destination's reply} \end{cases}$

$P_1$  —  $\begin{cases} 0000000 & \text{--- negative reply} \\ & \text{initial connection*} \\ 0000001 & \text{--- connection after} \\ & \text{provisional} \\ 0000010 & \text{--- cutting*} \end{cases}$

d) Echo command

Function: Request to the destination to send back the comment part as a packet.

Format: Echo Comment (the length of comment part is at most 126 characters).

Code:  $\begin{cases} 1000100 & \text{--- source} \\ 0000100 & \text{--- destination's reply} \end{cases}$

e) Type command

Function: Request to the destination to type out the comment part.

Format: Type Comment (the length of comment part is at most 126 characters).

Code: 0000101 — source.

f) Check command

Function: Specify the change of error check method alternatives.

Format: Check  $P_1$ .

Code:  $\begin{cases} 1000110 & \text{--- source} \\ 0000001 & \text{--- destination's reply} \end{cases}$

---

\*If the reply of the destination is positive, the destination must send the same code of  $P_1$  to the source.

0000000 — negative reply  
P<sub>1</sub> — 0000001 — change to normal error  
                    check method (VRC/LRC)\*  
0000010 — discontinue error checking\*.

g) Error command

Function: Announcement to the source IMP  
          from the destination IMP when the  
          latter finds some errors in the  
          receiving packet.

Format: Error P<sub>1</sub> Message.

Code: 0000111 — destination

P<sub>1</sub> — not yet designed (type of error  
          will be specified).

h) Report command

Function: Request answer about the statistical  
          information.

Format: Report P<sub>1</sub>.

Code: 1001000 — source  
      0001000 — destination's reply

P<sub>1</sub> — classifying number of statistical  
          information item. Answer will be  
          packed in the text part (details  
          are not yet designed).

### III FLOW CONTROL

#### 3.1 Communication Diagram

This computer network has the following three special  
features:

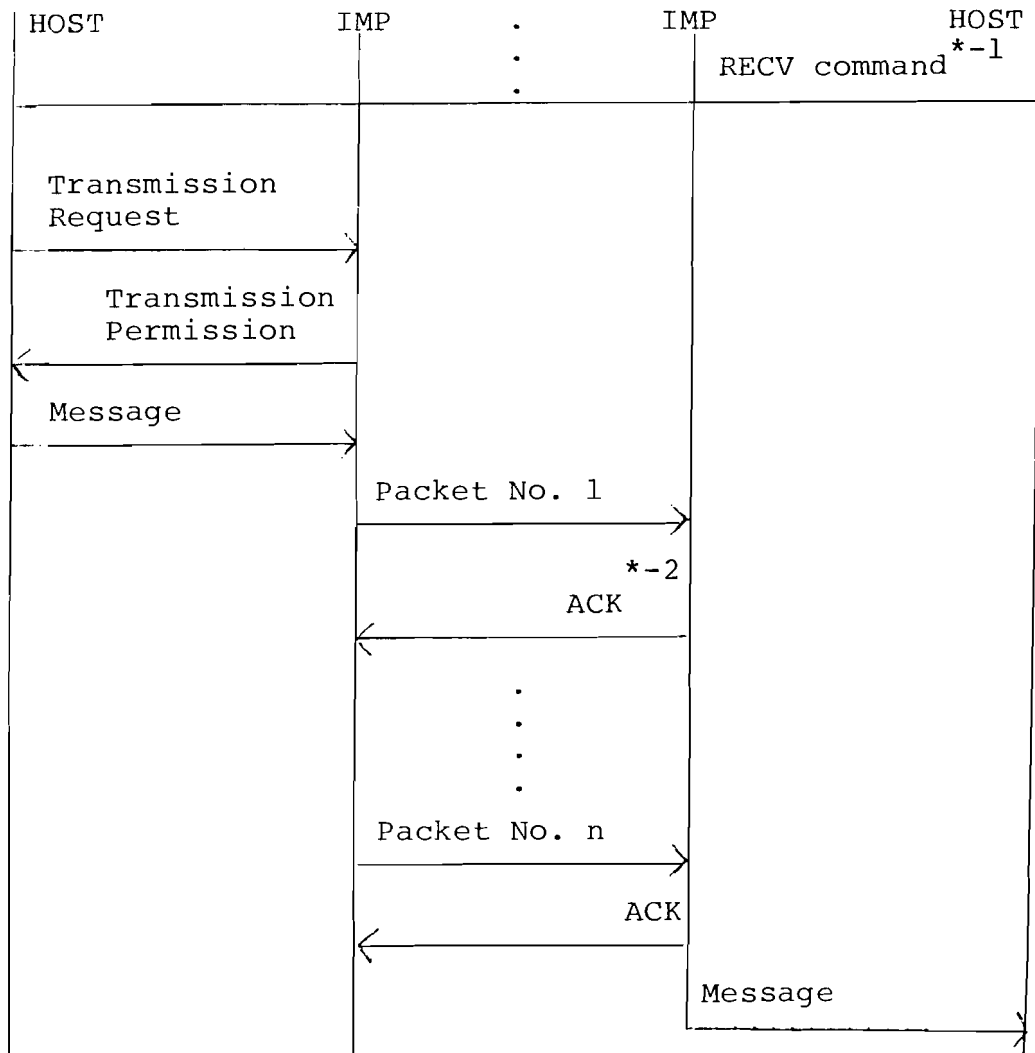
---

\*If the reply of the destination is positive, the  
destination must send the same code of P<sub>1</sub> to the source.



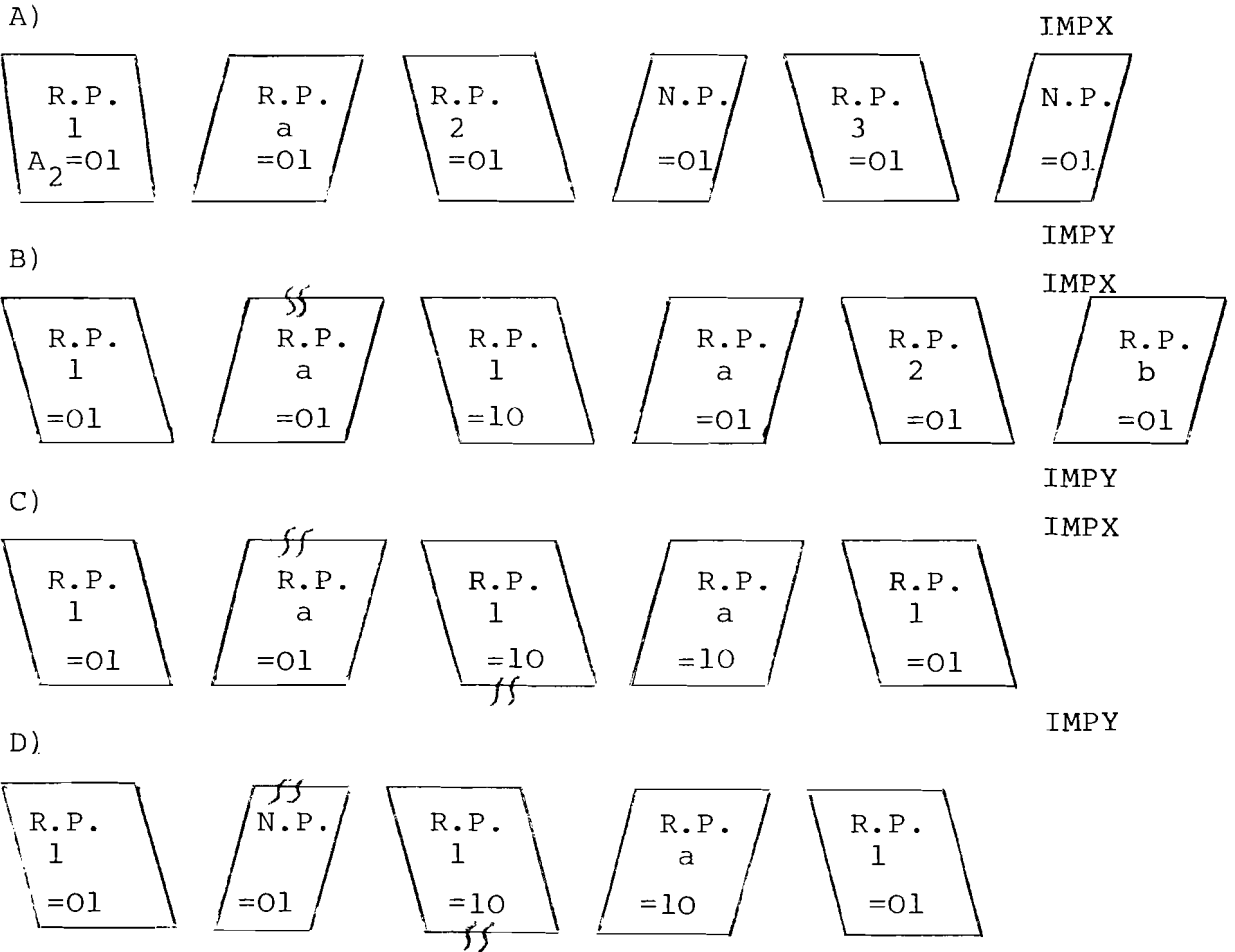
- a) Because each IMP is designed to have connection with only one public switched telephone line, the sending order of the packets from the source IMP is always identical to the receiving order of the packets at the destination IMP. So the ordering problem does not occur.
- b) Transmission speed between IMP's (1200 bps) is much slower than that between IMP and HOST.
- c) There will not be more than two or three concurrent processes in one computer in a multi-programming mode, because the terminal computer is so small.

Then the following communication diagram will be applicable:



- \*-1 Using RECV command, the destination HOST informs the source HOST it has enough buffers to receive a message.
- \*-2 The destination IMP must reserve necessary buffers to receive the specified number of packets, which is at most 4 in our case. If it succeeds, ACK command must be sent. If it does not succeed, wait acknowledgement must be sent.

3.2 IMP-IMP, ACK and NAK Information Examples\*



R.P.: Regular packet

N.P.: Null packet

=01 : ACK

=10 : NAK

~~ff~~ : Error

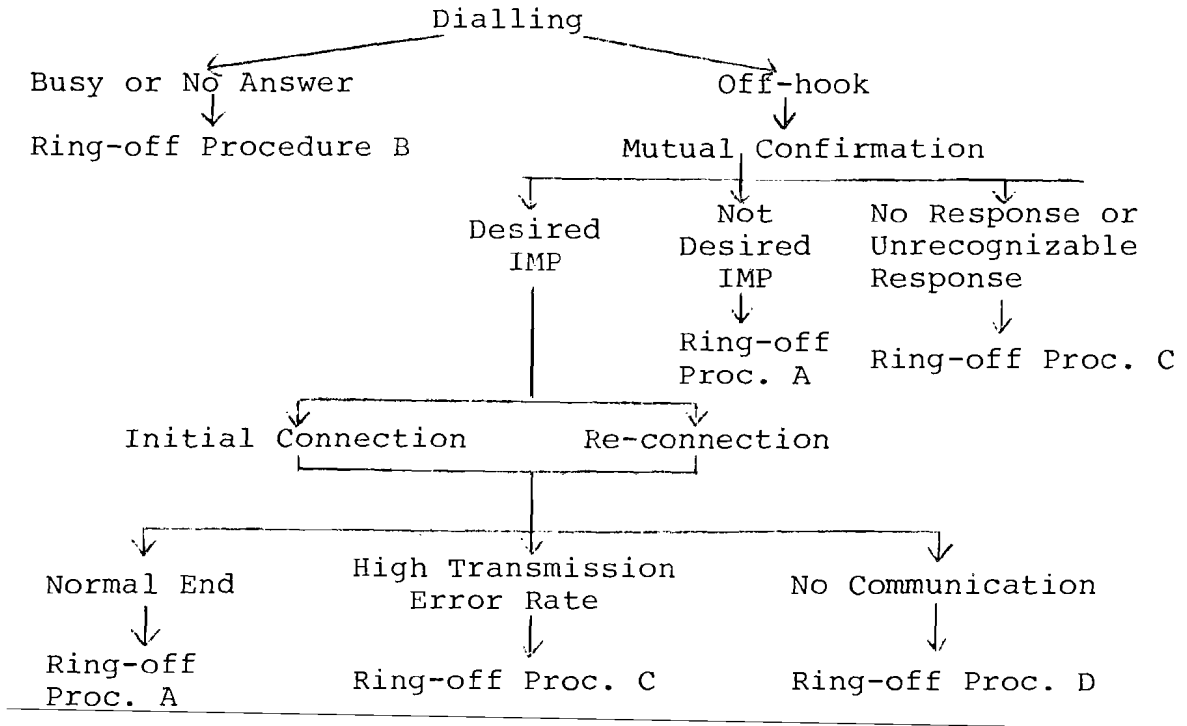
---

\*For more details about acknowledgement information, see Section 3.4.

### 3.3 Control of Public Switched Telephone Line

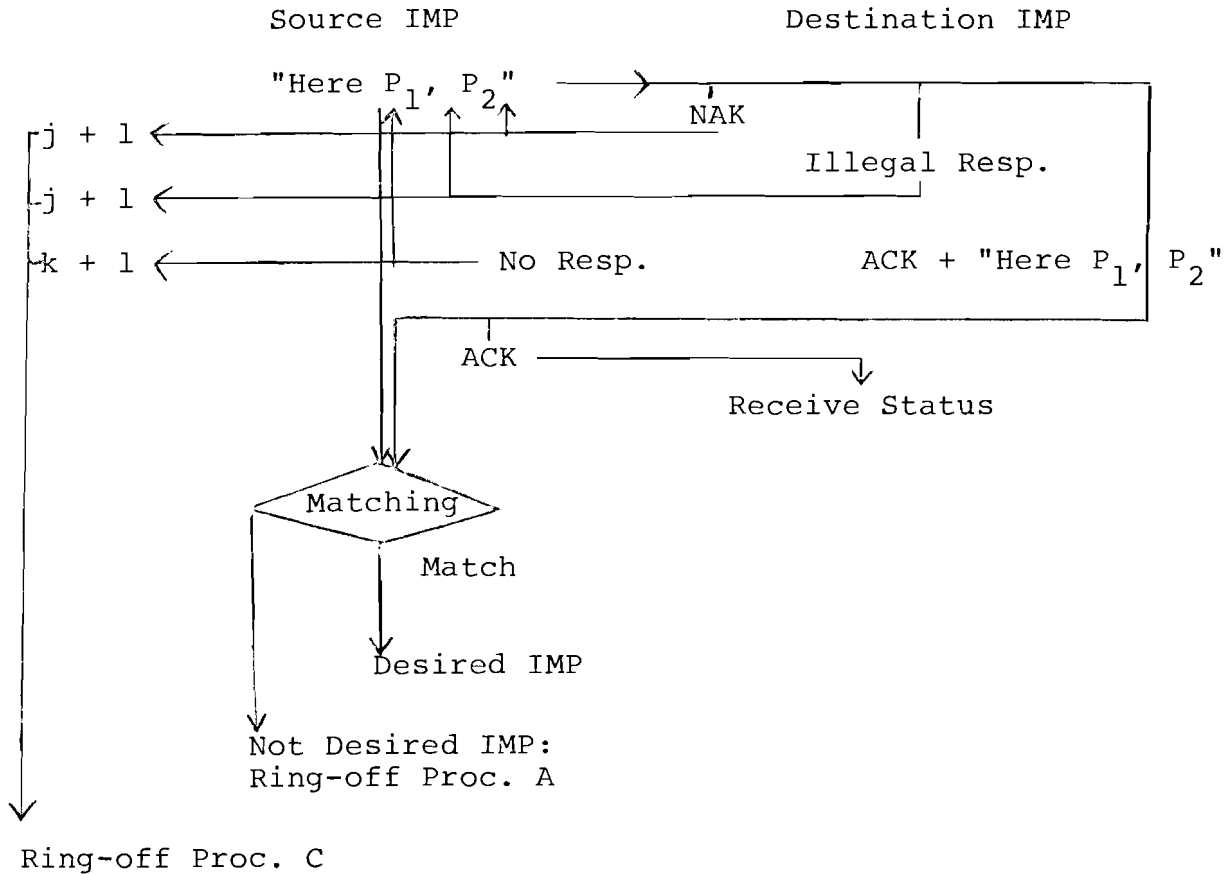
Any communication starts by dialling and ends by ringing off. But there are several different ring-off procedures corresponding to the communication status.

#### 3.3.1 Flow Chart



### 3.3.2 Mutual Confirmation

To make mutual confirmation we use "Here" command.



### 3.3.3 Ring-off Procedures

a) Procedure A.

•Normal end.

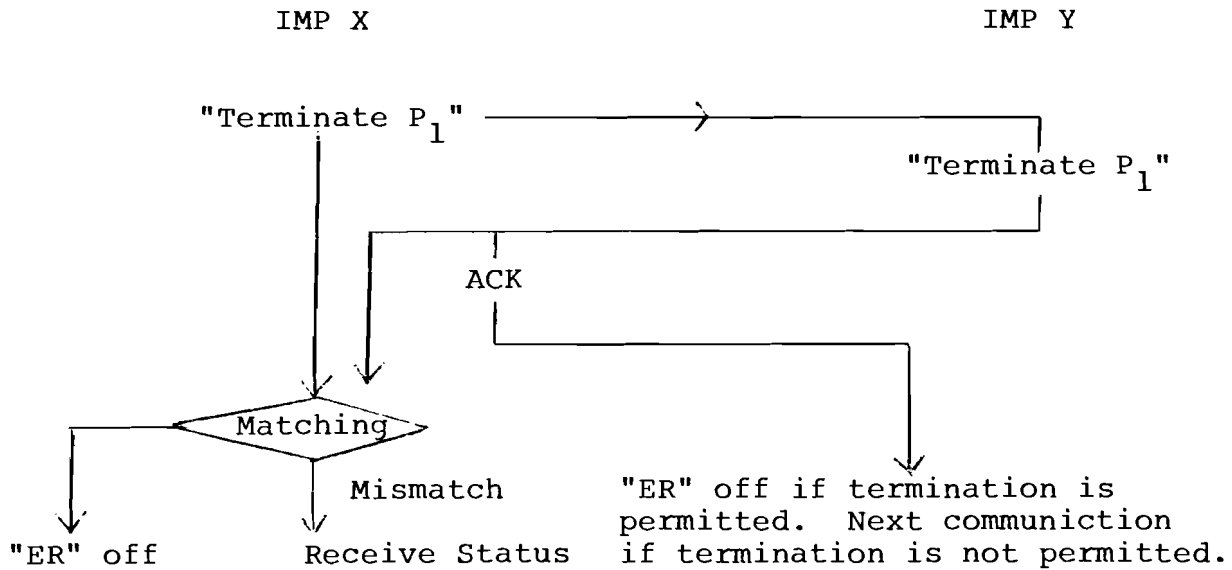
•Not desired IMP.

This procedure uses "Terminate" command.

For normal end, both the source IMP and the destination IMP are able to issue this command.

But for the not-desired IMP case, the source IMP should issue this command.

The next is a diagram for procedure A.



b) Procedure B.

- Busy or no answer.

The source IMP turns "ER(Equipment Ready)" off directly.

c) Procedure C.

- No response or unrecognizable response after off-hook.
- High transmission error rate between IMPs.
- When the IMP accepts illegal calls.

In this case, the IMP can ring off after sending  
D E  
a sequence of 64 pairs of L N. The destination  
E Q  
IMP can ring-off after receiving two pairs of  
it. Only in this case, packet format is not  
necessary for the transmission of this sequence.

d) Procedure D.

- No communication.

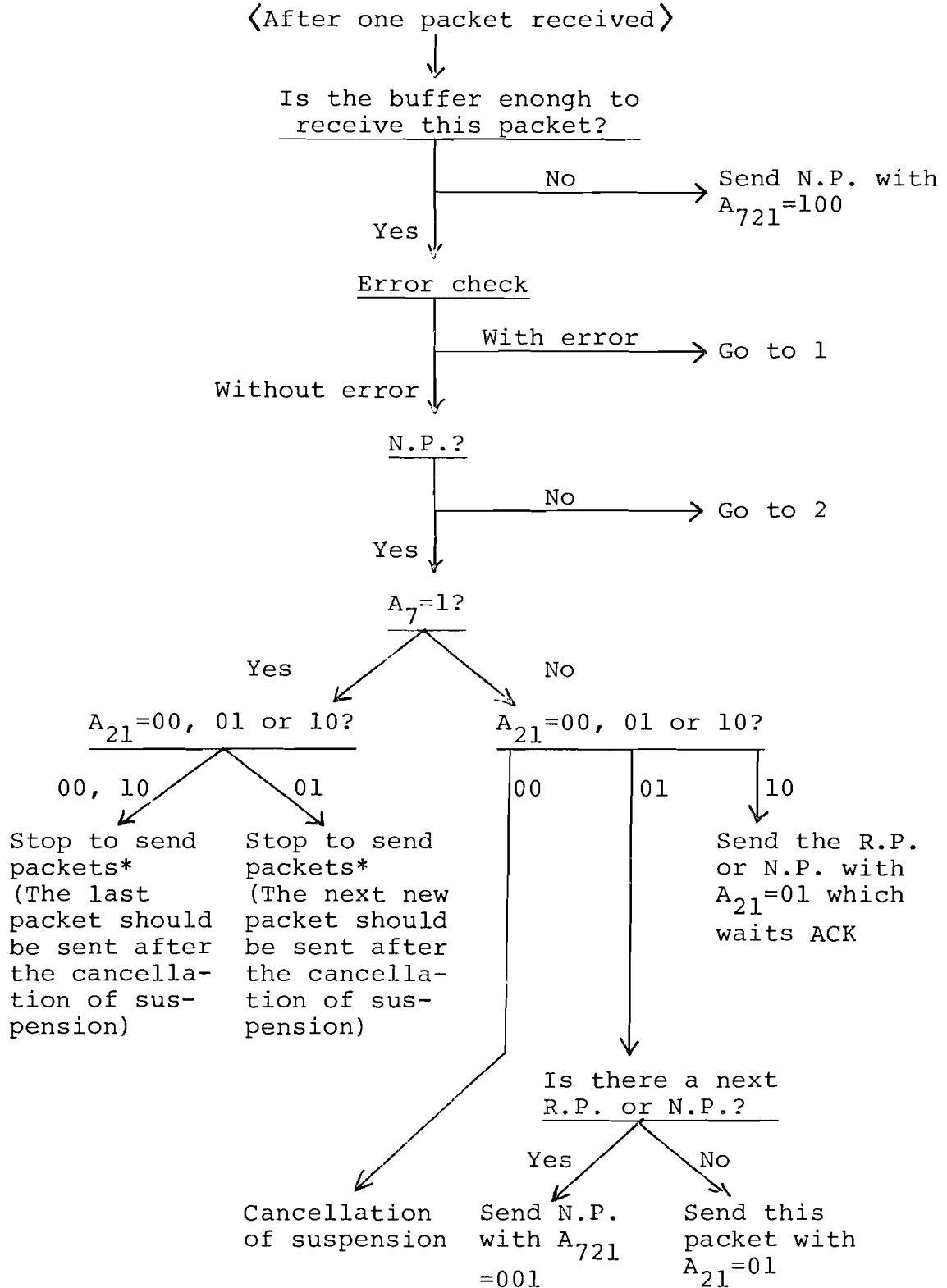
This is a temporary ring-off procedure which  
leaves some room for later communication. Any

IMP can use this procedure whenever he wants.

This procedure is just the procedure A with

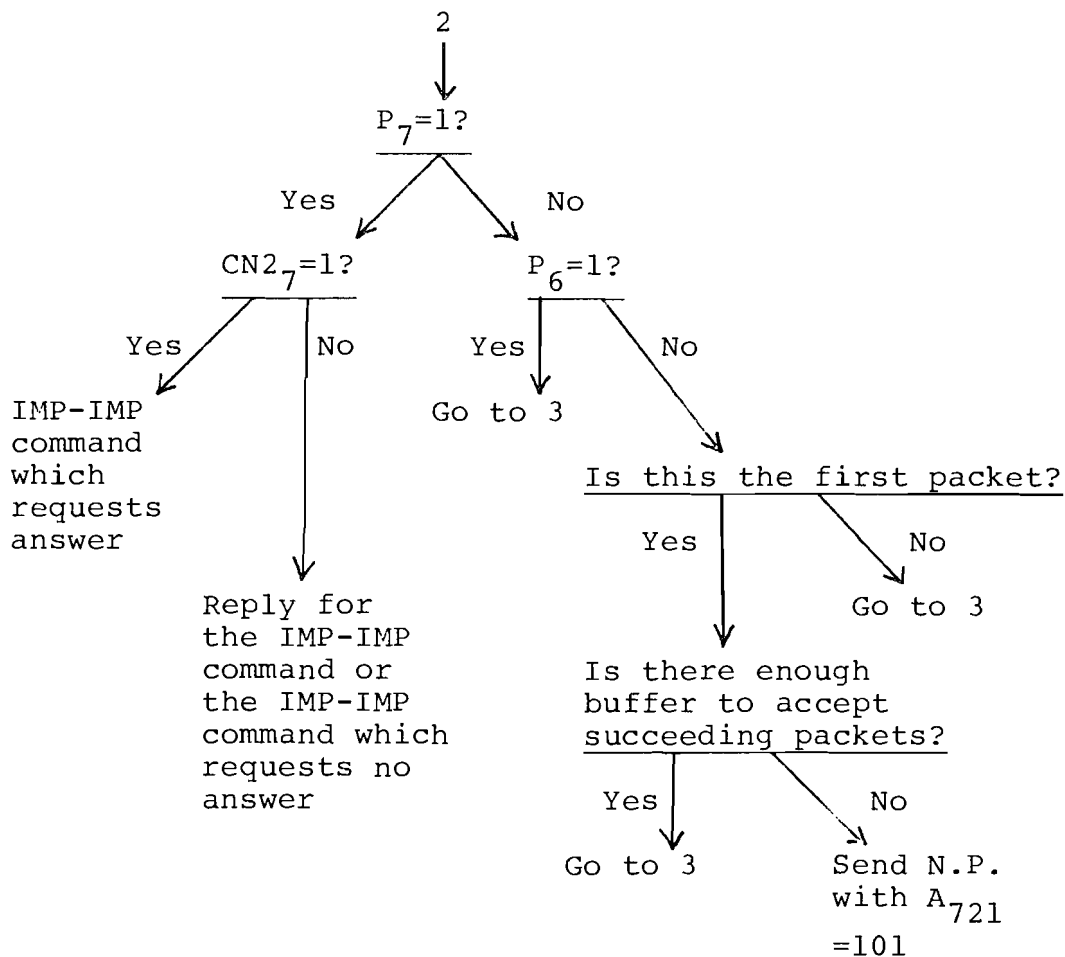
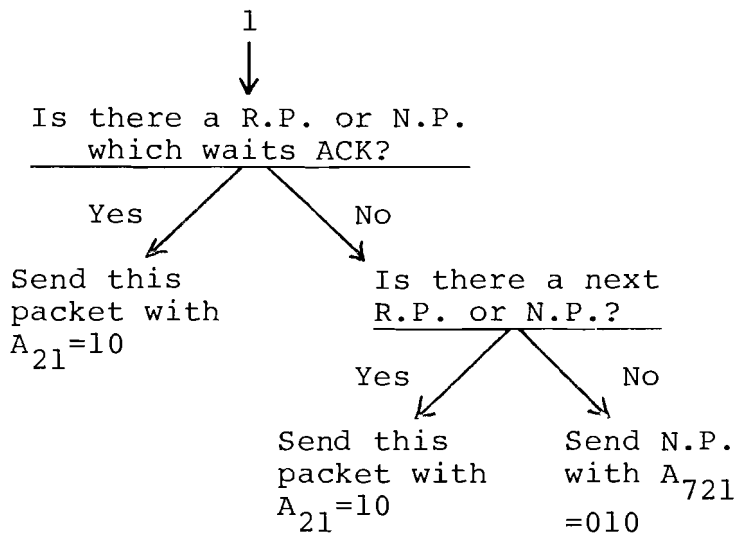
$P_1 = 2$ . So the logical status of the IMP should be preserved.

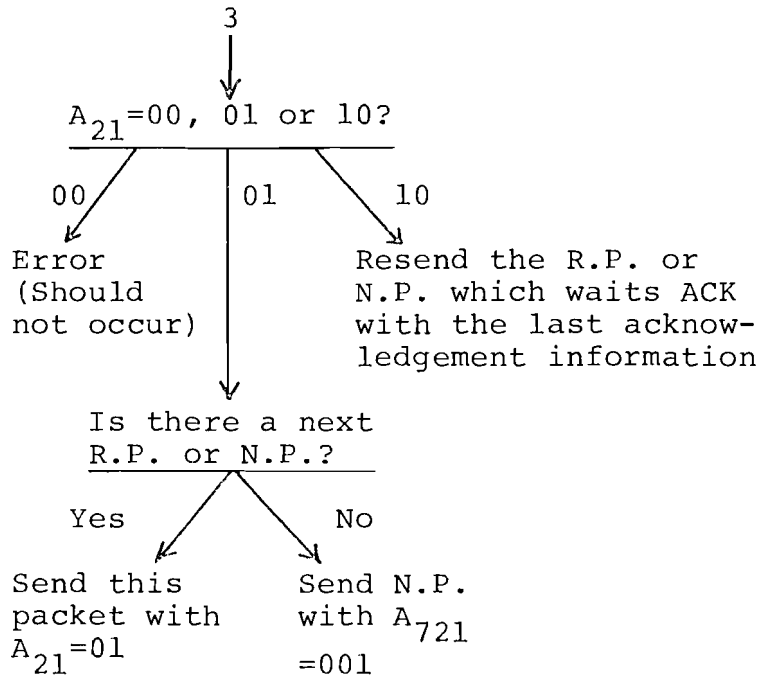
### 3.4 Packet Analysis



\* Except a packet with high priority or a command packet.







REMARK

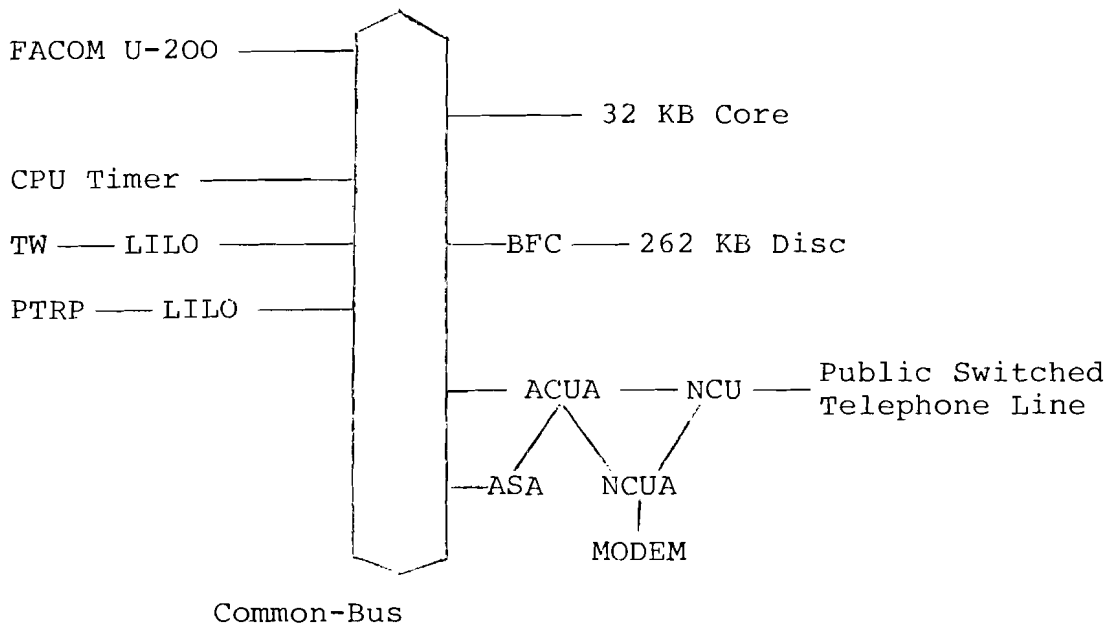
In every normal case, if the station is suspended to send a packet (except a packet with high priority or a command packet), a N.P. with a suitable acknowledgement should be sent back.

IV IMPLEMENTATION--CASE STUDY FOR THE FACOM U-200 SYSTEM

4.1 Introductory Remarks

- a) How to implement a network control program on the FACOM U-200 mini-computer system is a problem.
- b) FACOM U-200 system should be both the IMP and HOST of one station.
- c) FACOM U-200 system operates under DPS (Disc Programming System) which is a batch operating system.
- d) FACOM U-200 DPS system uses external interrupts with level 1 to process job requests from the public switched telephone line. This is the essential idea of this implementation. Clearly we need some modifications of DPS.
- e) At present, the network control program is being debugged.

4.2 Machine Configuration



ASA : ASynchronous Adaptor  
ACU : Auto Calling Unit adaptor  
NCUA : Network Control Unit Adaptor  
NCU : Network Control Unit  
MODEM: MODulator and DEModulator

4.3 DPS Interrupt

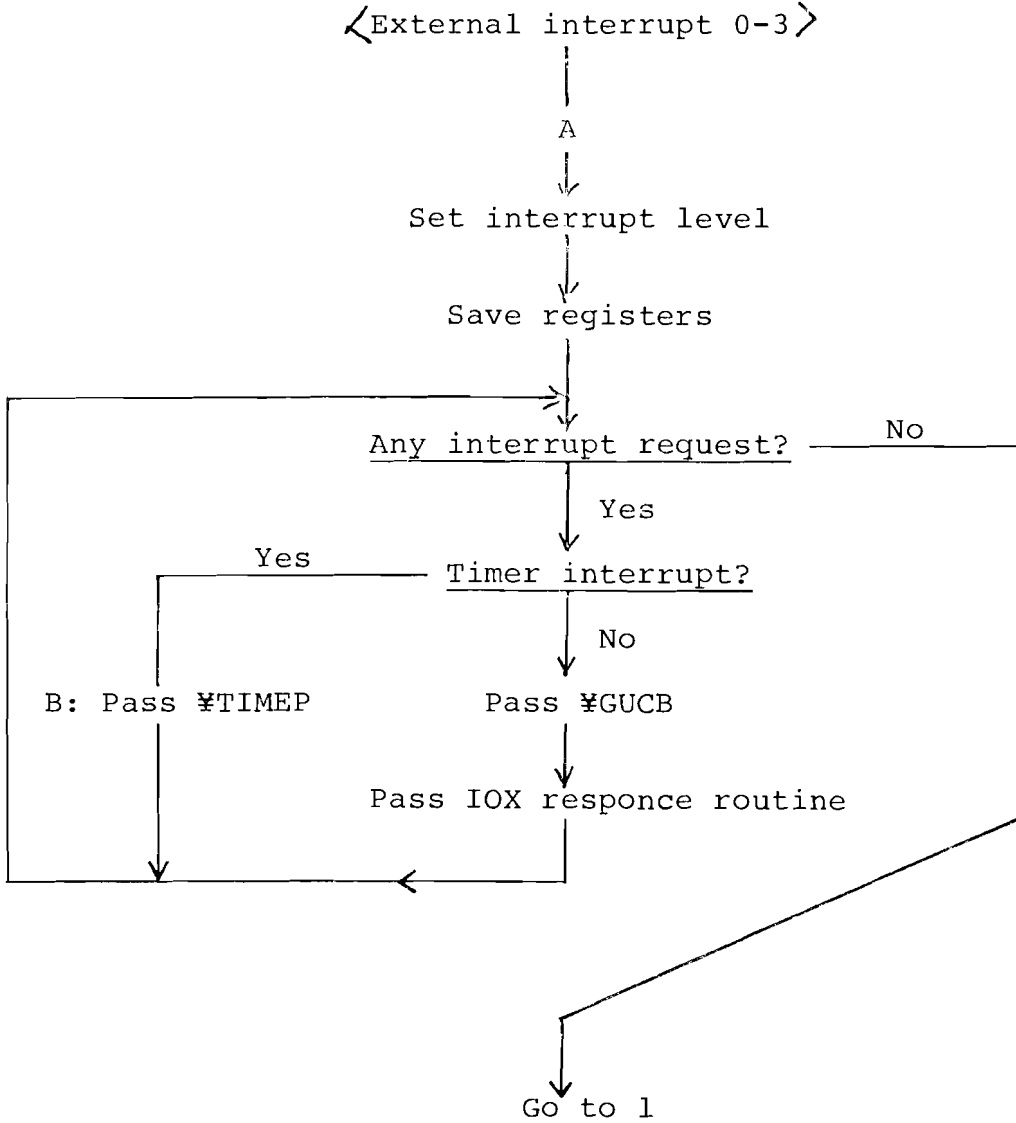
| No. | Name for Hardware Int. | Name for Software Int.      |
|-----|------------------------|-----------------------------|
| 0   | Hardware check int.    | Hardware check level (HC)   |
| 1   | Supervisor call int.   | Supervisor call level (SVC) |
| 4   | External int. level 0  | Task level 0 (T0)           |
| 5   | " 1                    | " 1 (T1)*                   |
| 6   | " 2                    | " 2 (T2)                    |
| 7   | " 3                    | " 3 (T3)                    |
|     |                        | Program level (P)           |

\*Communication line interrupt.

Remarks

- a) ·I/O response routine;  
·Interrupt control routine;  
·Timer routine;  
are processed at the external interrupt level 0 (T0).
- b) ·Console control routine;  
·Drum access routine;  
are processed at the external interrupt level 3(T3).

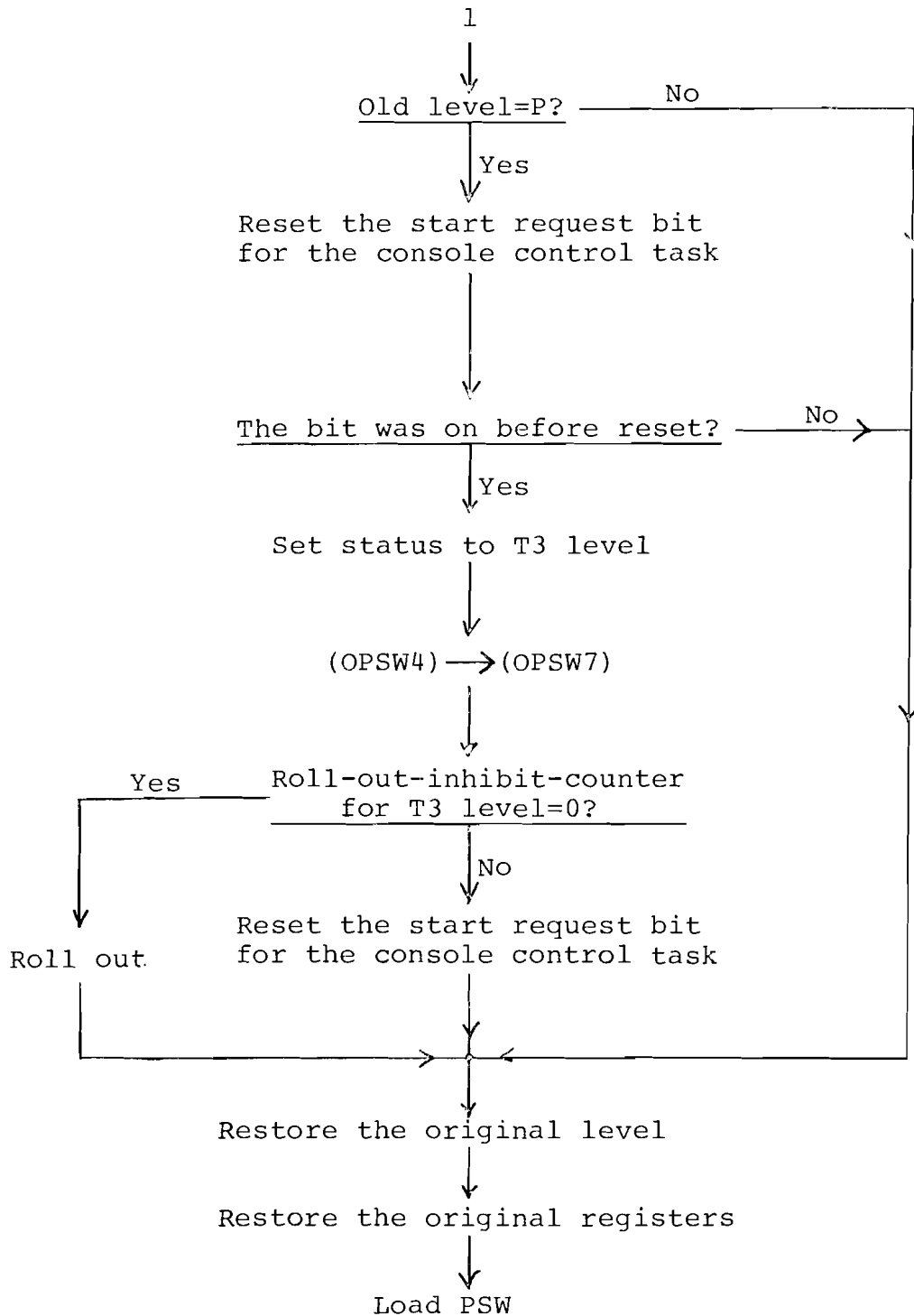
4.4 DPS External Interrupt Handling Flow Chart



A, B : will be used section 4.5

&#x2709;GUCB : Get UCB routine

&#x2709;TIMEP: Time processing routine



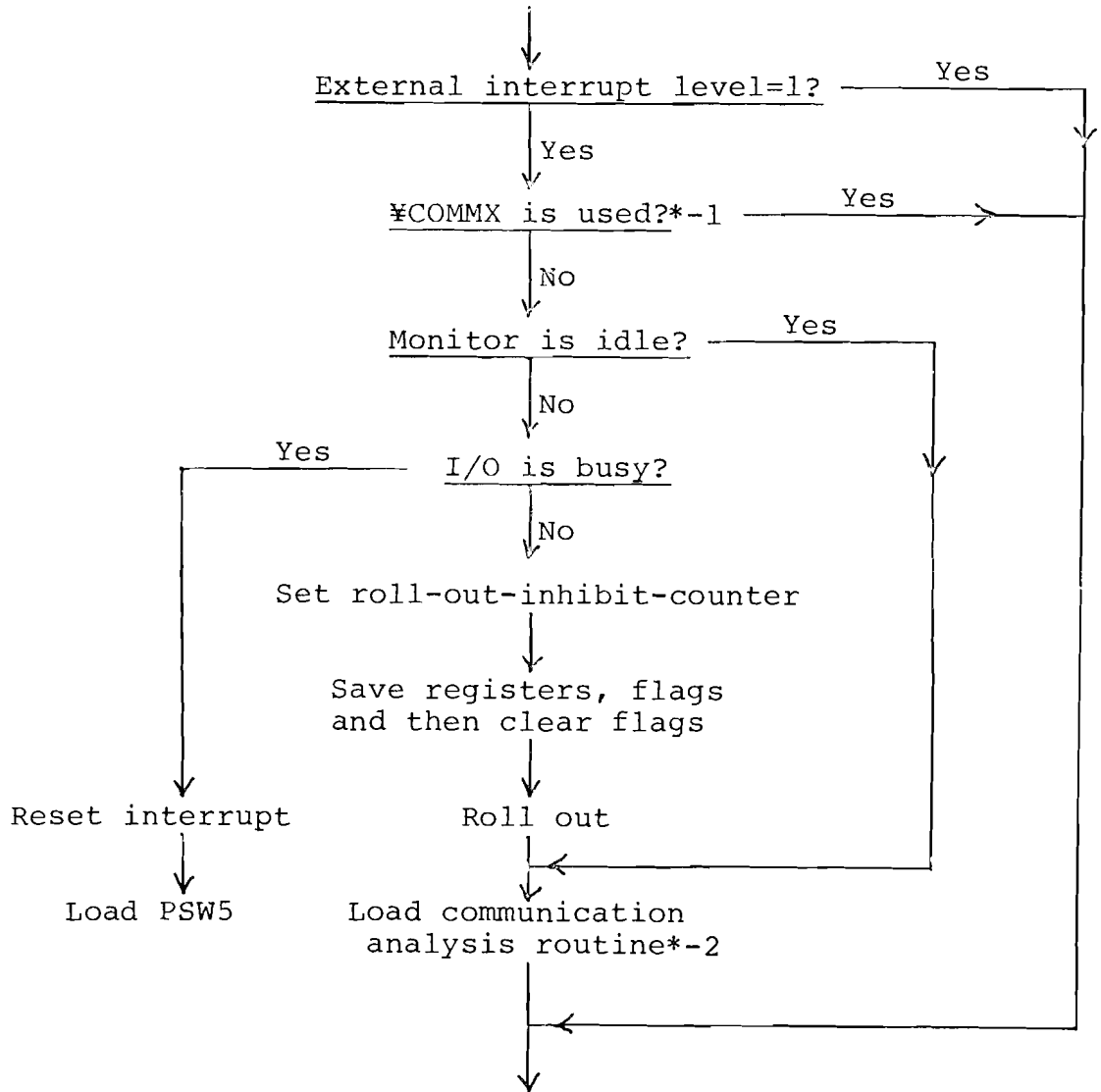
UCB : Unit Control Block

PSW : Program Status Word

OPSW: Old Program Status Word

4.5 Extended DPS to Accept Public Switched Telephone Line Communication

(1) Insert the next function at A.

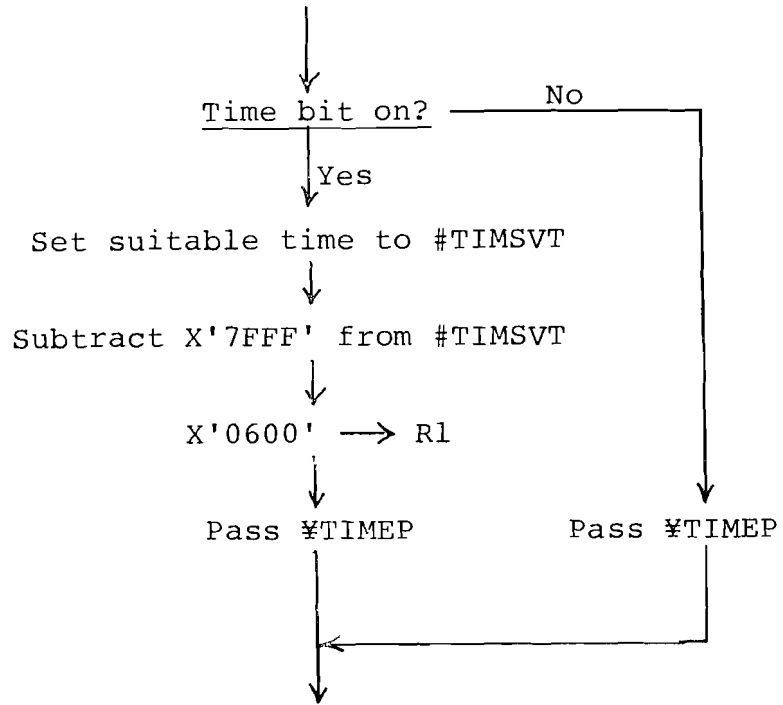


\*-1 : This is a communication response routine\*.

\*-2 : This is a communication oriented monitor\*.

\* : Both are developed in our implementation.

(2) Replace B by the next function.





#### 4.6 Design of the UCB for Public Switched Telephone

##### Line Interrupt Handling

UCB is a resident table which contains information necessary to control the communication line and to take the interface between DPS and network control program. The following shows the design of the UCB for our implementation.

##### Structure

```
# FLGUCB : Flags
# FLGUCB : Flags
# INTUCB : Entry address for response routine
# RILUCB : I/O management area
# PHYASA : ASA physical machine number
# PHYACUA: ACUA physical machine number
# EIAUCB : Information address for the destination
# DAOUCB : Sent data address
# DAIUCB : Received data address
# DNOUCB : Dial number address
# DLGUCB : Dial number length
# RBLUCB : Remaining data address
# LRCUCB : Area for LRC arithmetic
# PKCUCB : Packet count
# AENTUCB: Address of communication analysis routine
# BLGUCB : Received data length
# CONTUCB: Counter
# CONTUCB: Counter
# MSPUCB : Message pointer
# MSPUCB : Message pointer
# MSAUCB : Message address
# PKNUCB : Received packet number
# RTAUCB : Timer return address
# EIAUCB : Information address for the destination
```

# TNOUCB : Task number  
# RILUCB : I/O management area  
# TIMUCB : Timer physical machine address  
# TMCUCB : Time out count

Total 28 blocks and consists of 56 bytes.

#### 4.7 Network Control Program (NCP)

At present, our NCP functionally consists of a "Set UCB" block, an "Automatic Calling" block, a "Ringing off" block, a "Packet analysis" block, a "Packet edition" block, an "Interrupt handling" block and a "Timer" block. The total size is 2 KB, and a part of 500 B is resident in core.

Acknowledgement

I would like to acknowledge Professor J. Oizumi, Professor S. Noguchi and Mr. T. Tokumoto and Mr. K. Takahashi of the Research Institute for Electrical Communication, Tohoku University, and associate Professor S. Takahashi, Mr. Y. Ogawa and Dr. M. Sakata of the Large Computer Centre, Tohoku University, and others who contributed to this work.