The Local Computer Network in Tohoku District Japan

Yoshifumi Masunaga

August 1975 WP-75-102

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

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;

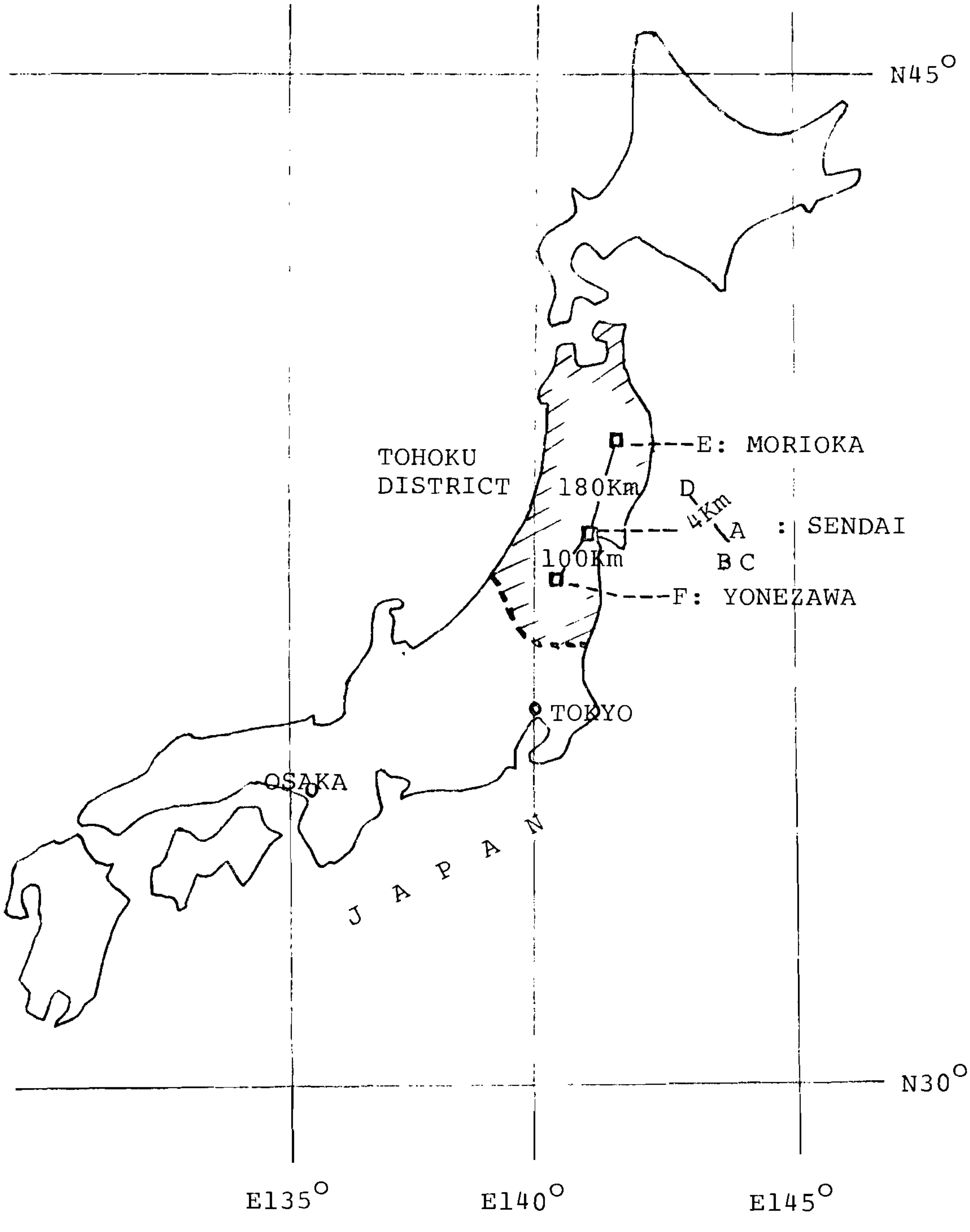
C. Research Centre for Applied Information Sciences, Tohoku University, Sendai
OKITAC 4300-C system: 24 KW core, 5.12MB disc, DOS;

D. Faculty of Engineering, Tohoku University, Sendai
OKITAC 4500-C system: 20 KW core, 2MB disc, DOS;

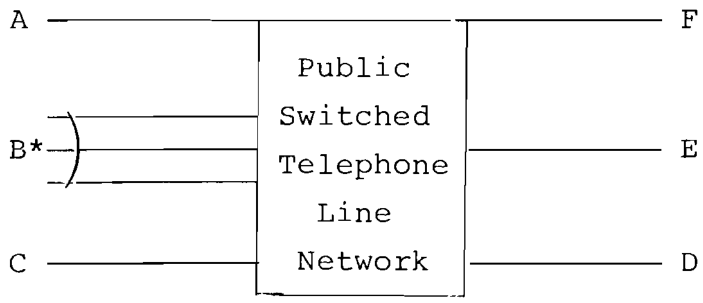
E. Faculty of Engineering, Iwate University,
Morioka, Iwate
OKITAC 4300-S system: 8KW;

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.

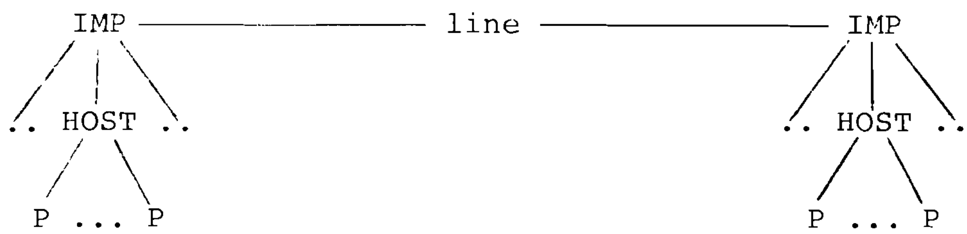
II PROTOCOLS

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

Message

C_1	C_2	H	C	B·C	B·S	

Message Header (4 Byte) — Message body ($\leq$ 512 Byte)

C_1 : Message priority;

C_2 : 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

Packet

DLE STX	Header	Text	DLE ETX	LRC

8 ch. (Header) — $\leq$ 128 ch. (Text)

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

```
    D  b1      b8
       ↓       ↓
a)  L (00001001)
    E

    S
b)  T (01000001)
    X

    E
c)  T (11000000)
    X

    E
d)  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.

P	A	S	M	C_1	C_2	H	C

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($b_3 \ldots b_7$)

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) DLE must be doubled as DLE DLE in the Header part and the Text part. But the length of DLE DLE must be counted as 1

2) Any character which precedes DLE has no meaning.

3) LRC applies from the beginning of the Text part to the last (including ETX). But DLE DLE must be summed up as if it were DLE.

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

Packet

Header	CN_1	CN_2	P_1	P_2	

Text part

CN : Command name;

P : Command parameter;

CN_1: Future use;

CN_2: Command name

b_7: command which requires reply from the destination IMP;

$b_{6,\ldots,1}$: command in binary form.

When the destination IMP receives command packet with b_7 of $CN_2 = 1$, then the destination IMP must reply to a (command) packet with b_7 of $CN_2 = 0$ to the source IMP.

2.5.1 IMP-IMP Commands

a) Here command

Function: Information about the destination IMP.

Format: Here P_1, P_2.

Code: { 1000001 —— source
0000001 —— destination's reply }

P_1 —— source IMP code

P_2 —— destination IMP code.

b) Terminate command

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

Format: Terminate P_1.

Code: { 1000010 —— source
0000010 —— destination's reply }

P_1 —— { 0000000 —— negative reply for cutting
0000001 —— request for cutting*
0000010 —— provisional request for cutting*. }

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

c) Status command

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

Format: Status P_1.

Code: { 1000011 —— source
0000011 —— destination's reply

P_1 —— { 0000000 —— negative reply
0000001 —— initial connection*
0000010 —— connection after provisional cutting*.

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: { 1000100 —— source
0000100 —— destination's reply.

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: { 1000110 —— source
0000001 —— destination's reply

---

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

P_1 —— 0000000 —— negative reply
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_1 Message.

Code: 0000111 —— destination

P_1 —— not yet designed (type of error will be specified).

h) Report command

Function: Request answer about the statistical information.

Format: Report P_1.

Code: 1001000 —— source
0001000 —— destination's reply

P_1 —— 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:

---

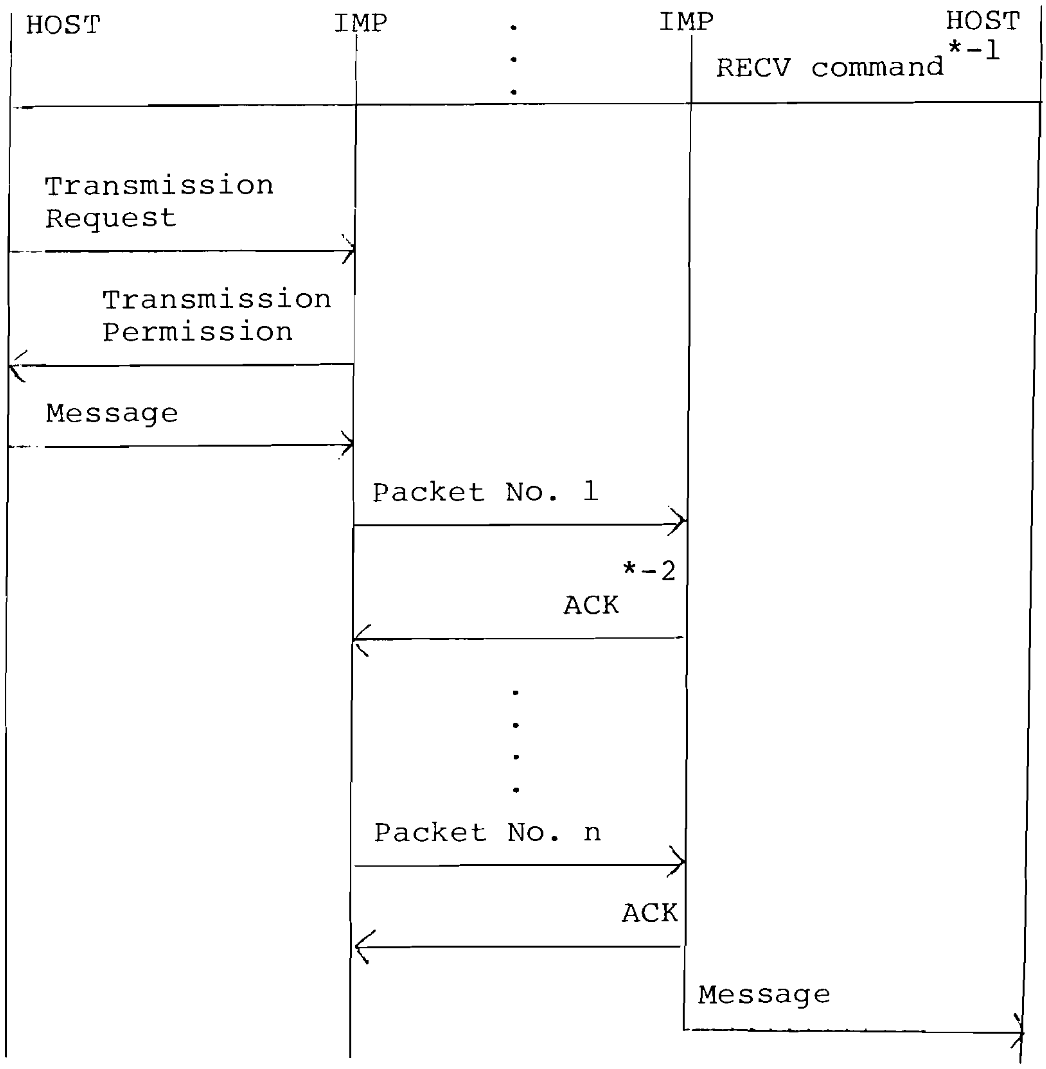
*If the reply of the destination is positive, the destination must send the same code of P_1 to the source.

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.

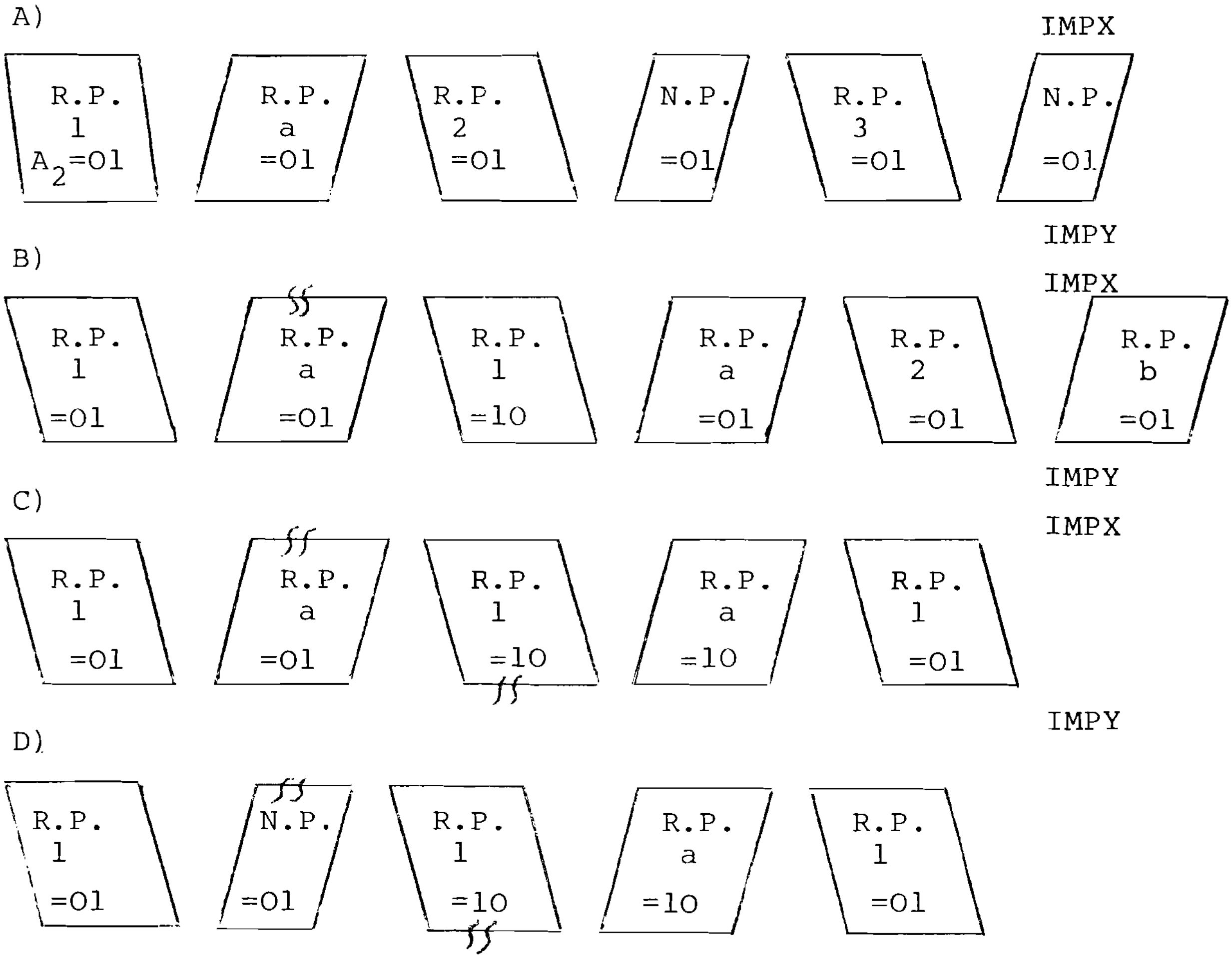
Then the following communication diagram will be applicable:



*-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

ʃʃ : Error

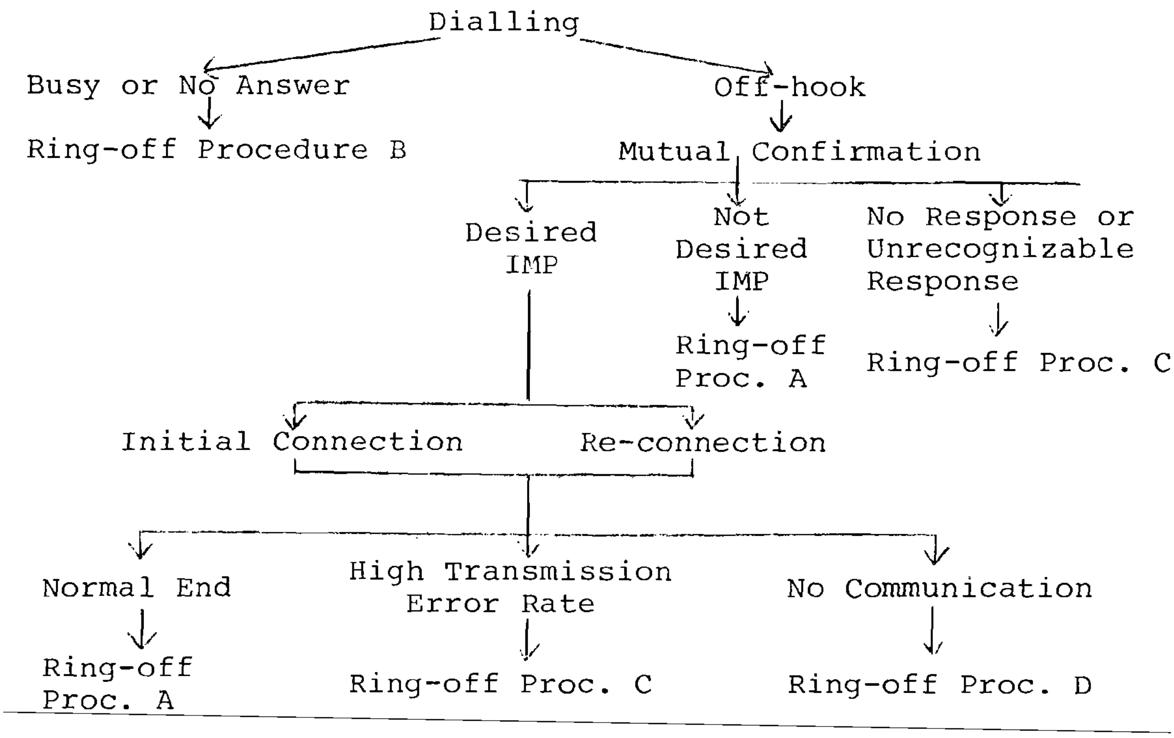
---

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

3.3 Control of Public Switched Telephone Line

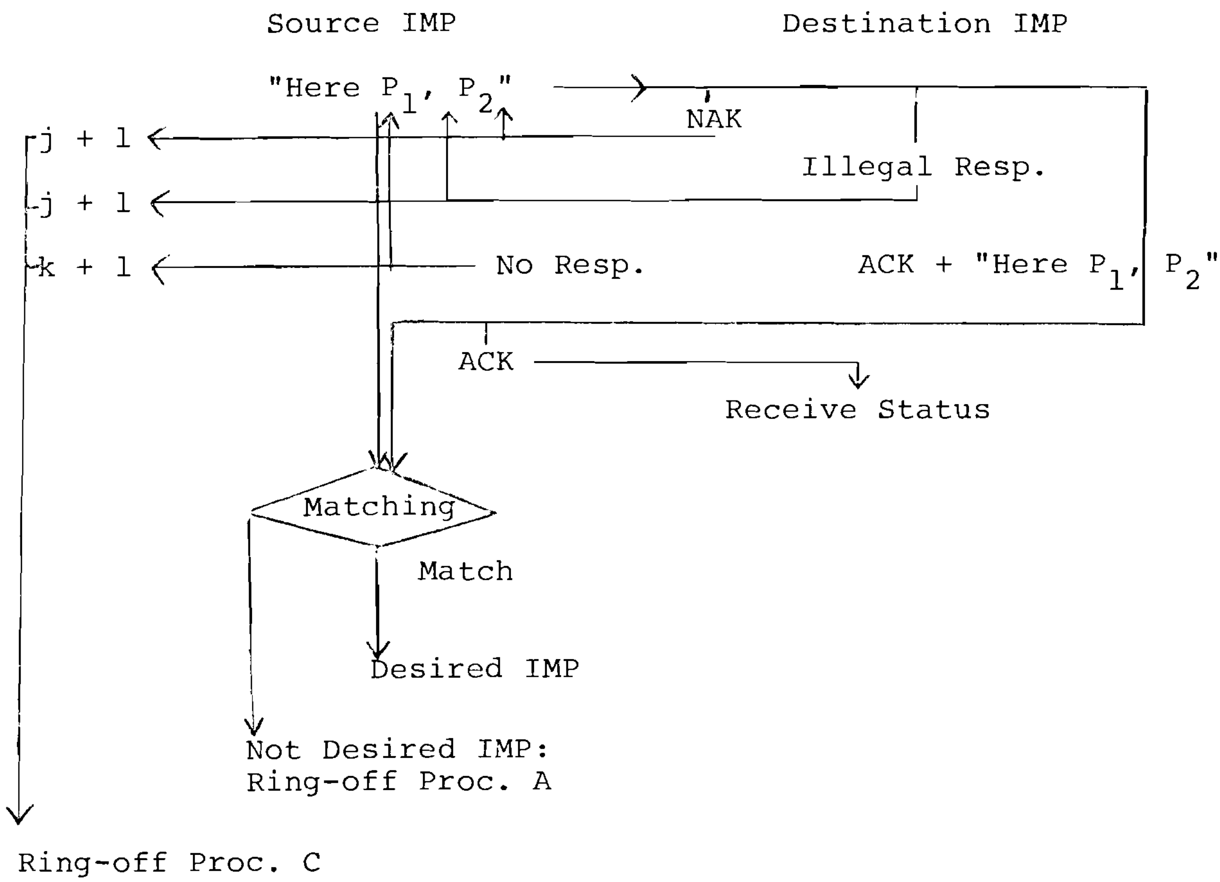
Any communication starts by dialling and ends by ringing off. But there are several different ring-off procedures corresponding to the communication status.

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.

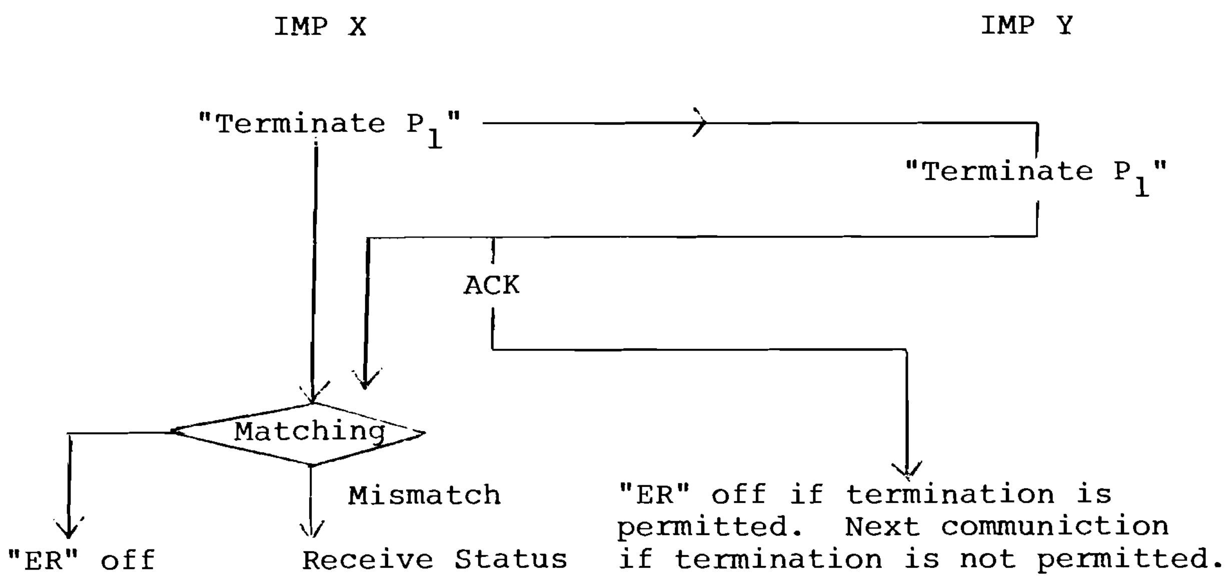
·Normal end.

·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 a sequence of 64 pairs of DLE ENQ. The destination 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.

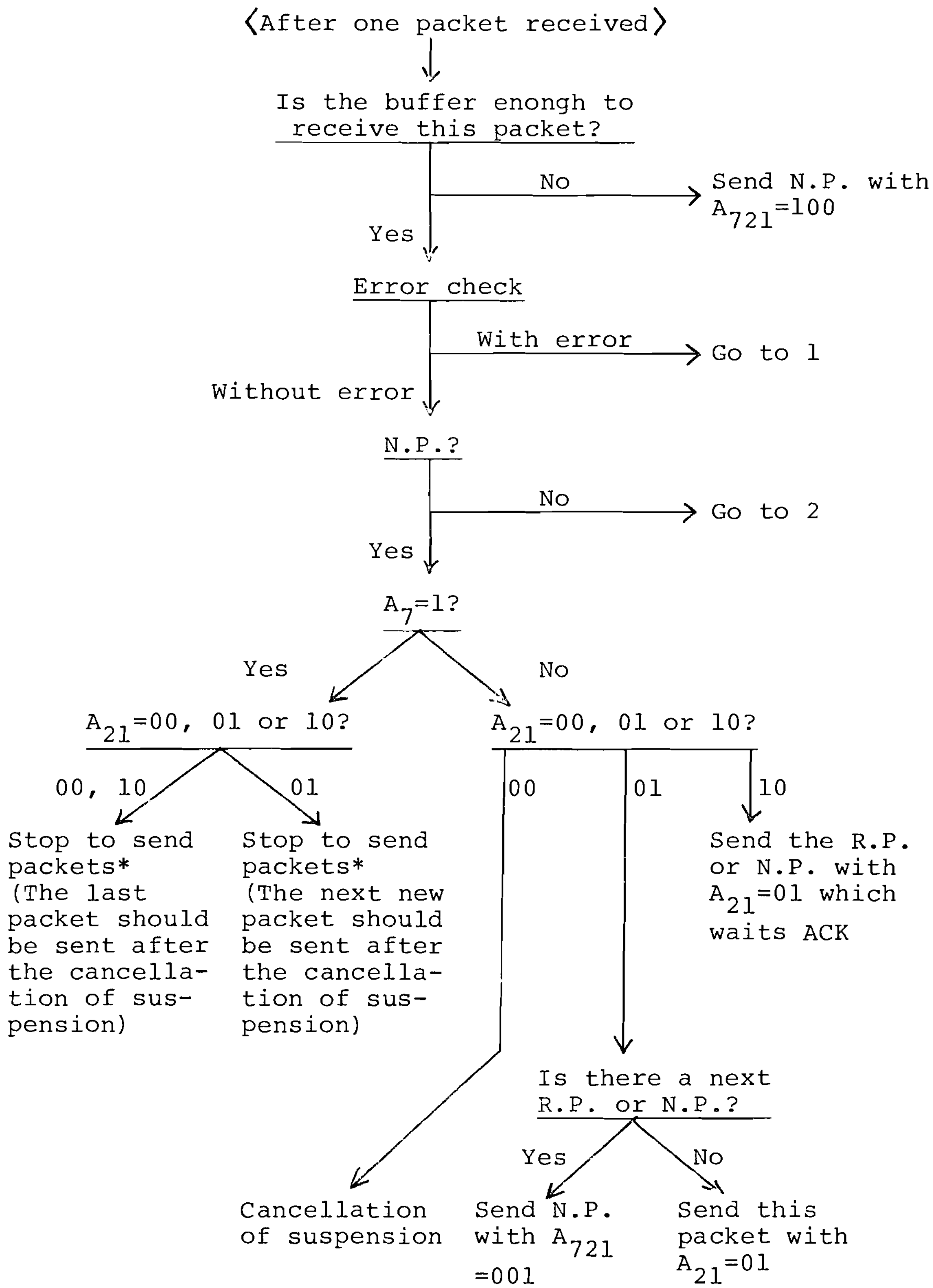
d) Procedure D.

·No communication.

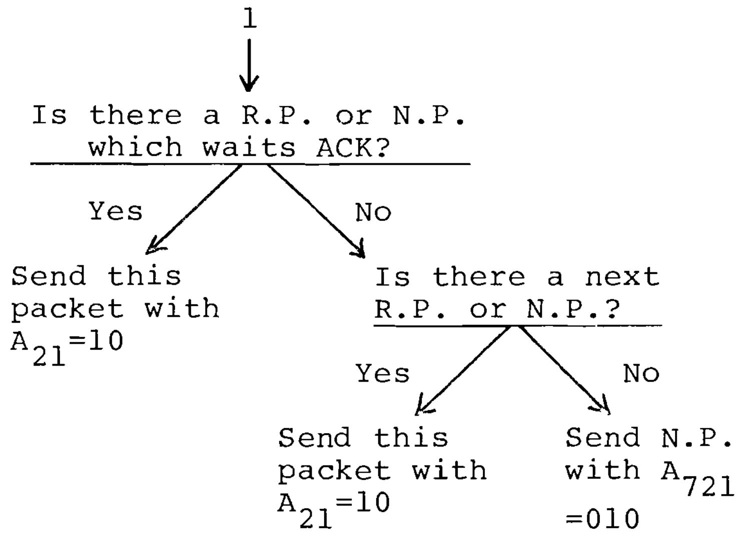
This is a temporary ring-off procedure which leaves some room for later communication. Any

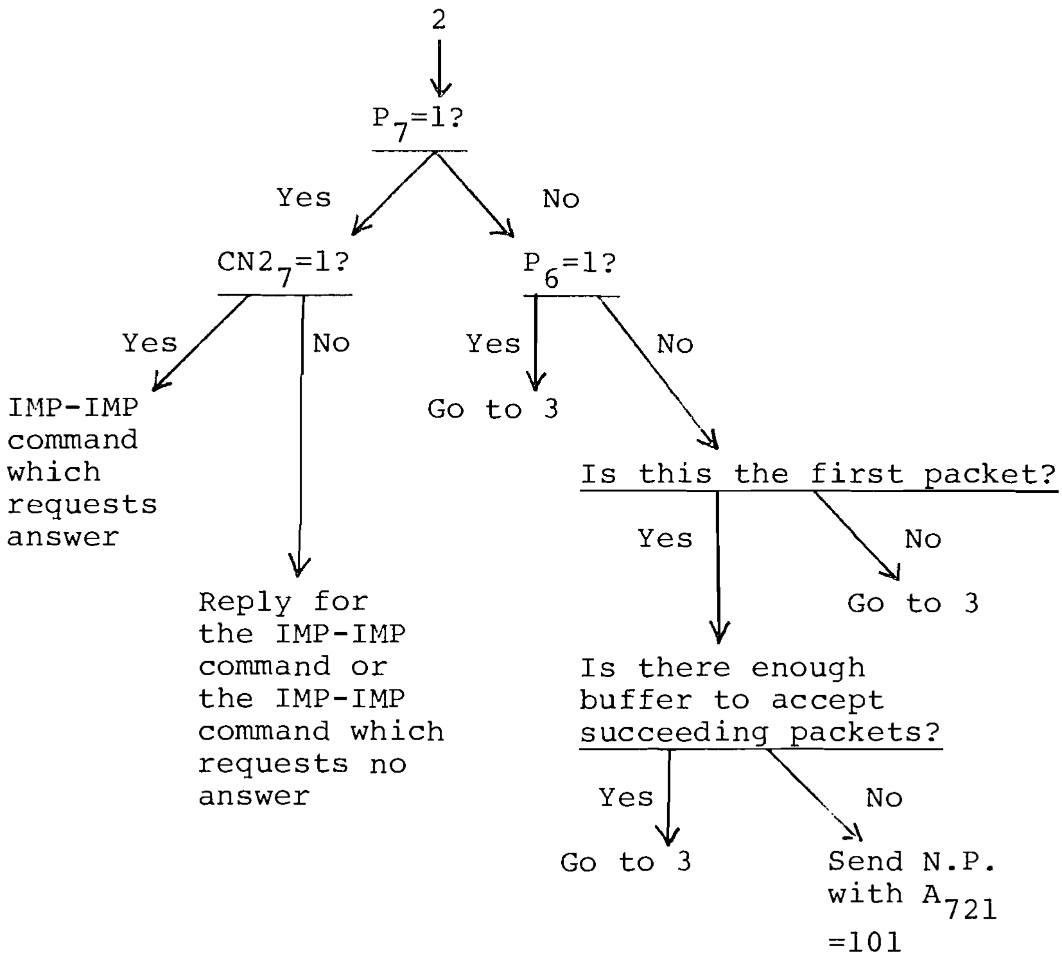
IMP can use this procedure whenever he wants. This procedure is just the procedure A with $P_1 = 2$. So the logical status of the IMP should be preserved.

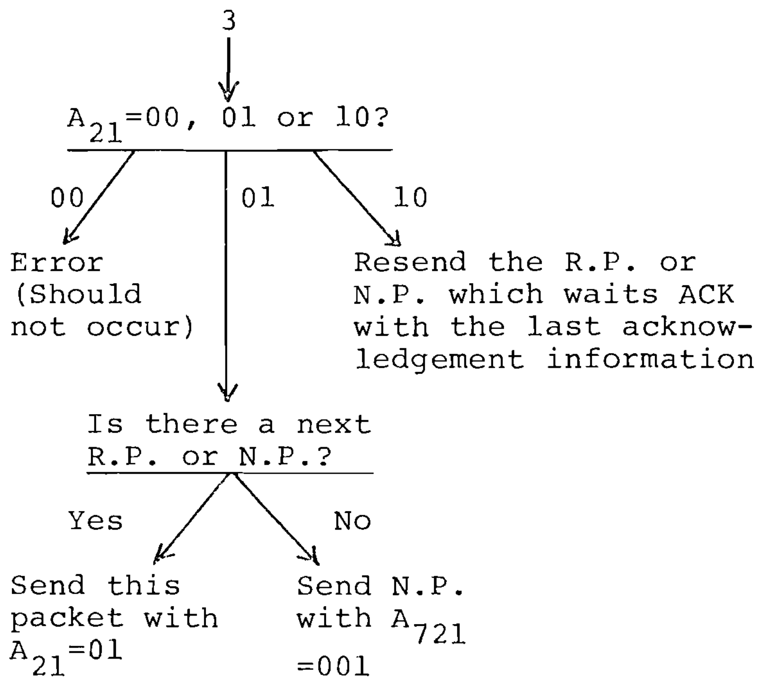
3.4 Packet Analysis



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


1
Is there a R.P. or N.P. which waits ACK?
Yes
No
Send this packet with A_{21}=10
Is there a next R.P. or N.P.?
Yes
No
Send this packet with A_{21}=10
Send N.P. with A_{721} =010


2
P_7=1?
Yes
No
$CN2_7$=1?
P_6=1?
Yes
No
IMP-IMP command which requests answer
Reply for the IMP-IMP command or the IMP-IMP command which requests no answer
Yes
No
Go to 3
Is this the first packet?
Yes
No
Go to 3
Is there enough buffer to accept succeeding packets?
Yes
No
Go to 3
Send N.P. with A_{721} =101



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.

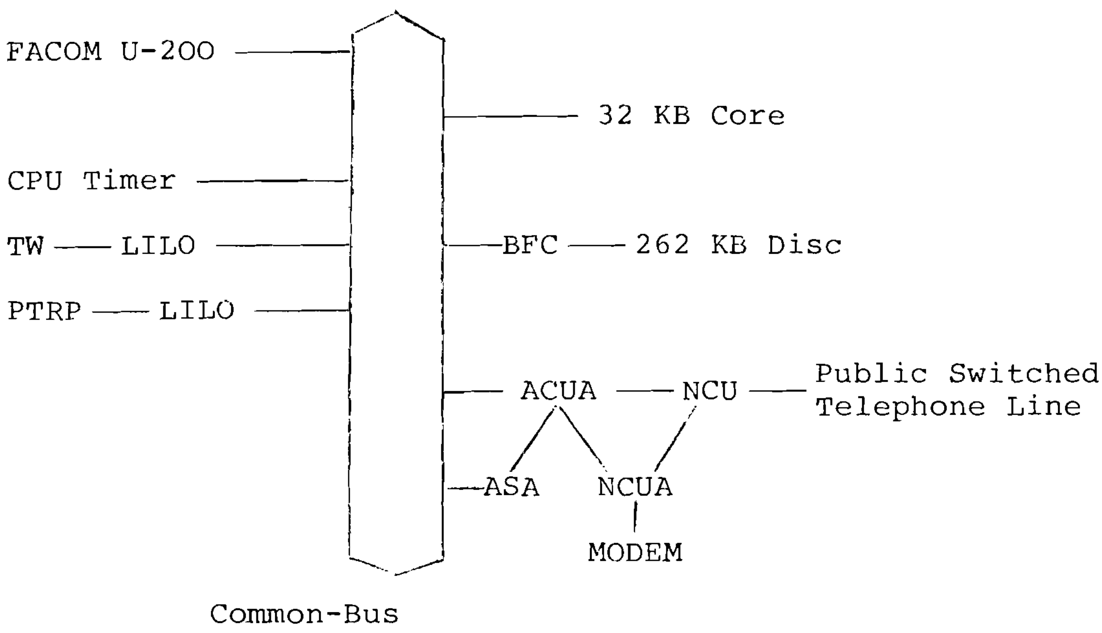
b) FACOM U-200 system should be both the IMP and HOST of one station.

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;

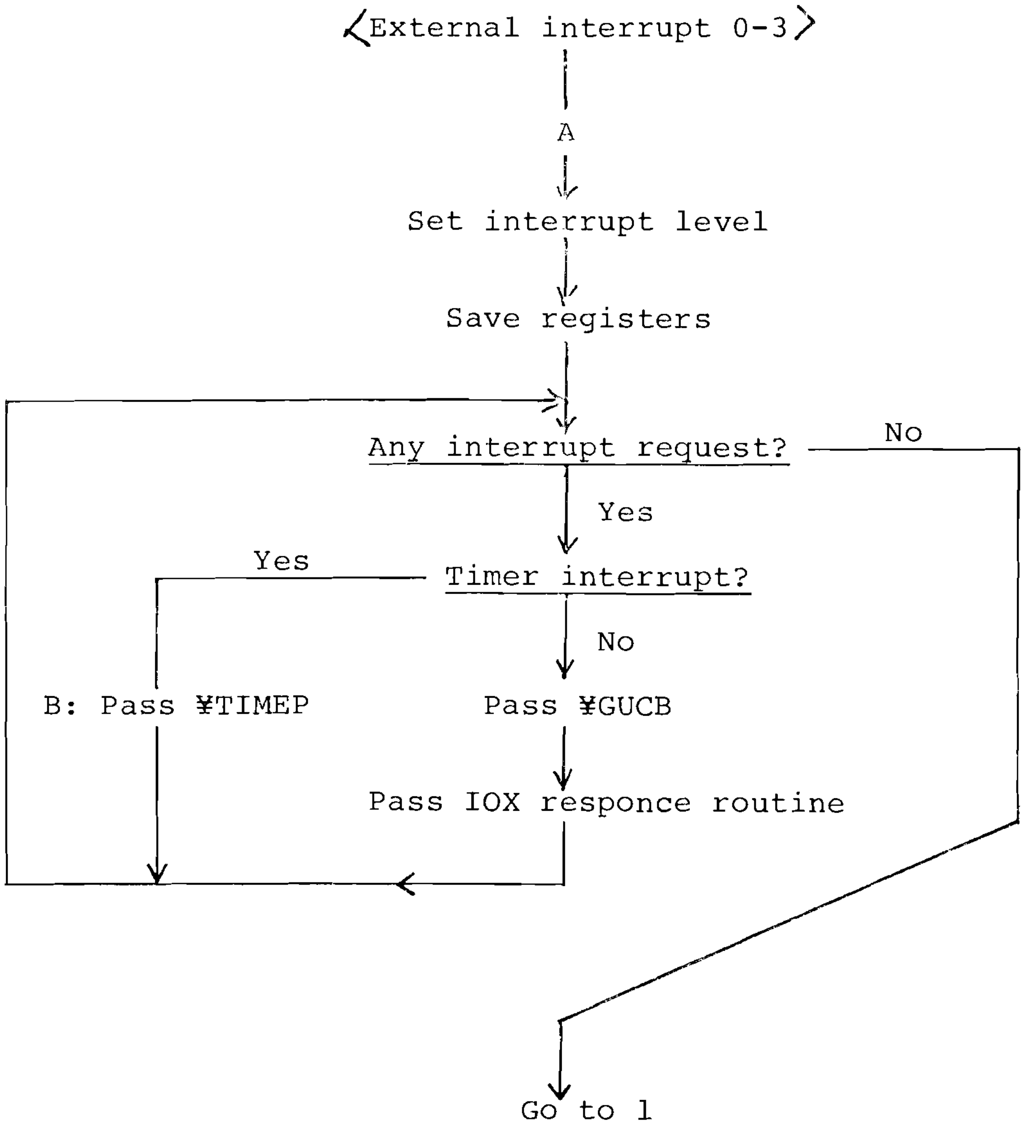
are processed at the external interrupt level 0 (T0).

b) ·Console control routine;

·Drum access routine;

are processed at the external interrupt level 3(T3).

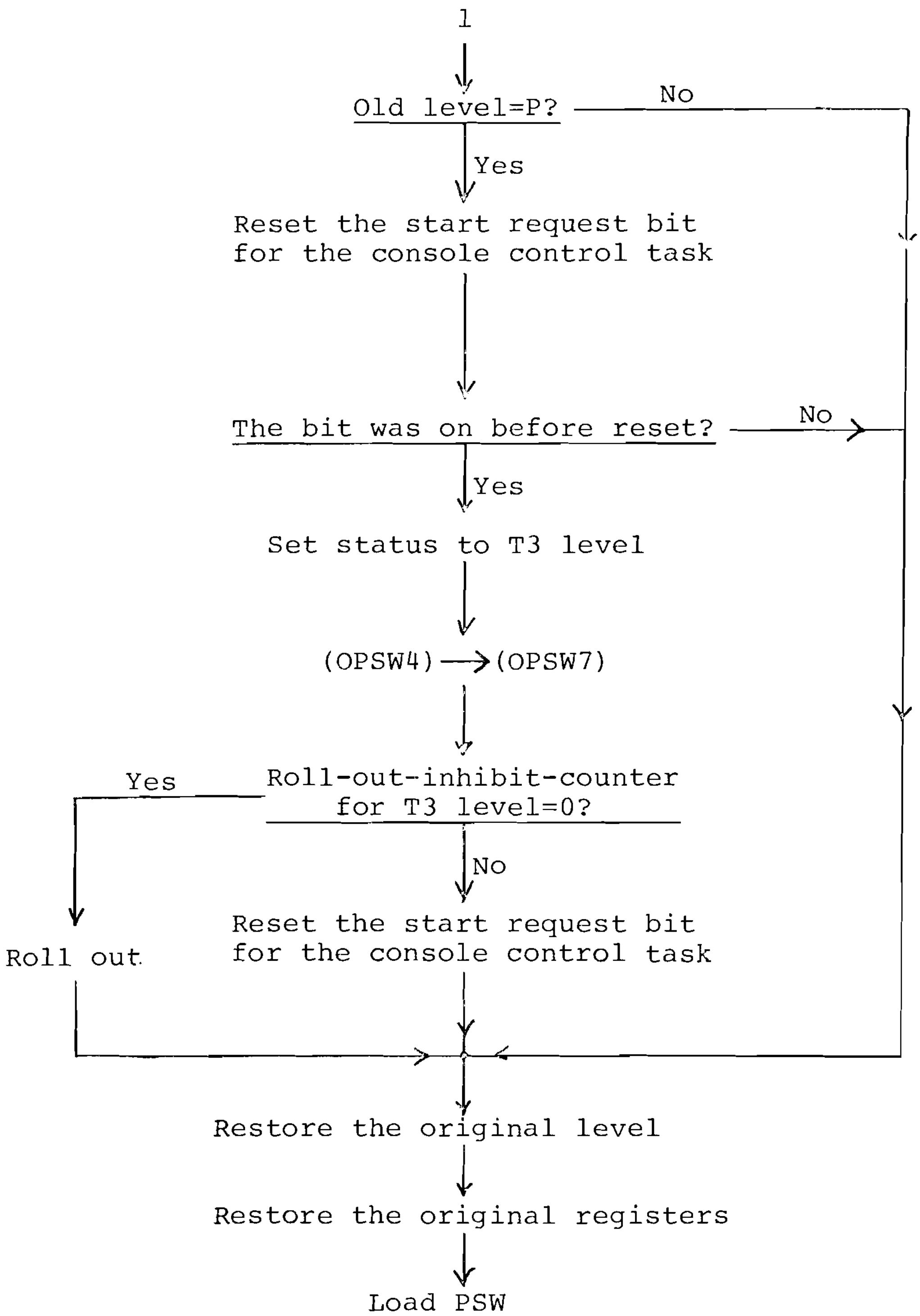
4.4 DPS External Interrupt Handling Flow Chart



A, B : will be used section 4.5

¥GUCB : Get UCB routine

¥TIMEP: Time processing routine



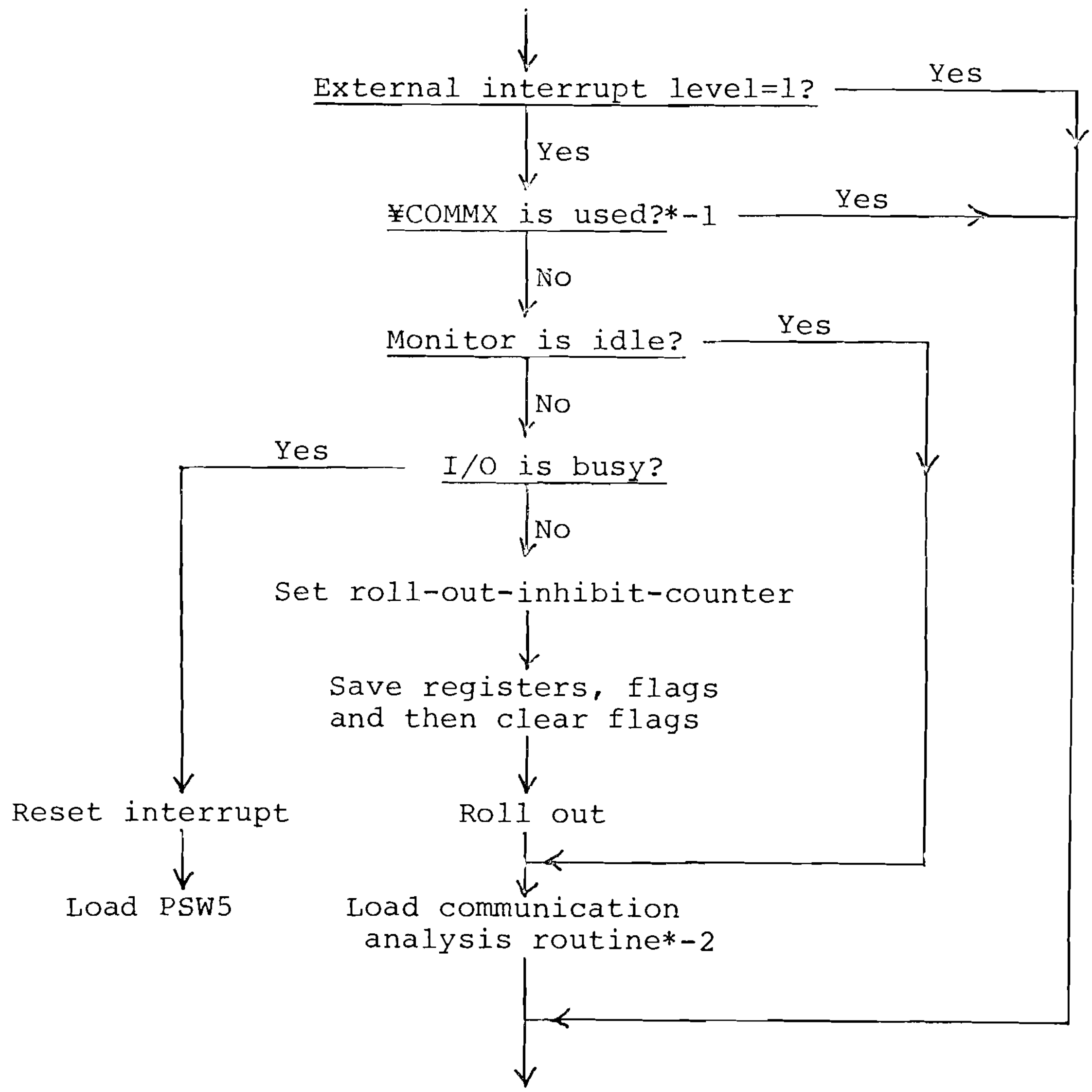
UCB : Unit Control Block

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.

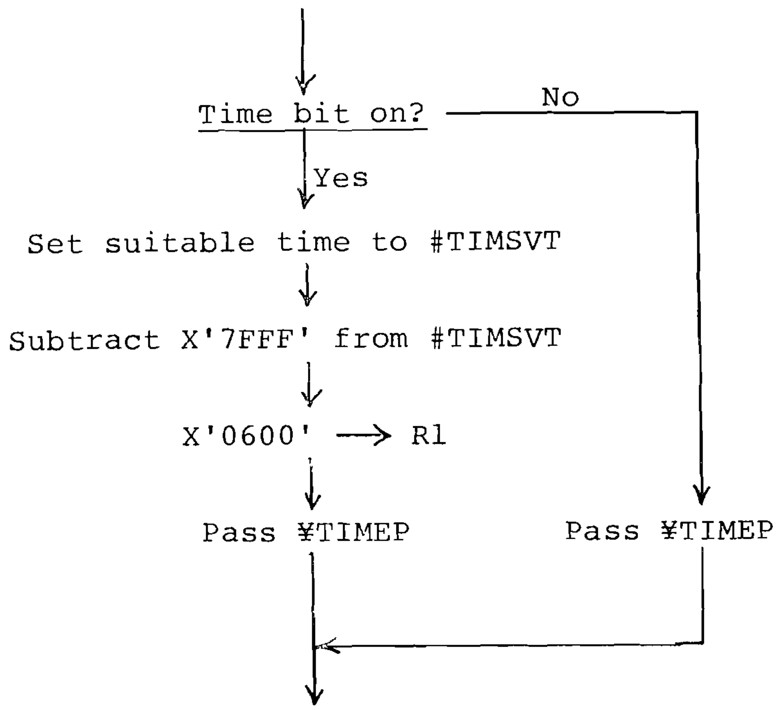


-1 : This is a communication response routine.

-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.