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ABSTRACT

Future development and operations of the Korean Educational Computer Network are discussed and possible network layout and cost implications are studied. The Aloha System radio communication, telephone lines and satellite systems are considered as possible alternatives to the present network. The availability of telecommunication facilities and technologies of data transmission in Korea are briefly discussed. It is concluded that the lowest-cost layout is the Aloha radio communication system. (SK)

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A STUDY ON THE KOREAN EDUCATIONAL COMPUTER NETWORK

BY

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A STUDY OF THE KOREAN EDUCATIONAL COMPUTER NETWORK

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Moon-Suk Ahn

ABSTRACT

This report concerns possible layouts of the Korean Educational Computing Network, which is being considered as a development in the near future.

Consideration is given to the possible network layout and its economic implications. As major alternatives for the network, telephone lines, the ALOHA System radio communication method, and satellite method are used. The availability of telecommunication facilities and technologies of data transmission in Korea are briefly discussed.

It is concluded that the lowest costing layout is that of the ALOHA radio communication method.

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CONTENTS

1. INTRODUCTION

This report concerns possible layouts of the Korean Educational Computer Network, which is being considered as a development in the near future. It will connect major rural cities throughout the country with emphasis being on their economic concerns.

In Section 2, the state of university computers is briefly described. An account of the Cyber 72-14, which will be assumed as a central computer in the network is also given.

Section 3 discusses the basic assumptions concerning the availability of telecommunication facilities and technologies of data transmissions in Korea.

The possible network layouts and its economic implications will be studied in section 4.

Finally, in section 5, a comparison of the network layouts is given.

2. COMPUTERS OF EDUCATIONAL AND RESEARCH INSTITUTIONS IN KOREA

Except for one university located at Deaku, all other educational and research institutions along with their computers are centered in Seoul. In addition, since the computers are usually donated by the manufacturer (IBM) or purchased from Japan through government funds (Korean)[1], many of the computers (except the KIST computer)[2] have small computing capabilities.

A list of universities and their computers follows.

- Seoul National University, College of Engineering - Seoul, IBM
- Yunsei University - Seoul, IBM
- Sogang University - Seoul, IBM
- Sungkyunkwan University - Seoul, IBM 1401 (32 byte memory)
- Hanyang University - Seoul, FACOM 222 (32 byte memory)
- Soongjun University - Seoul, IBM
- Youngnam University - Daeku, FACOM

(1) Since the main source of government funds is the Compensation Fund from the Japanese Government for the Occupation of Korea, the fund should be spent only for Japanese products. (Several FACOMs have been installed in Korea.)

2) This computer will be discussed latter in this section.

Since the above computers are too small[1] to allow time to students who want to study the computer and since the hardware configurations are almost the same, the benefits from a network which will connect these computers is minimal.

Fortunately, Korea has a very large computer facility which can be used as a central computer in the network - specifically, the Cyber 72-14 of the Korea Institute of Science and Technology (KIST)[2].

The Cyber 72-14 (see Appendix for configuration) has one CPU which consists of 65 K words (60 bits per word) and 10 PPU (Peripheral Processing Unit) each of which has 4 K words (12 bits per word) memory size and acts independent of each other (mainly for system operation and I/O processing). Also, the Cyber 72-14 has 200 mil. character disk file capacity.

The PPUs with Cyber's multiprogramming feature enables the system to have a vast number of terminals.

In addition to the hardware capacity for networking, the Cyber has the following software that can be shared by the universities in the event the network is formed.

- *Algorithmic Languages*
  - COMPASS (CDC ASSEMBLER)
  - FORTRAN
  - EXTENDED FORTRAN (Extension of ANSI FORTRAN)
  - BASIC
  - ALGOL-60
  - COBOL
  - SORT/MERGE
  - QUERY/UPDATE (For information retrieval)
  - DDL (Data Definition Language)
  - FORM (File Organizer and Record Manager)
  - SIS (Scope Indexed Sequential)

- *Canned Programs*
  - BMD
  - TSP (Time Series Processor)
  - X-II (Seasonal adjustment program)
  - CSSL-II (Simulation language for continuous dynamic system)
  - SIMSCRIPT
  - GPSS
  - MIMIC

---

(1) For production runs, programmers of the universities (usually universities have professional programmers for researchers) use the Assembler language. A few graduate students use FORTRAN in a very limited way.

(2) The Korea Institute of Science and Technology was established by the U.S. Government and the Korea Government in 1966 for scientific research which was badly needed for the economic development of Korea.

- APT (For numerical control)
- PERT
- TLP
- OPHERIE II, OPTIMA } (For linear programming)
- Math Science Library

Operating System

- SCOPE (Operating system-maximum 15 jobs can be processed simultaneously)
- KRONOS (Operating system for terminal operation)
- EXPORT/IMPORT (For remote batch job)
- INTERCOM (For interactive time-shared access)

Since KIST already has its own network(1), the knowhow and the experiences(2) that KIST has accumulated can be extended to the Educational Network. Also, the objectives(3) of the proposed computer network becomes evident only in the case where the KIST's Cyber 72-14 participates. The following section will therefore assume a computer network in which the KIST computer acts as a central computer.

3. BASIC ASSUMPTIONS FOR THE KOREAN EDUCATIONAL COMPUTER NETWORK

In studying the state of educational computers, the Korean Government's basic policy(4) on education and the available technologies that may be imported into Korea, we can derive the following basic assumptions for our educational computer network.

Assumption 1. The Cyber 72-14 of the Korea Institute of Science and Technology will play a central role in the network.

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(1) So far, KIST has installed its terminals at the following sites: Bureau of Budget, Economic Planning Board (Batch Terminal); Ducksoo Commercial High School (Batch Terminal); Downtown Branch of KIST (Batch Terminal); National Defense Research Institute (Display Terminal); Agricultural Management Research Institute (Display Terminal); seven Display Terminals within KIST's boundary.

(2) Since 1970, KIST has provided computer lectures for the public. They have also developed various kinds of instructional softwares such as the Hanguel COBOL program and the English-Korean Translation Program.

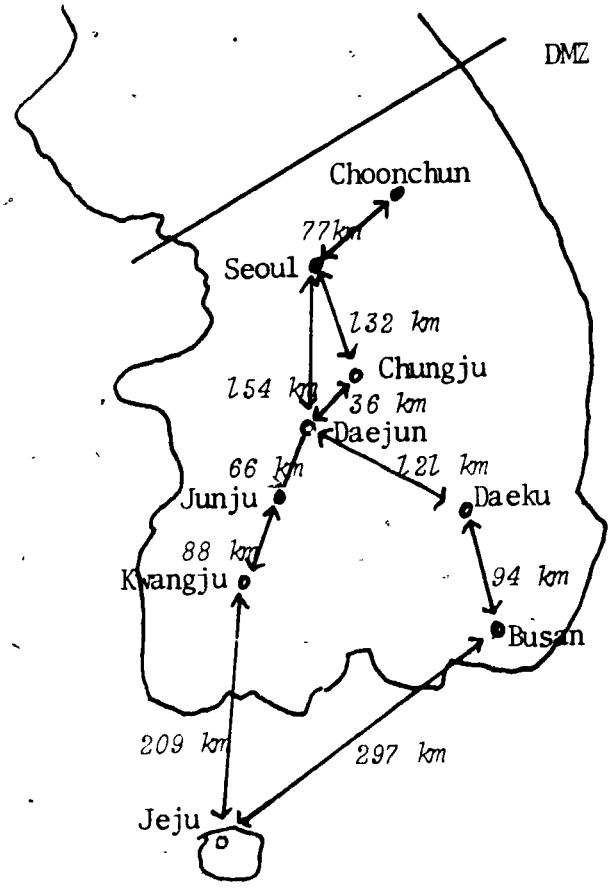
(3) Easy programming and easy access to the computer; sharing of canned programs; sharing of data base.

(4) Recently, the Korean Government set its educational goal to reduce regional gaps that exist between Seoul and other regions.

Assumption 2. In the near future, there will be 10 Regional Computer Centers located mainly at the Provincial Capitals and operated by the National Universities located at these places. Of the 10, eight regional centers will be located in the following cities.

Name of Cities	*Name of Universities*
Choonchun, Kangwon Province	Kangwon University
Daejun, Choongchungnam Province	Choongnam University
Chungju, Choongchungbuk Province	Choongbuk University
Daeku, Kyungsansbuk Province	Kyungbuk University
Busan, Kyungsangnam Province	Busan University
Junju, Junlabuk Province	Junbuk University
Kwangju, Junlanam Province	Junnam University
Jeju, Jeju Province	Jeju University

Figure 1 shows the geographical locations of the above cities.



(note: all figures are approximation)

Assumption 3. It is probable that the Korean Government will only permit the same size computers as the existing ones for use at the regional computer centers. The Government will require the regional centers to use Cyber's batch terminals, and in that case the following terminals and modems will be available.

Low Speed Batch Terminals
- 8K memory
- Reading 300 CPM
- Printing 300 LPM
- Display Console
- Purchase $30,300
- Rental $830/month
- Maintenance $244/month

Medium Speed Batch Terminals
- 8K memory
- Reading 500 CPM
- Printing 600 LPM
- Display Console
- Purchase $45,820
- Rental $1,253/month
- Maintenance $359/month

High Speed Batch Terminals
- 8K memory
- Reading 1200 CPM
- Printing 1200 LPM
- Display Console
- Purchase $96,800
- Rental $2,330/month
- Maintenance $650/month

Low Speed modem ... Modem 300 (up to 300 BPS)

Medium Speed modem ... Modem 2200/24 (up to 2400 BPS)

High Speed modem ... Modem 4600/48 (up to 4800 BPS)

Assumption 4. All equipment needed in data transmission will have the same probability distribution in the life span of the equipments. Norman distribution will be assumed in our analysis.

Assumption 5. The network can employ the ALOHA communication techniques in which the central computer is linked to the radio-communication channel via a small interface computer.

Assumption 6. NASA will permit the Korean Educational Computer Network to use the ATS-1 satellite after NASA moves the position of the satellite whereby all regional centers of Korea will have access to the satellite.

4. NETWORK LAYOUTS AND ECONOMIC CONSIDERATIONS

4.1 Network Layouts

The first problem that should be solved in forming a network is the problem of network layout, i.e., how to connect the regional computers together.

4.1.1

One solution to the network layout problem is to use the existing common carriers of the Ministry of Communications (MOC).

Currently, the MOC has the following long distance telephone circuits that connect Seoul and other cities.

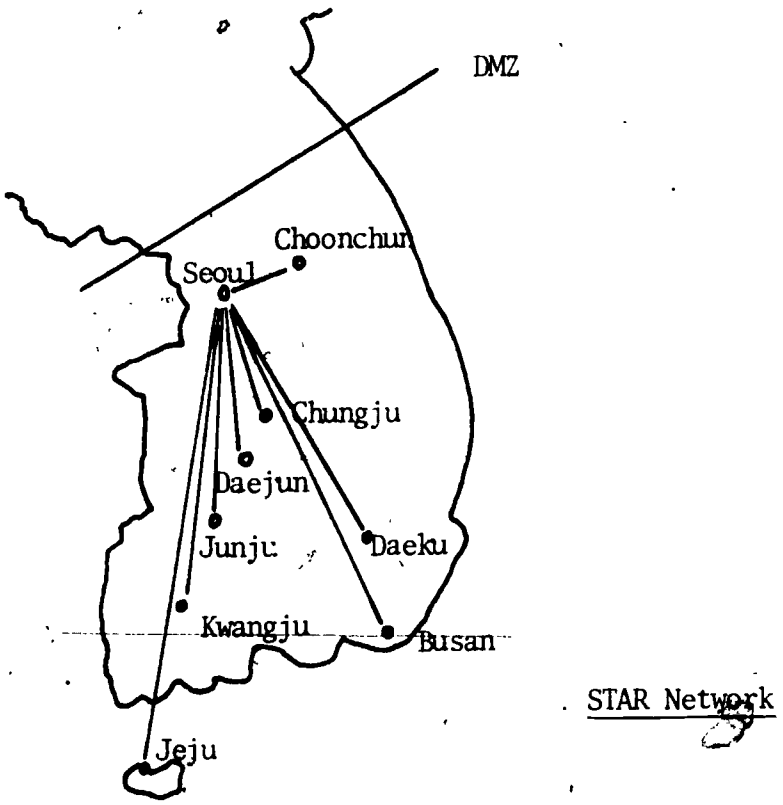
Long Distance Telephone Circuits From Seoul

As of the end of 1971

To Cities	Total Circuits	Private Use	Exclusive Use
Busan	472	429	43
Daeku	230	183	47
Daejun	251	139	112
Choongju	36	26	10
Junju	89	71	18
Choonchun	52	37	15
Chungju	17	13	4
Ganneung	34	26	8
Pohang	15	11	4
Masan	30	21	9
Gunsan	21	18	3
Mokpo	28	23	5
Wonju	20	19	1
Jeju	18	13	5
Kwangju	119	95	24

Source: The Statistical Year Book, The Ministry of Communications, 1972, Seoul, Korea

As we see from the above table, all regional centers can directly access the main computer at Seoul. Therefore, one possible layout, the STAR layout, can be derived in the following way.



STAR Network

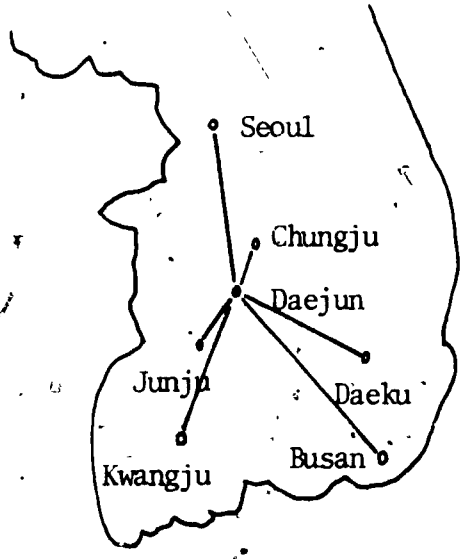
4.1.2

The MOC also provides long distance telephone circuits among major cities in the following ways.

Long Distance Circuits from Daejun

As of the end of 1971

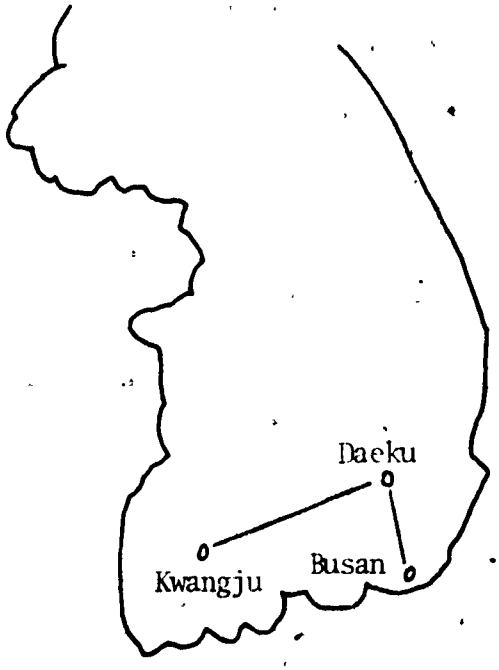
To Cities	Total	Public Use	Exclusive Use
Busan	34	28	6
Daeku	46	36	10
Kwangju	24	21	3
Junju	36	27	
Chungju	25	19	



Long Distance Circuits from Daeku

As of the end of 1971

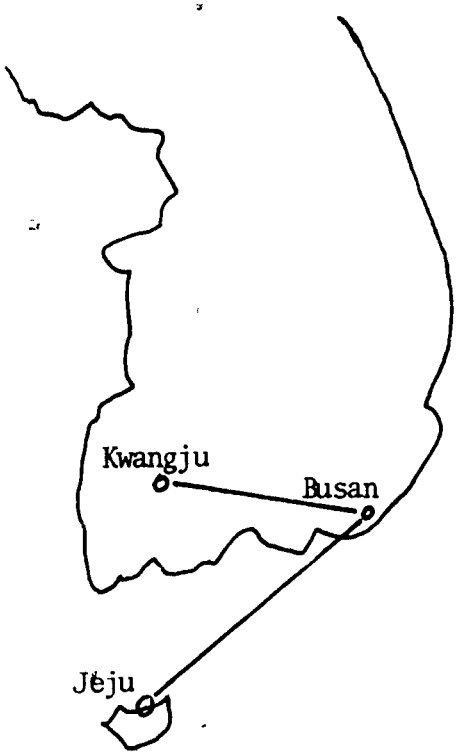
To Cities	Total	Public Use	Exclusive Use
Busan	99	79	20
Kwangju	34	20	14
Wonju	3	3	--



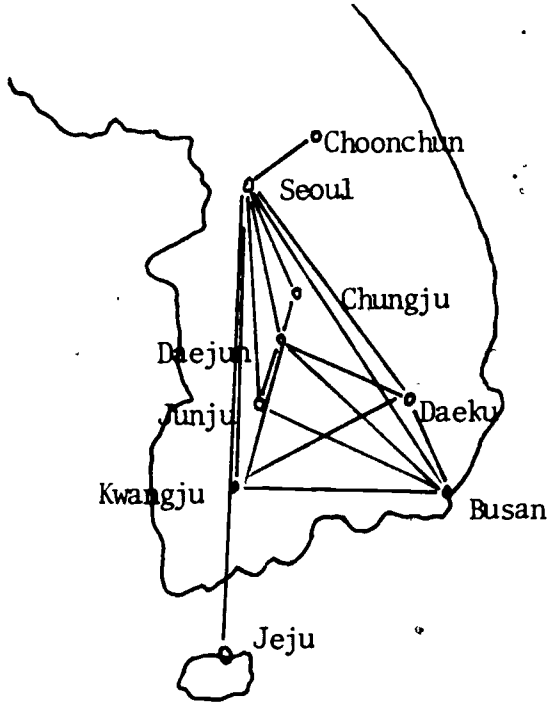
Long Distance Circuits from Busan

As of the end of 1971

T	Total	Public Use	Exclusive Use
Kwangju	19	18	1
Masan	49	35	14
Pohang	11	11	--
Jeju	10	9	1



From the above circuits, we can draw the following possible connections among regional centers.

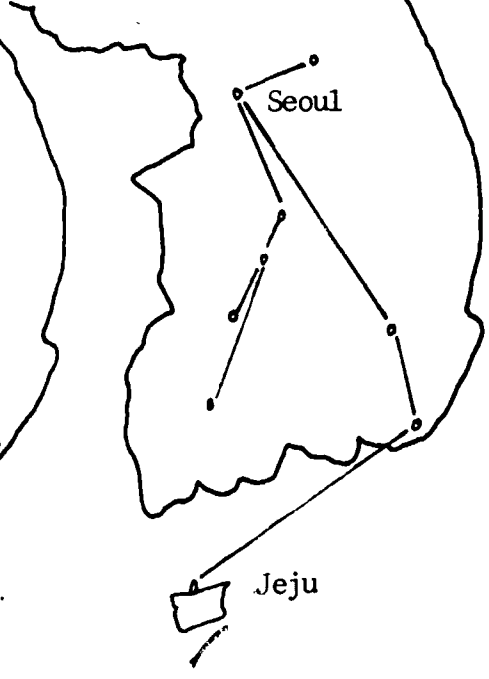


From the above figure, we can design the following three different layouts.

Type 1

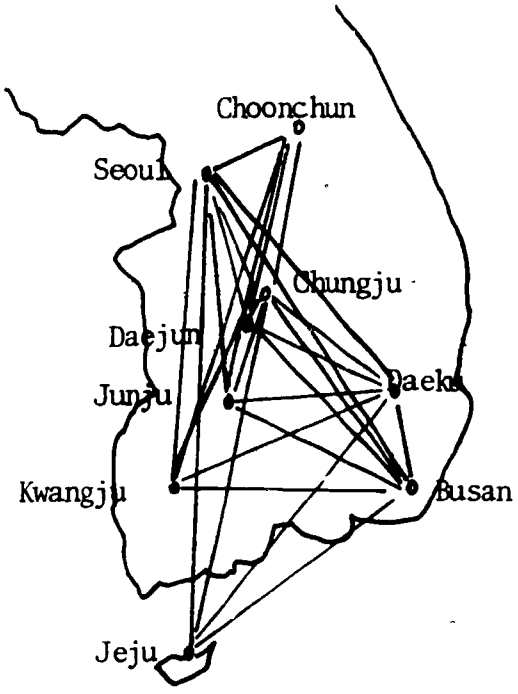
Type 2

Type 3

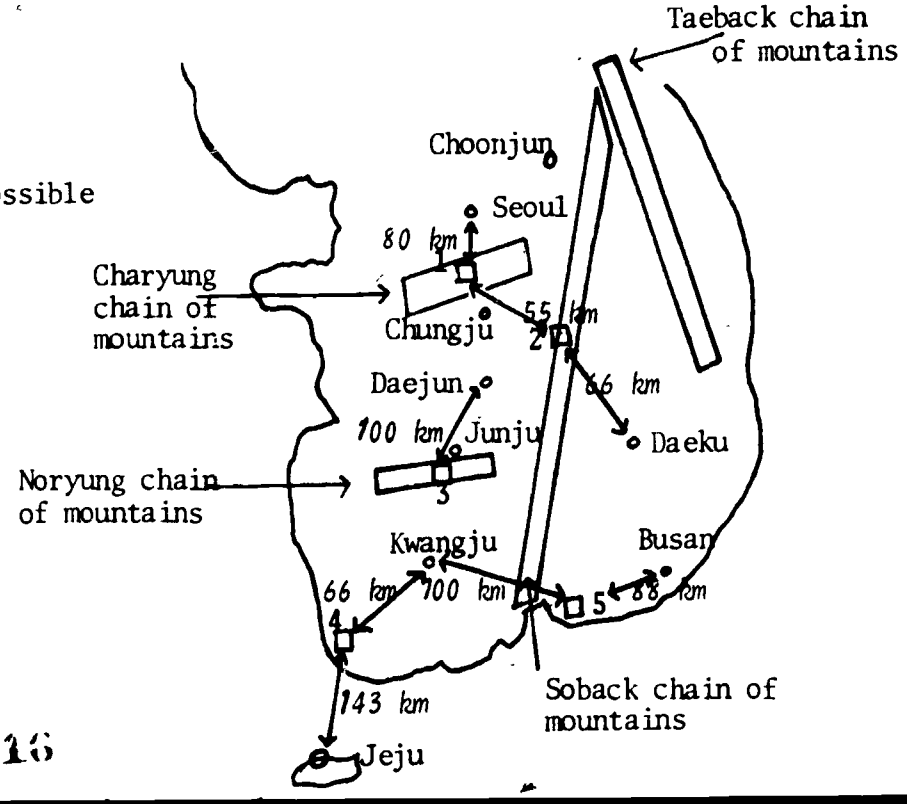


4.1.3

From Assumption 4, in which the network uses the ALOHA technique of radio communication, the following network layout can be derived.



Since Korea has several mountain chains between regional centers, five repeaters will be needed in order to implement the packet-switched broadcasting method in the network.



Note: Squares point to possible sites of repeaters.

1: Chunan
2: Choopoongryung
3: Jungju
4: Mokpo
5: Jinju

And Chunan, Choopoongryung, Jungju, Mokpo, and Jinju are recommendable sites for these radio repeaters.

4.1.4

If Assumption 5 is used, in which the Network utilizes the ATS-1 satellite, the five repeaters of the previous layout will be replaced by the satellite and the network will have the same layout as that of the radio communication linkage.

4.1.5

From the above descriptions, we can summarize the possible layouts of the Korean Educational Computer Network in the following way.

Layout 1 ... use MOC's circuits
STAR Network

Layout 2 ... use MOC's circuits

2.1 Type-1. Daejun will connect 4 circuits to Seoul-Daejun circuit

2.2 Type-2. Daejun will connect 3 circuits to Seoul-Daejun circuit

2.3 Type-3. Daejun will connect 2 circuits to Seoul-Daejun circuit

Layout 3 ... use THE ALOHA SYSTEM radio communication method

Layout 4 ... use ATS-1 satellite

4.2 Economic Considerations

4.2.1

The total cost of a computer system consists of four costs, namely, cost of computers, cost of user terminals, cost of software, and cost of data transmission.

Among these costs, the data transmission cost is the most important in a computer network analysis. Data transmission costs include the cost of modems, the cost of data concentrators, and the cost of transmission lines when common carriers are used.

In the case where radio communications is used, the cost of the TCU (Terminal Control Unit) and repeater will play a major role in the cost configuration.

If the satellite is used, the cost of the satellite and the cost of a ground station will be the major data transmission cost.

In the following sections, we will analyze the cost of data transmission among the different layouts.

4.2.2.1 Layout 1 - Star Network

In this layout, the cost is comprised of modem costs, data concentrator (multiplexor) costs[1] and MOC telephone line costs.

Cost of Modems

Three types of Modems are available for the Cyber's batch terminals in Korea.

Modem	Up to 300 bps Teletype compatible Purchase $600 Maintenance $10/month
Modem 2200/24	Up to 2400 bps Full or half duplex Purchase $2,450
Modem 4600/48	Up to 4800 bps Full or half duplex Purchase $4,750

In the case of the star layout, the network will need 16 Modems[2].

$8^{ports} * 2 = 16^{modems}$

Hence, the purchasing costs of Modems are as follows.

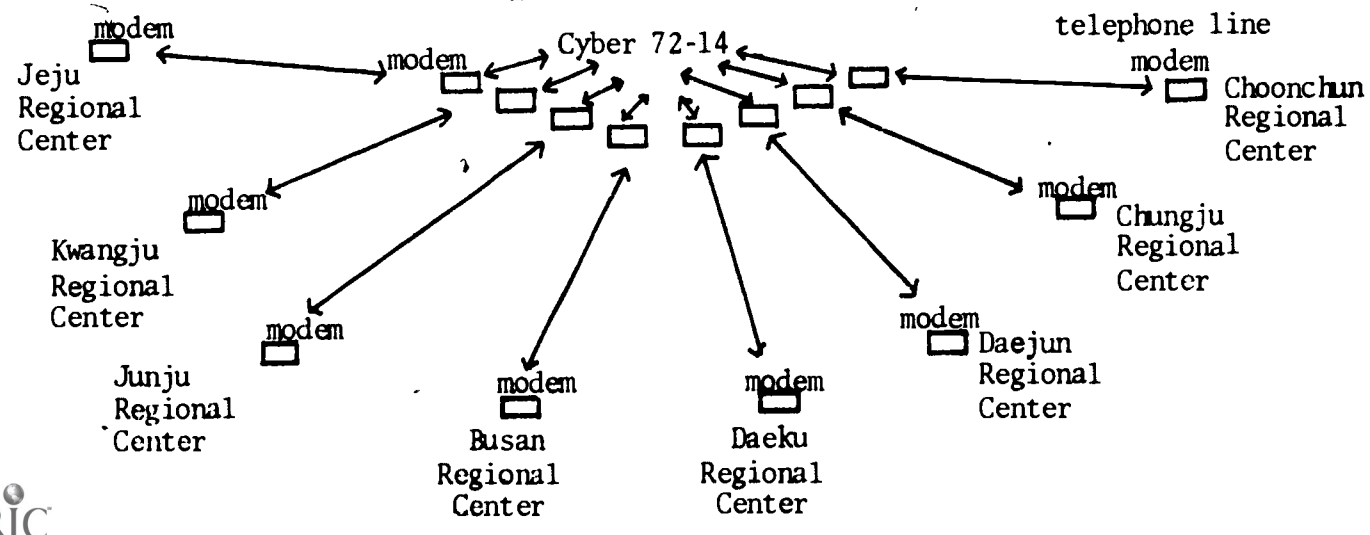
Modem 300 ——— 16^{modems} X $600 = $9,600

Modem 2200/24 ——— 16^{modems} X $2,450 = $39,200

Modem 4600/48 ——— 16^{modems} X $4,750 = $76,000

(1) Since the Cyber system already has this capacity and other layouts need this capacity commonly, I will not include this cost in this analysis.

(2)



4.2.2.2 Layout 2

This layout requires 9 modems. And since some ports have to work as communication nodes, additional communication equipment should be attached to the nodes when we use Cyber's batch terminals in the network. (The price of the equipment will be assumed at $1,000 per unit.)

The purchasing cost of the modems will be

9 modems x $600 = $5,400 for low speed modem

9 modems x $2,450 = $22,050 for medium speed modem

9 modems x $4,750 = $42,750 for high speed modem

The cost of telephone lines will be $8,991/year, $10,370/year and $10,179/year for the type 1, type 2 and type 3 layouts, respectively.(1)

(1) leased line (In this layout, dial-up connections among regional centers will bring serious administrative problems. Therefore, only leased lines will be considered here.)

Seoul-Choonchun	₩ 23,100	Seoul-Choonchun	₩ 23,100	Seoul-Choonchun	₩ 23,100
Seoul-Daejun	46,200	Seoul-Daeku	82,500	Seoul-Daeku	82,500
Daejun-Chungju	10,800	Daeku-Busan	28,200	Daeku-Busan	28,200
Daejun-Daeku	36,300	Busan-Jeju	89,100	Busan-Jeju	89,100
Daejun-Junju	19,800	Daejun-Chungju	10,800	Seoul-Chungju	89,600
Daejun-Kwangju	46,200	Daejun-Junju	19,800	Chungju-Daejun	10,800
Daeku-Busan	28,200	Daejun-Kwangju	46,200	Daejun-Junju	19,800
Busan-Jeju	89,100	Seoul-Daejun	46,200	Daejun-Kwangju	46,200
	₩299,700/mo.		₩345,900/mo.		₩339,300/mo.

The total communication cost will be as follows:

life span	types of modems		cost of leased line			cost of node equipment[1]			total cost		
			type 1	type 2	type 3	type 1 $5,000	type 2 $4,000	type 3 $5,000	type 1	type 2	type 3
3	L	$1,800	$8,991	$10,377	$10,179	$1,667	$1,333	$1,667	$12,458	$13,510	$13,646
	M	7,350	8,991	10,377	10,179				17,341	19,060	19,196
	H	14,250	8,991	10,377	10,179				24,908	25,960	26,096
5	L	1,080	8,991	10,377	10,179	1,000	800	1,000	11,071	12,257	12,259
	M	4,410	8,991	10,377	10,179				14,401	15,587	15,589
	H	8,550	8,991	10,377	10,179				18,541	19,727	19,729
10	L	540	8,991	10,377	10,179	500	400	500	11,198	11,317	11,219
	M	2,205	8,991	10,377	10,179				11,696	12,982	12,884
	H	4,275	8,991	10,377	10,179				13,766	15,052	14,954
15	L	360	8,991	10,377	10,179	333	267	333	9,684	11,004	10,872
	M	1,470	8,991	10,377	10,179				10,794	12,114	11,982
	H	2,850	8,991	10,377	10,179				12,174	13,594	13,362
20	L	270	8,991	10,377	10,179	250	200	250	9,511	10,847	10,699
	M	1,103	8,991	10,377	10,179				10,344	11,682	11,532
	H	2,138	8,991	10,377	10,179				11,379	12,715	12,567

The expected costs[2] of the layouts are shown in the table below:

Types of Modem	Expected Cost		
	type 1	type 2	type 3
low	$10,115	$11,395	$11,303
medium	11,883	13,163	13,071
high	14,091	15,371	15,279

[1] type 1 and 3 need 5 communication equipment and type 2 needs 4 equipment.

5 X $1,000 = $5,000 for type 1, type 3
4 X $1,000 = $4,000 for type 2

[2] See table on next page.

X	Node Equip. (E)		P	C			P*C			E*P	
	T1 or T3	T2		low	medium	high	low	medium	high	T1 or T3	T2
1	$5,000	$4,000	0	$5,400	$22,050	$42,750	0	0	0	0	0
2	2,500	2,000	0.0025	2,700	11,025	21,375	7	28	54	6	5
3	1,666	1,333	0.0025	1,800	7,350	14,250	5	18	36	4	3
4	1,250	1,000	0.005	1,350	5,512	10,688	7	28	53	6	5
5	1,000	800	0.01	1,080	4,410	8,550	11	44	86	10	8
6	833	667	0.04	900	3,675	7,125	36	147	285	33	27
7	714	571	0.07	771	3,150	6,107	54	221	427	50	40
8	625	500	0.12	675	2,756	5,344	81	331	641	75	60
9	556	444	0.16	600	2,450	4,750	108	392	760	89	71
10	500	400	0.18	540	2,205	4,275	97	397	770	90	72
11	455	364	0.16	490	2,005	3,886	78	321	622	73	58
12	417	333	0.12	450	1,838	3,562	54	221	427	50	40
13	385	308	0.07	415	1,696	3,288	29	119	230	27	22
14	357	286	0.04	386	1,575	3,054	15	63	122	14	11
15	333	267	0.01	360	1,470	2,850	4	15	29	3	3
16	312	250	0.005	337	1,378	2,672	2	7	13	2	1
17	294	235	0.0025	318	1,297	2,515	1	3	6	1	1
18	278	222	0.0025	300	1,225	3,275	1	3	6	1	1
19	263	211	0	284	1,160	2,250	0	0	0	0	0
20	250	200	0	270	1,102	2,138	0	0	0	0	0
							∑ $590	$2,358	$4,566	$534	$428

ex

T1 low: $590 + $534 + $8,991 = $10,115

T2 medium: $2,358 + $428 + $10,377 = $13,163

T3 high: $4,566 + $534 + $10,179 = $15,279

4.2.2.3 Layout 3 - Radio Communication

The cost estimation of this layout is quite simple. The purchasing cost of the TCU and Repeaters is $14,000.

9^{TCU} X $1,000 = $9,000

$5^{Repeaters}$ X $1,000 = $5,000

Total $14,000

The annual cost of this layout will be as follows:

Life Span (years)	Annual Cost
3	$4,667
5	2,800
10	1,400
15	933
20	700

If we take the same position as in Assumption 4 of Section 3, that is, if we assume that the life span of the TCU and Repeater are normally distributed with a mean value of 10 years, then the expected cost of this layout is $1,492.

4.2.2.4 Layout 4 - Satellite

This layout needs 9 ground stations and the total installation cost is $45,000.

$$\$5,000 \times 9^{\text{stations}} = \$45,000$$

If NASA permits the network to use the satellite without fee, the ground station cost will be the only cost for this layout.

Hence, the annual cost of communication will be as follows:

Life Span	Annual Cost
3	$15,000
5	9,000
10	4,500
15	3,000
20	2,250

and the expected cost of the layout is $4,793.

5. CONCLUSIONS

The following table shows us the characteristics and costs of the different network layouts.

Comparison of layouts

Characteristics	layout 1	layout 2			layout 3	layout 4
		type 1	type 2	type 3		
low	$19,493	$10,115	$11,395	$11,303	$1,492	$4,793
medium	22,655	11,883	13,163	13,071	1,492	4,793
high	26,448	14,091	15,371	15,179	1,492	4,793
Need extra equipment in addition to the current available equipment in Korea?	No	yes node equipment	yes node equipment	yes node equipment	yes TCU & repeater	yes ground station
when you expand the regional center, what is required?	Modems (One for main computer, the other for terminal)	Modem for terminal and if the port does not have node-equipment then node equipment are needed			TCU for terminals	Ground Stations for terminals
degree of certainty of the technology in Korea (subjective utility of the researcher)	100%	70%	70%	70%	90%	60%

5.1

It is quite clear from the above table that the lowest costing layout is that of layout 3 specifically that of radio communication.

5.2

Because of the appreciable difference in expected costs between the common-carrier layout (layouts 1 & 2) and the radio communication layout (layout 3) it would be possible, if layout 3 were used, to add Menehune-type communication equipment to the central computer. The possible range in budget for this expansion would be approximately $110,000, but it will enhance the system's capacity greatly.

5.3

The cost of Layout 4, that of using the satellite, is less than that of the common-carrier layout. The cost difference, between the two layouts would be about $8,000/port (total $72,000).

5.4

Layout 1 is the most expensive but it does not carry any risks in operating the network since this method has already shown to be workable in Korea. On the contrary, the implementation of layout 2 and layout 4 has some degree of uncertainty.

If we assume the degree of uncertainty stated in the above table (30% to layout 2, 10% to layout 3, and 40% to the layout 4) and assign same scale of penalty cost to the uncertain layouts, then we can have the following expected layout costs.

Modified Expected Costs (Annual Costs)

data transmission	layout 1	layout 2			layout 3	layout 4
		type 1	type 2	type 3		
low	$19,493	$13,150	$14,814	$14,694	$1,641	$6,710
medium	22,655	15,448	17,112	16,993	1,641	6,710
high	26,448	18,318	19,982	19,732	1,641	6,710

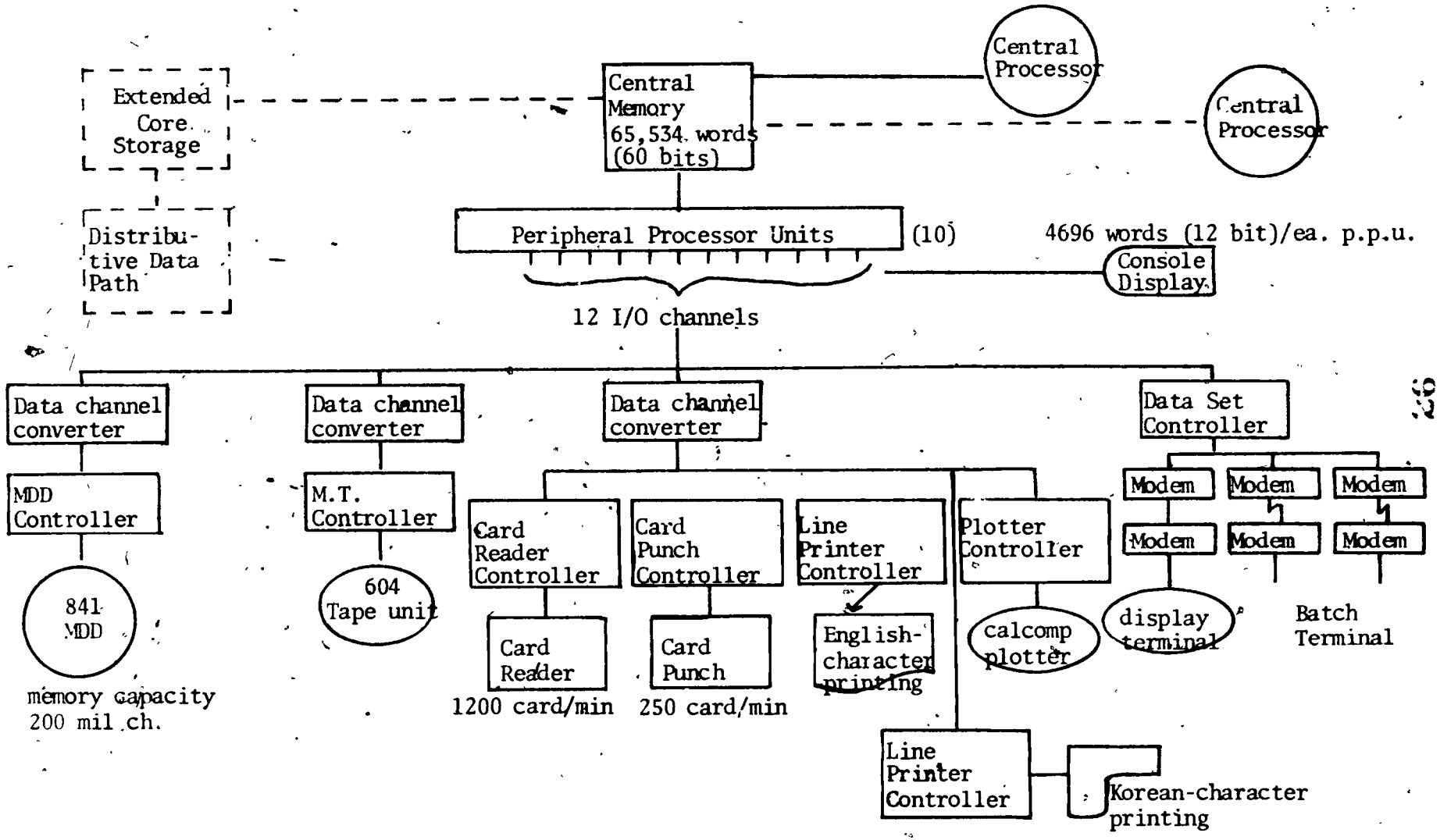
As we see in the above table, even if the cost of risk is considered, the choice of layout 3 as the network's layout does not seem to be changed. (If the designer of the network assigns 100% of the expected cost as the risk cost to layout 2, 1100% to layout 3 and 300% to layout 4, the 4 alternatives will be chosen indifferently by the designer.)

5.5

If the price of the node equipment needed in the layout 2 exceeds $26,000/unit, the cost of layout 1 and the cost of layout 2 will be the same.

APPENDIX

CYBER 72-14 SYSTEM



* In addition to this system CDC 1700/936 OCR System is separately being operated.

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