

**Proceedings
from**

NETWORK MANAGEMENT WORKSHOP

Sponsored by

**Defense
Advanced Research
Projects Agency**

**Held at
USC Mount Ada Conference Center
9 - 11 January 1983**

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Dale McNeill
Bolt, Beranek and Newman

4. Attendees

4. Attendees

Barry Leiner	DARPA
Jon Postel	USC-ISI
Jil Westcott	BBN
John Jubin	Rockwell
Gil Falk	BBN
Jim Herman	BBN
Steve Kent	BBN
Jack Haverty	BBN
Keith Klemba	SRI
Cliff Weinstein	Lincoln Labs
Jim Forgie	Lincoln Labs
Dale McNeill	BBN
Dave Mills	Linkabit

3. Presentations

3.1 Internet and Local Net

Dave Clark

MIT

LOCAL NETWORKS

BASIC APPROACH: BANDWIDTH IS "FREE", SO WASTE IT.

Clearly, wire is not free. But the economics of local networking is completely different from long haul networking, where bandwidth is the dominating cost. In local area nets, it is seldom useful to add components to increase bandwidth utilization

FEATURES:

CONGESTION CONTROL IS OUTSIDE NET

Local nets have very simple congestion control, e.g. Ethernet collision back off. The net itself does not get congested, since there is no storage in the net. Instead, congestion is manifested as backup in host buffers. This means that detection and control of congestion depends on host co-operation.

FLOW CONTROL: SOMETIMES

The ring net has a "refused bit" which a receiver can set to say that there are no buffers available. This is a very low level mechanism, and does not extend well to internet architectures. Ethernets lack even this.

ROUTING: BROADCAST

The use of broadcast is a way to reduce system cost by using up bandwidth. It is not always thought of in this way, but this is actually a fundamental design characteristics of LANs.

ALLOCATION: ROUND ROBIN, CONTENTION, PRIORITY

SUMMARY POINTS

LOCAL NETS ARE HIGH SPEED AND LOW DELAY

LANS ARE BROADCAST

CONTROL ALGORITHMS ARE WEAK

NO PROGRAMMABLE COMPONENTS

That is, there are no IMPs in an Ethernet.

SECOND TALK: THE INTERNET PROJECT

RESEARCH PROBLEMS OR GOALS:

1) VARYING NETWORK CHARACTERISTICS

This is a problem both for performance (how can one internet utilize both a 1200 bps phone line and an Ethernet) and for control (how can one build an Internet congestion control algorithm out of nets that have no congestion control algorithm).

2) MULTI-VENDOR GATEWAY

In the ARPANET, the IMP is not a stock item obtained by competitive bid. Only through the intervention of wizards does the ARPANET operate well. The Internet project hopes to understand what gateways do well enough that its functions can be specified in enough detail that it can be made a stock item. This will require new techniques in specification.

3) MORE FUNCTIONS IN THE HOST

In the ARPANET and also in X.25, functions such as flow control are performed inside the network, where in some sense they can be trusted. In Internet, we view the host as not trusting the net, and move these functions into the host.

4) BOTH GENERALITY AND PERFORMANCE

It is easy to get performance if that performance is over a narrow range of network characteristics. When the networks are very different in delay, speed, and control algorithms, it is difficult to build protocols which cover the range of possibilities and adapt well to all possibilities. This is a goal of Internet.

QUESTION: IS A COMMUNICATION LINK LIKE A NETWORK

In building the Internet, many design decisions have been made based on our understanding of networks, comparing the gateways to packet switches (e.g. IMPs) and the networks to communications paths. However, this comparison is imperfect, telephone lines do not have flow and congestion control algorithms. In fact, moving from the specific networks to the Internet, the building blocks out of which the facility is made are much more complex. The full implications of this is not clear.

CURRENT STATUS OF THE INTERNET

HOSTS ARE STABLE -- GATEWAYS ARE NOT

Just as in the ARPANET the HHP was quickly frozen but the IMP code continues to change, the gateway design is still in flux.

ROUTING: NOT VERY GOOD

We only support small Internets, and we do not support routing based on TOS, or on security or other traffic parameters. This is a subject of current study.

We are introducing EGP, a gateway protocol that partitions the Internet into Autonomous systems of gateways. This will allow research in new gateway algorithms, permit the Internet to grow, and permit several gateway builders to occupy the same Internet.

CONGESTION CONTROL: SOURCE QUENCH

Source Quench is the current mechanism, but there is little faith that it works. Several groups are considering alternatives.

FLOW CONTROL: A PROTOCOL SPECIFIC MECHANISM

TCP has a fairly traditional window scheme for flow control. However, TCP is not mandatory. Some other protocol might use some other form of flow control, e.g. timer based rates. The Internet must be prepared to deal with all of these.

PROBLEMS

GROWTH AND TOPOLOGY

It was a goal of the internet to take whatever networks seemed to be around, and to combine these using gateways into an Internet. This implies that there are no topological restrictions on the Internet. As the Internet grows, this goal seems unreasonable. Some structure is needed to make addressing and routing work. However, the form of this restriction is unclear.

BETTER ROUTING AND CONGESTION CONTROL

The Internet project concentrated its early effort in getting the bits through, and paid less effort to the issue of resource control in the networks and the gateways. The pressure to provide good performance is forcing us to now consider this latter issue. The integration of these ideas into the existing protocols will be a good test of our foresight.

3.2 Internet Packet Speech Communication
C.J. Weinstein and J.W. Forgie
MIT Lincoln Labs

INTERNET PACKET SPEECH COMMUNICATION

- REQUIREMENTS FOR SPEECH IN PACKET NETS
- ST PROTOCOL GOALS
- SPEECH IN THE EXPERIMENTAL WIDEBAND INTERNET
- THE ST/IP GATEWAY AND ASSOCIATED FLOW CONTROL ISSUES

REQUIREMENTS FOR SPEECH IN PACKET NETS

- GUARANTEED PEAK DATA RATE
- CONTROLLABLE (AND LOW) DELAY
- SMALL QUANTITY OF SPEECH PER PACKET
- HIGH LINK UTILIZATION TO COMPETE WITH CIRCUIT-SWITCHING
- CONFERENCING
 - EFFICIENT USE OF RESOURCES INCLUDING BROADCAST NET
 - DISTRIBUTED CONTROL

MULTIPLEXING CONSIDERATIONS AND LIMITS

VOICE MULTIPLEXING

TASI OR DSI

- SINGLE LINK
- HIGH EFFICIENCY FOR LARGE NUMBER OF TALKERS

PACKET

- MULTILINK
- ALLOWS DELAY VS. TASI TRADEOFF
- COST IN PACKET OVERHEAD
- CONVENIENT FRAMEWORK FOR VARIABLE RATE OPERATION

DATA/VOICE MULTIPLEXING

USE OF SILENCES FOR DATA TRANSMISSION

- CAN GET HIGH THROUGHPUT
- PACKET SYSTEMS GIVE MOST FLEXIBILITY

LOCAL NETS

ETHERNET-LIKE SYSTEMS GIVE VOICE MUXING PERFORMANCE SIMILAR TO
FIXED-TDMA BUT WITH MUCH GREATER FLEXIBILITY

SATELLITE NETS

NEED STREAM RESERVATIONS

LOCAL TASI-LIKE MUXING OK

SATELLITE-WIDE TASI LIMITED BY RESERVATION DELAY

FLOW AND CONGESTION CONTROL IN PACKET VOICE/DATA SYSTEMS

VOICE

- BLOCKING
- PRE-EMPTION
- VARIABLE RATE
 - DIAL UP
 - EMBEDDED CODING

DATA VS. VOICE

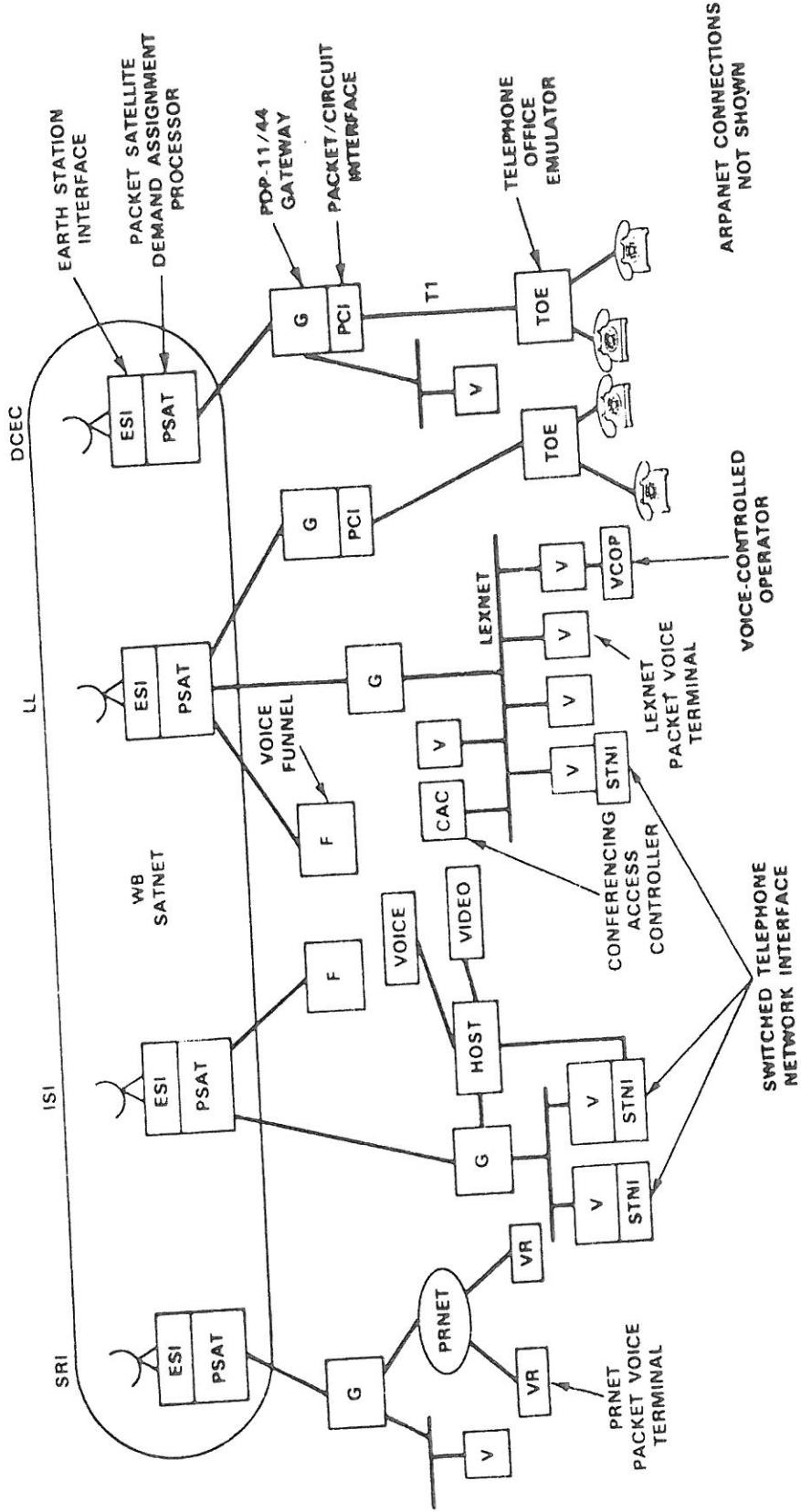
- PRIORITY OF VOICE AND DATA
- INTERACTION OF DATA FLOW CONTROL MECHANISMS
(I.E., TCP PARAMETERS) WITH VOICE TRAFFIC

THE ST PROTOCOL FOR PACKET SPEECH

REQUIREMENTS

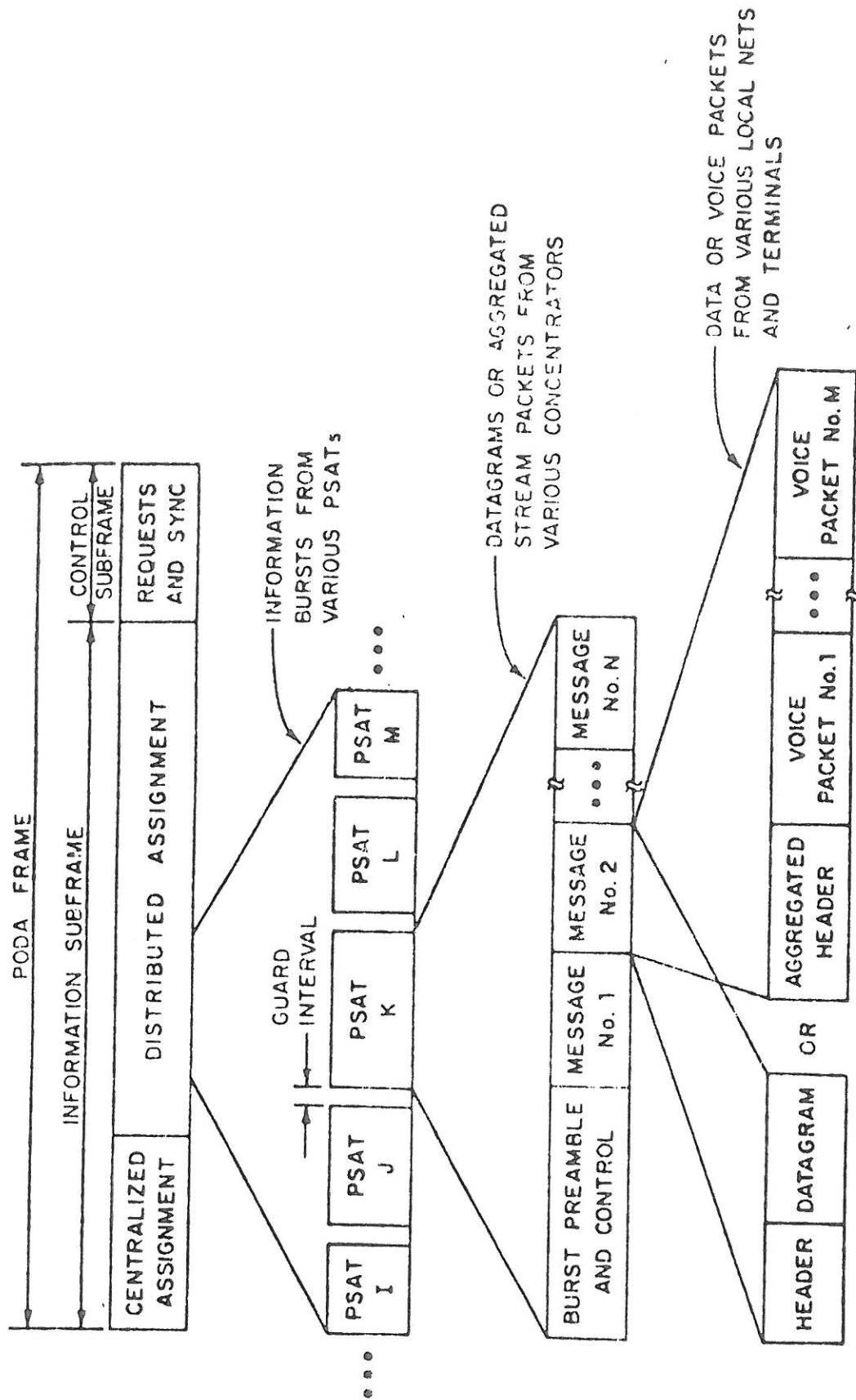
1. GUARANTEED DATA RATE.
 2. CONTROLLED DELAY (PREDICTABLE DISPERSION).
 3. SMALL QUANTITY OF SPEECH PER PACKET.
 4. EFFICIENCY EQUAL TO OR BETTER THAN CIRCUIT SWITCHING WITHOUT TASI.
 5. EFFICIENT USE OF BROADCAST MEDIA.
-
- ### ST APPROACH
1. KNOW REQUIREMENTS IN ADVANCE.
ASSIGN LOADS TO LINK STATISTICALLY.
 2. PREVENT CONGESTION BY CONTROLLING ACCESS ON A CALL BASIS.
 3. USE ABBREVIATED HEADERS.
AGGREGATE SMALL PACKETS FOR EFFICIENCY.
 4. ABBREVIATED HEADERS FOR PACKET EFFICIENCY. GOAL OF HIGH LINK UTILIZATION WITH EFFECTIVE TRAFFIC CONTROL.
 5. REPLICATE PACKETS ONLY WHEN NECESSARY.

WIDEBAND INTEGRATED VOICE/DATA EXPERIMENT STATUS —
AUGUST 1982



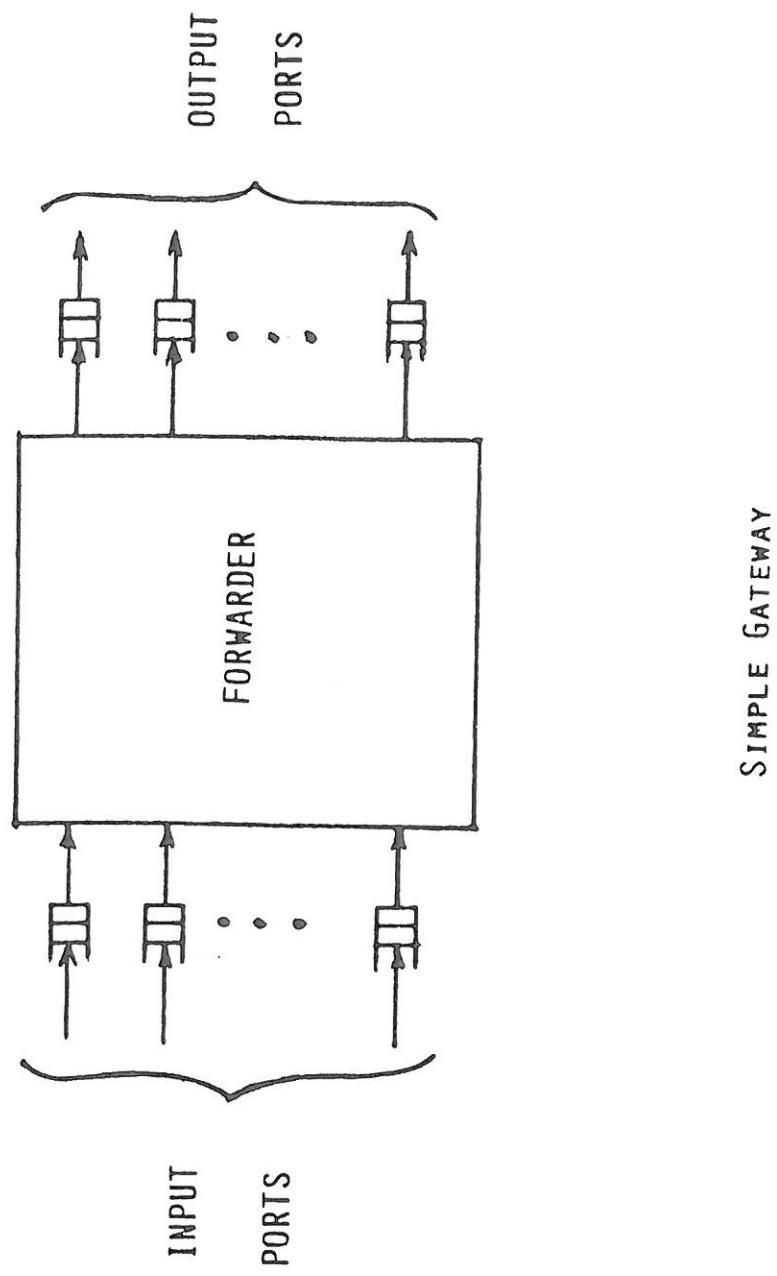
PACKET MULTIPLEXING HIERARCHY

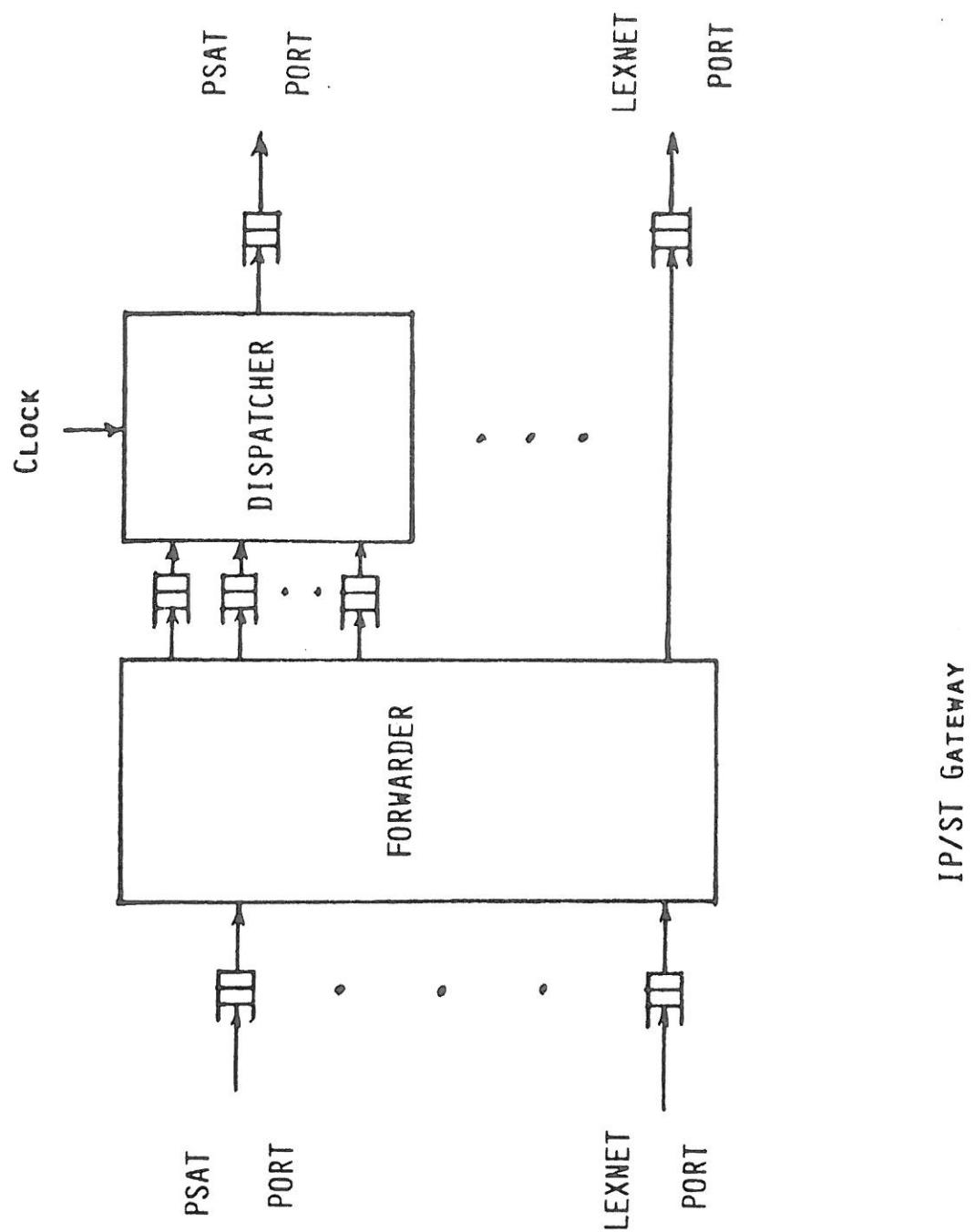
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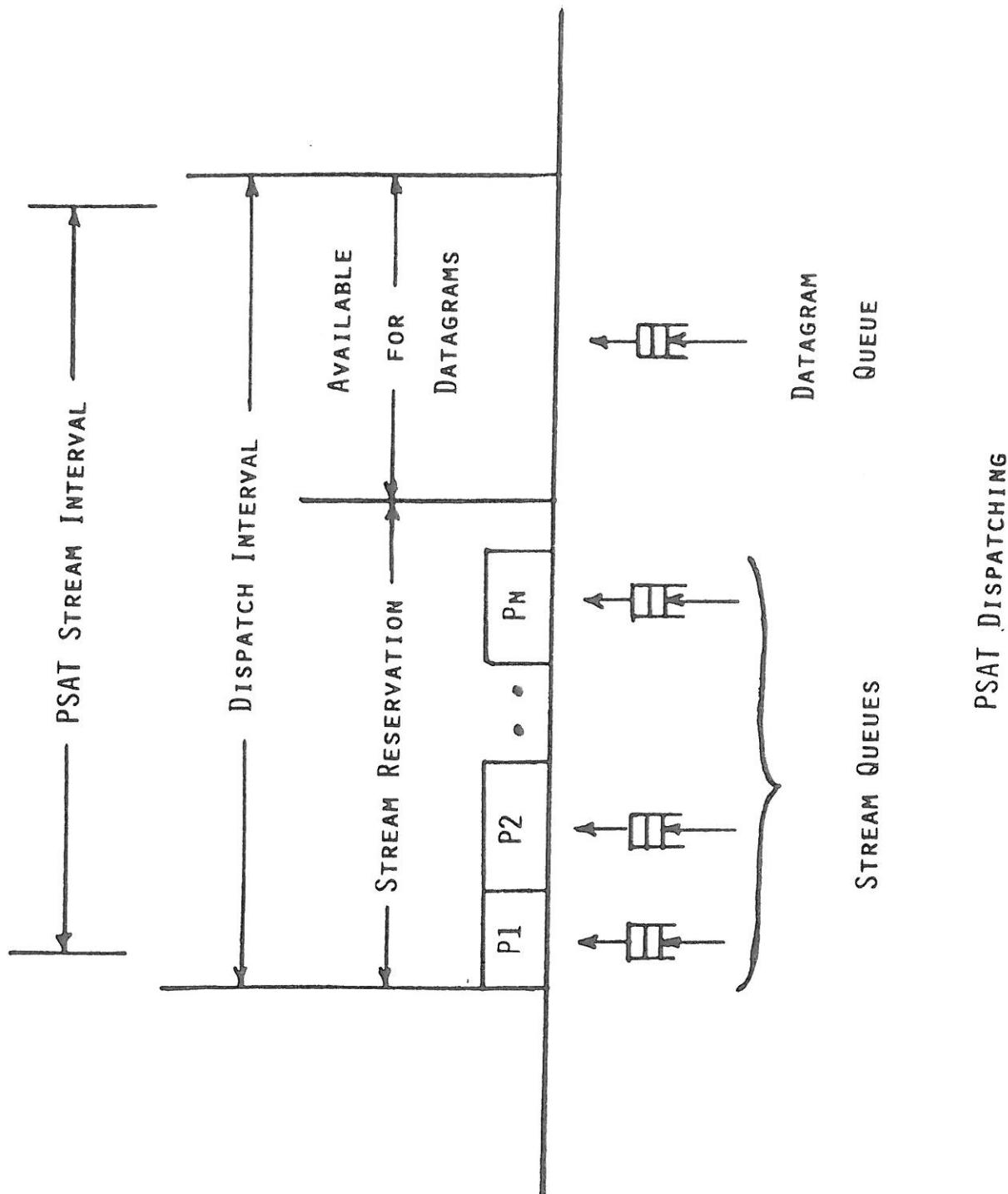


WIDEBAND NETWORK SPEECH EXPERIMENTS

- BASICALLY ALL INTERNET PATHS HAVE BEEN VALIDATED
- SOME PINCHPOINTS DUE TO CASCADING OF INTERFACES AND PROCESSORS
- ACCESS TO RESERVED RESOURCES HAS BEEN OBTAINED USING ST
AND PODA STREAMS
- HOWEVER, SOME REDUNDANT EXTRA BUFFERING (DELAY) IN GATEWAY AN
PSAT ARE NEEDED TO USE STREAMS EFFECTIVELY

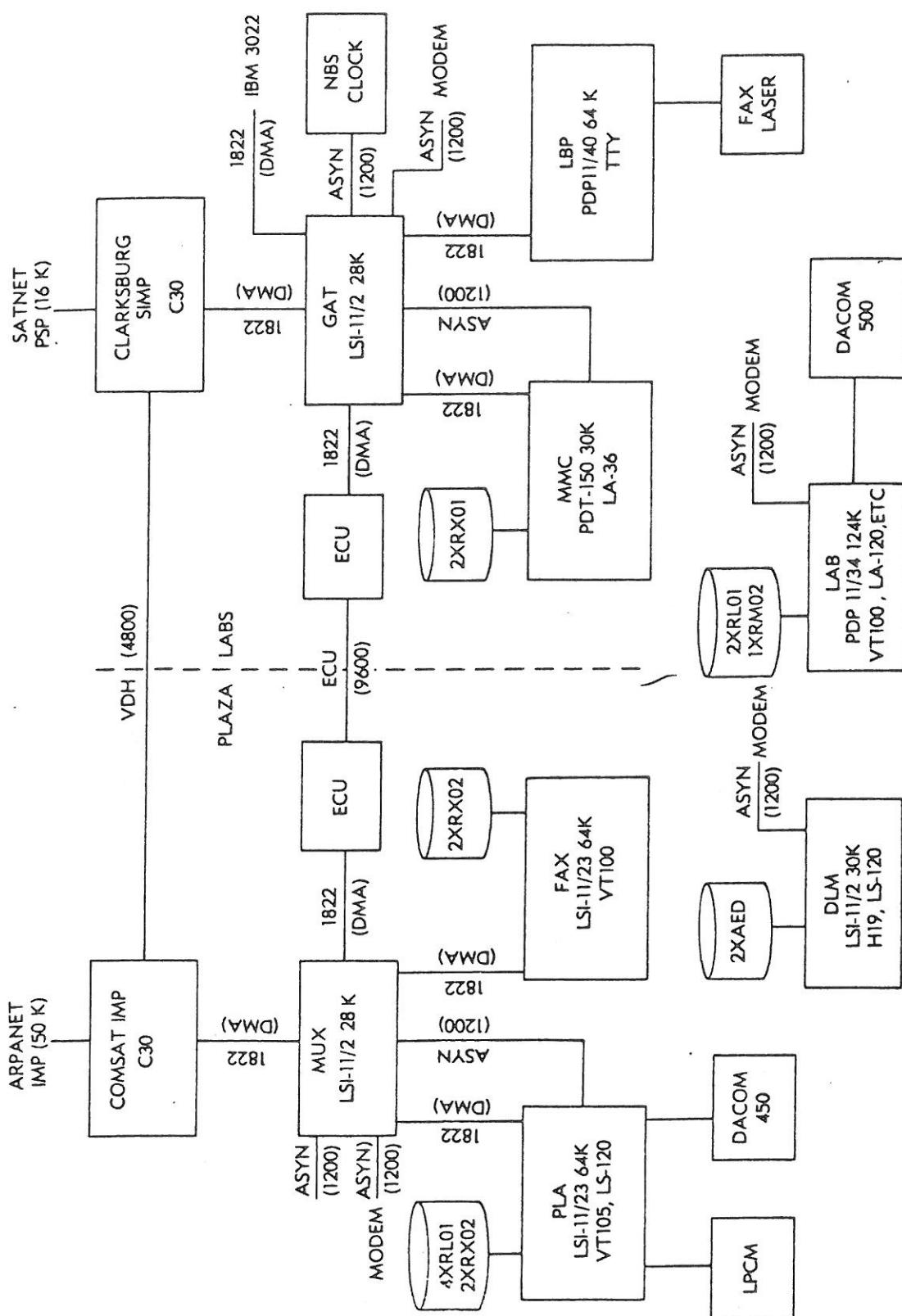


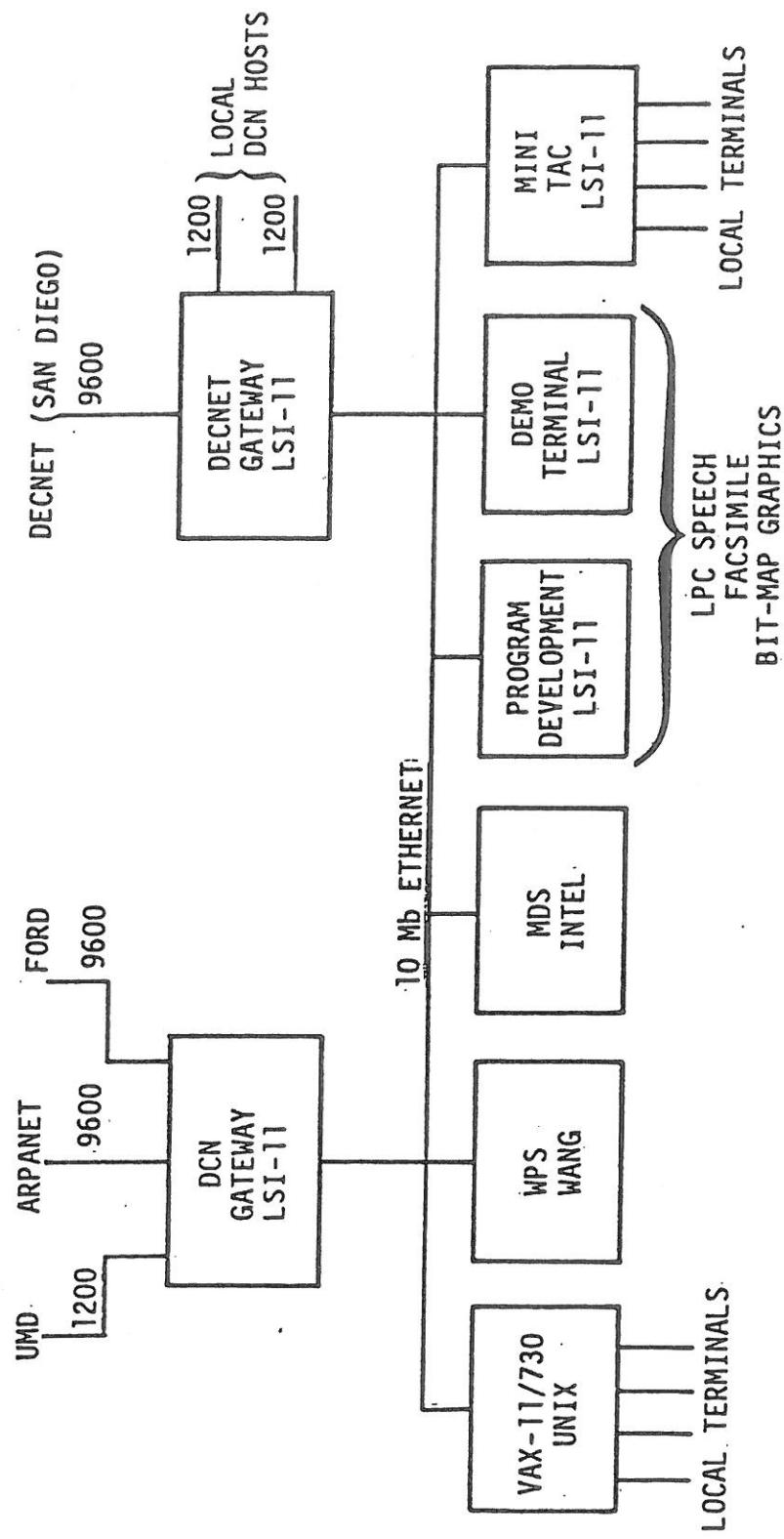




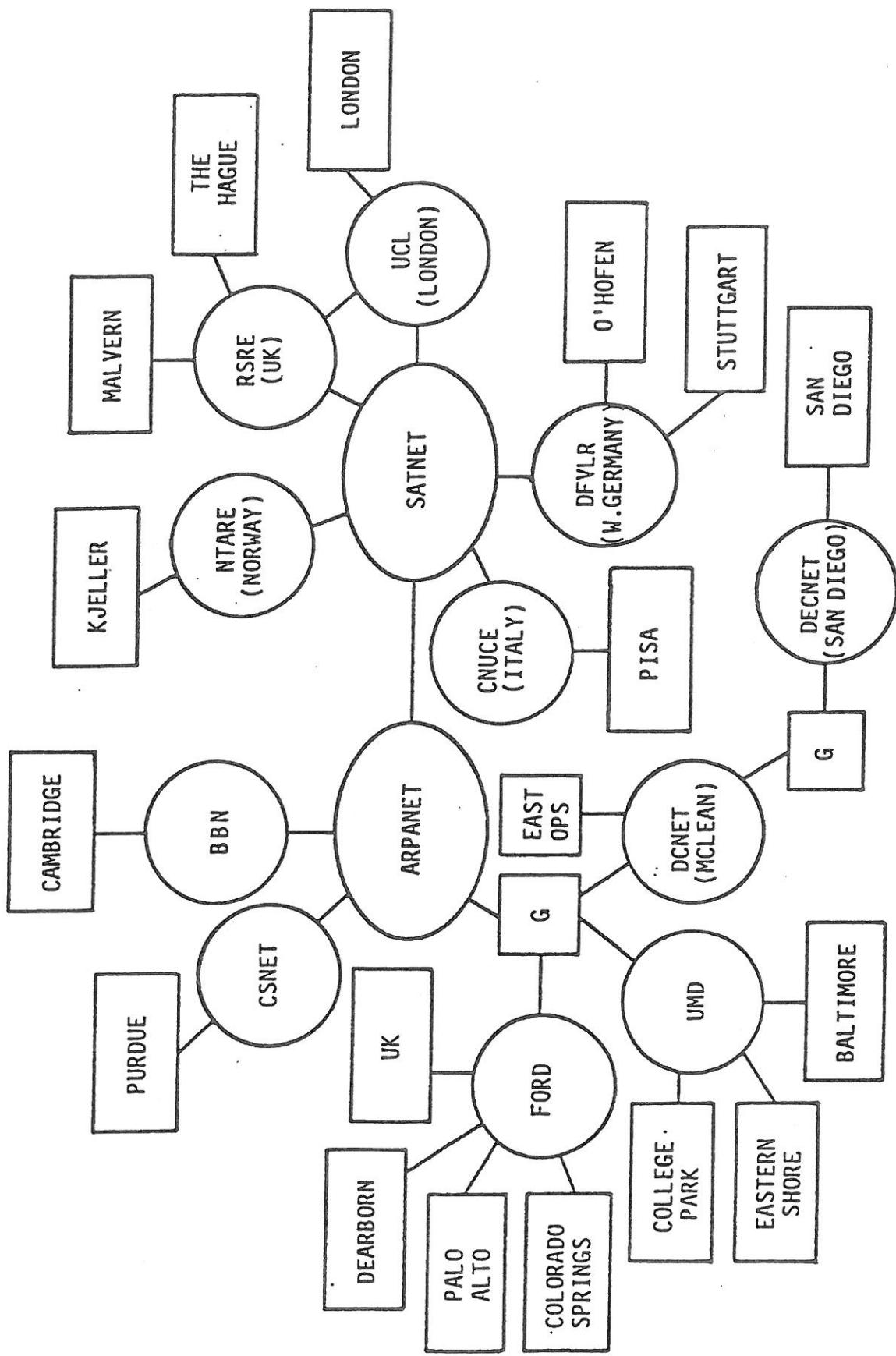
3.3 Local Nets and Hosts

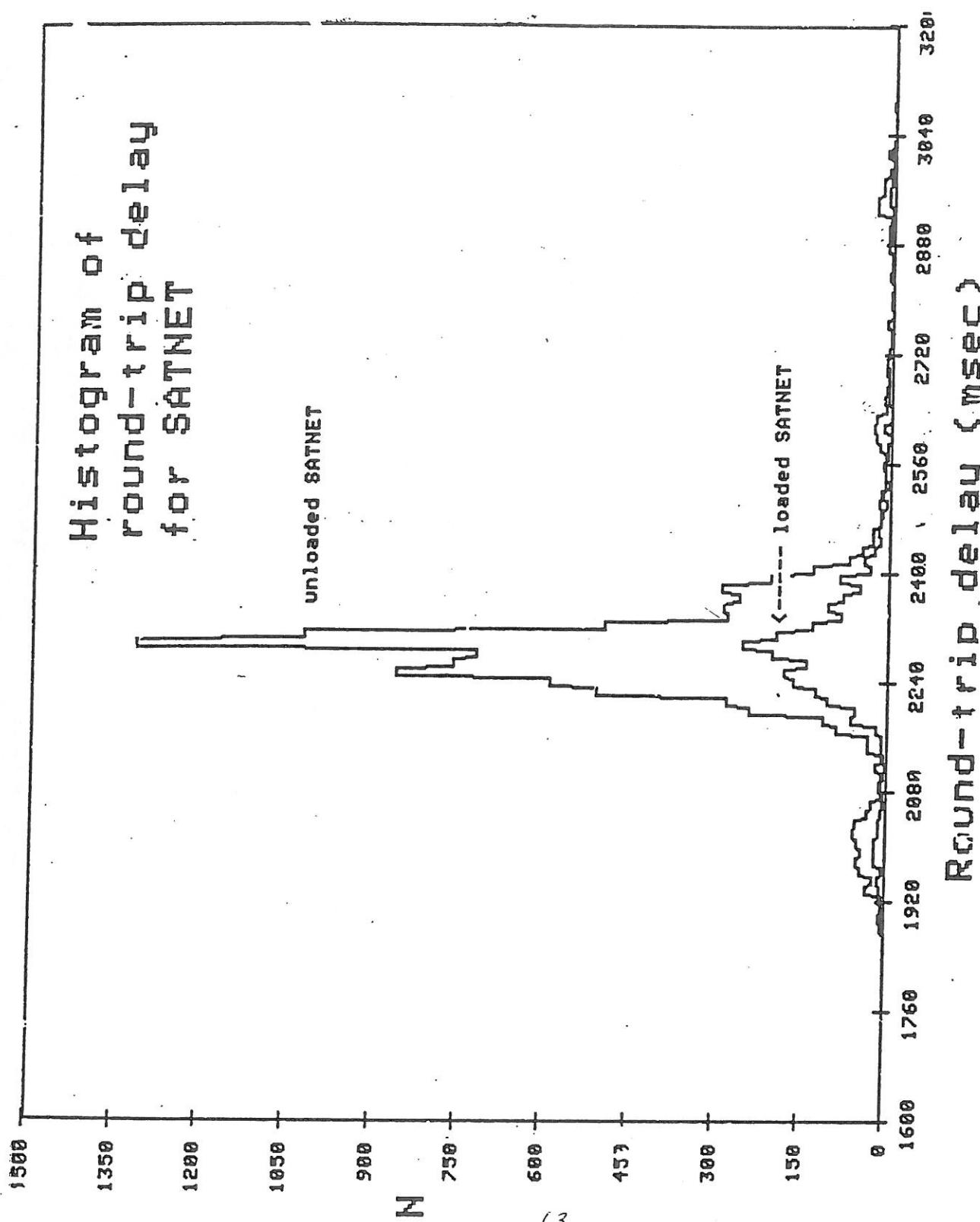
Dave Mills
M/A-Com Linkabit

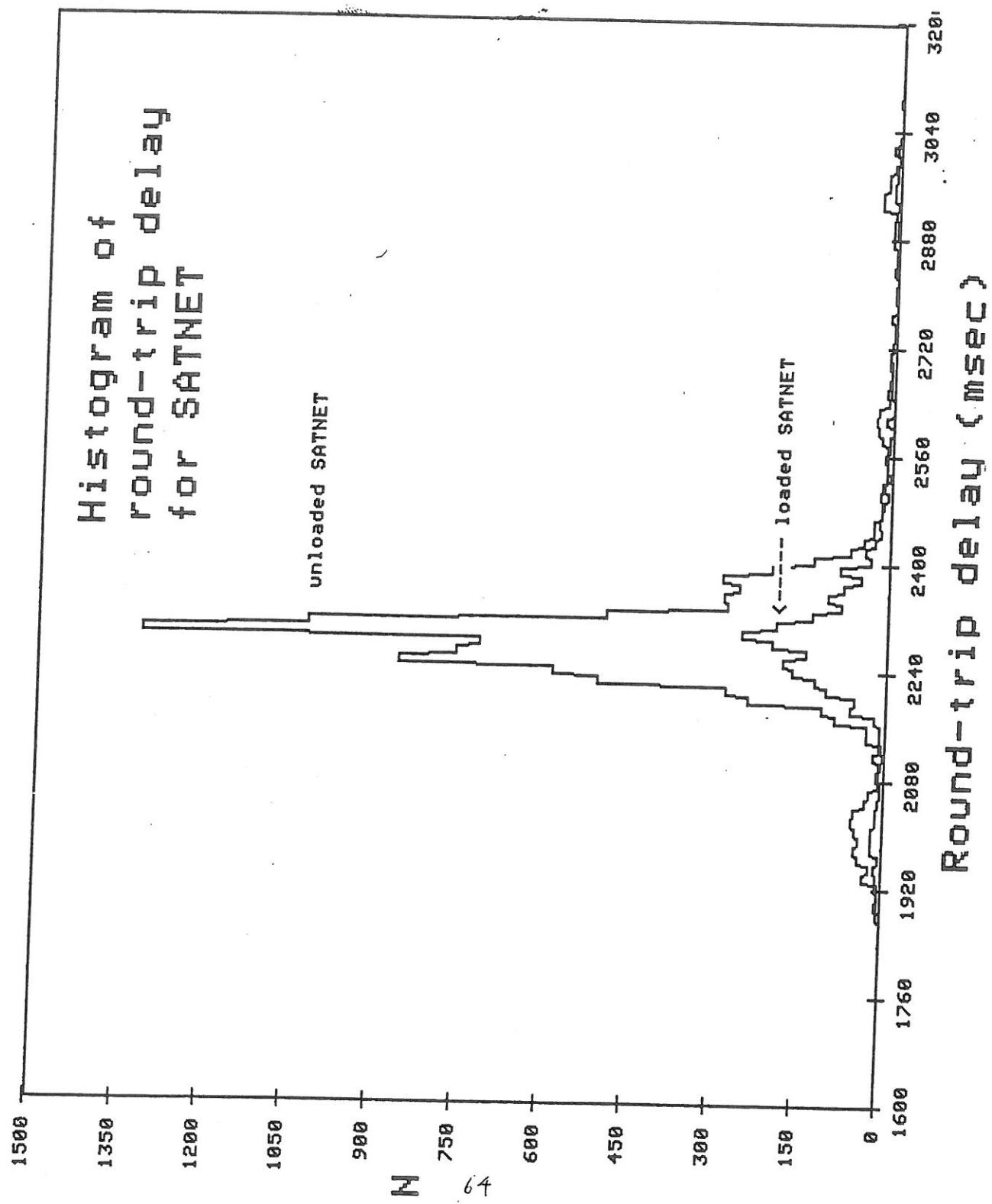




DCNET Linkabit Eastern Operations







Seq	ID	Start	Length	Window	Offset
15673	15655	0	536	376	-224
15688	15689	0	152	224	-760
15834	15805	0	536	376	0
15858	15839	0	376	0	-536
16022	16005	0	448	464	0
16151	16139	0	464	448	-448
16269	16239	0	536	376	0
16332	16322	0	376	97	-536
16467	16439	0	536	376	0
16482	16472	0	136	240	-536
16644	16622	0	536	376	0
16669	16655	0	376	0	-536
16837	16805	0	536	376	0
16861	16839	0	376	0	-536
17014	17005	0	224	688	0
17142	17122	0	536	376	-224
17157	17155	0	152	224	-760
17300	17272	0	536	376	0
17325	17305	0	376	0	-536
17498	17472	0	448	464	0
17626	17605	0	464	0	-448
18133	18105	0	536	376	0
18151	18139	0	376	0	-536
18390	18372	0	536	376	0
18404	18405	0	136	240	-536
18553	18522	0	536	376	0
18577	18555	0	376	0	-536
18744	18722	0	536	376	0
18769	18755	0	376	0	-536
18940	18922	0	224	688	0
19073	19055	0	536	152	-224
19087	19089	0	152	0	-760
19342	19322	0	536	376	0
19367	19355	0	376	0	-536
19533	19505	0	448	464	0
19670	19655	0	464	448	-448
19789	19772	0	536	376	0
19812	19789	0	376	0	-536

Seq	ID	Start	Length	Window	Offset
573	63720	0	216	696	-216
2747	250	0	216	696	-432
5764	2334	0	216	696	-216
7939	4400	0	216	696	-432
9180	6984	0	104	808	-216
11356	8034	0	216	696	-320
13531	10617	0	216	696	-216
15706	12700	0	216	696	-432
17880	15284	0	216	696	-216
20061	17867	0	216	696	-432
22236	19967	0	216	696	-216
24738	22550	0	216	696	-432
26912	24634	0	216	696	-216
29087	26717	0	216	696	-432
30329	28784	0	104	808	-216
32537	30350	0	216	696	-432
34712	32417	0	216	696	-216
37729	34500	0	216	696	-432
39903	36567	0	216	696	-216
42078	38634	0	216	696	-432

FTP: fuzzball - fuzzball (1200-bps link)

Seq	ID	Start	Length	Window	Offset
26250	36497	0	536	376	0
38321	36497	-536	536	912	0
39630	36634	536	376	912	0
40195	36498	0	536	0	0
41539	36648	0	536	376	0
54795	36648	-536	536	912	0
56096	36649	0	536	376	0
3695	36705	0	536	0	0
8989	36880	96	536	912	0
10263	36881	632	536	912	0
16224	36705	-440	536	0	0
17664	36961	256	536	912	0
27057	36881	-280	536	120	0
43698	36881	-1072	536	344	0
44825	37049	0	344	568	0
45623	37055	0	536	376	0
47021	37062	0	536	376	0
65365	37062	-536	536	912	0
1046	37063	0	536	376	0
2308	37148	0	536	0	0

FTP: TOPS-20 - fuzzball 1200-bps device

Seq	ID	Start	Length	Window	Offset
26939	38115	0	536	376	0
28332	38179	0	536	376	0
28886	38193	0	536	376	0
29520	38206	0	376	536	0
30883	38226	0	536	376	0
36788	38226	-536	536	912	0
38069	38227	0	536	376	0
39351	38271	0	536	376	0
40010	38278	0	536	376	0
41361	38285	0	536	376	0
45952	38285	-536	536	912	0
47184	38286	0	536	376	0
48637	38353	0	536	376	0
49215	38373	0	536	376	0
50862	38401	0	536	376	0
54554	38401	-536	536	912	0
55821	38402	0	536	376	0
57316	38452	0	536	376	0
61436	38452	-536	536	912	0
62727	38461	0	536	376	0

FTP: TOPS-20 - fuzzball disk

Seq	ID	Start	Length	Window	Offset
50606	44808	0	246	154	0
50846	44810	0	154	246	0
51256	44808	-400	246	400	0
51414	44818	0	92	308	0
51628	44820	0	154	245	0
51851	44810	-400	154	246	0
52192	44825	0	154	246	0
52479	44829	0	92	308	0
52730	44830	0	154	246	0
53002	44833	0	92	308	0
53369	44837	0	154	154	0
53564	44838	0	92	154	0
54004	44844	0	154	154	0
54238	44847	0	92	154	0
55011	44852	0	154	246	0
55248	44853	0	92	308	0
55486	44856	0	154	246	0
55596	44858	0	53	193	0
55649	44859	0	3	190	0
56590	44869	0	1	399	0

TELNET: TOPS-20

Seq	ID	Start	Length	Window	Offset
4155	45437	0	92	154	0
4568	45440	0	154	154	0
4803	45442	0	92	154	0
5233	45445	0	154	246	0
5450	45449	0	92	154	0
5823	45452	0	154	154	0
6020	45455	0	92	154	0
6480	45459	0	154	246	0
6745	45464	0	92	308	0
7131	45468	0	154	246	0
7276	45470	0	92	154	0
7721	45476	0	154	0	0
8268	45468	-400	154	0	0
8966	45484	0	1	0	0
10631	45484	0	1	0	0
12288	45484	0	1	0	0
13935	45484	0	1	0	0
15649	45484	0	1	0	0
17254	45484	0	1	0	0
18915	45484	0	1	0	0

TELNET: TOPS-20 window closedown

Sq	ID	Start	Length	Window	Offset
53381	41503	0	1	399	17971
53434	41504	0	1	399	17970
53498	41505	0	1	399	17969
53659	41506	0	1	399	17968
53711	41507	0	1	399	17967
53926	41508	0	1	399	17966
54005	41509	0	1	399	17965
56845	41518	0	2	398	17964
61442	41519	0	32	368	17962
61596	41520	0	61	339	17930
61650	41521	0	3	397	17869
61704	41522	0	6	391	17866
61756	41523	0	2	389	17860
61835	41524	0	32	366	17858
1139	41525	0	2	398	17826
1660	41526	0	43	357	17824
1841	41527	0	2	398	17781
2350	41528	0	48	352	17779
2403	41529	0	2	398	17731
4592	41530	0	16	384	17729

C/70: TELNET

Seq	ID	Start	Length	Window	Offset
60777	41625	0	61	299	15001
60829	41626	0	3	336	14940
60890	41627	0	12	324	14937
62997	41629	24	61	400	14901
63049	41630	85	2	400	14840
63152	41631	87	61	400	14838
63203	41632	148	1	400	14777
63276	41633	149	27	400	14776
63361	41634	176	40	400	14749
63477	41635	216	61	400	14709
63530	41636	277	3	400	14648
63937	41637	280	10	400	14645
64024	41638	290	25	400	14635
64561	41639	315	61	400	14610
64627	41640	376	1	400	14549
64697	41641	377	23	400	14548
1521	41642	0	400	0	14925
3063	41643	0	400	0	14525
4172	41644	0	90	310	14125
27114	41645	0	52	348	14035

C/70: TELNET congestion



3.4 Packet Radio Network Overview

Keith Klemba

SRI International

PACKET RADIO NETWORK OVERVIEW

- FEATURES**
- COMPONENTS**
- COMPOSITION**

PACKET RADIO NETWORK FEATURES

1. AUTOMATED NET MANAGEMENT
 - SELF-CONFIGURING
 - RECONFIGURES UPON GAIN OR LOSS OF NODES
 - AUTOMATIC ALT-ROUTING WITH REDUNDANT REPEATER COVERAGE
 - DYNAMIC TRACKING/HANDOFF REROUTING
 - MULTIPLE CONTROL STATIONS
 - BACKUP STATIONLESS OPERATION
2. MOBILE OPERATION
 - TRANSPARENT HANDOFF OF ROUTING
 - USERS, REPEATERS, STATIONS MAY BE MOBILE
 - ANTI-MULTIPATH TECHNIQUES USED
3. END-TO-END RELIABILITY
 - VIRTUALLY NO DATA ERRORS (10^{-12})
 - ERROR DETECTION/RETRANSMISSION USED
 - SURVIVE TEMPORARY OUTAGES, NODE FAILURES
 - COMPATIBLE WITH PACKET ENCRYPTION

PACKET RADIO NETWORK COMPONENTS

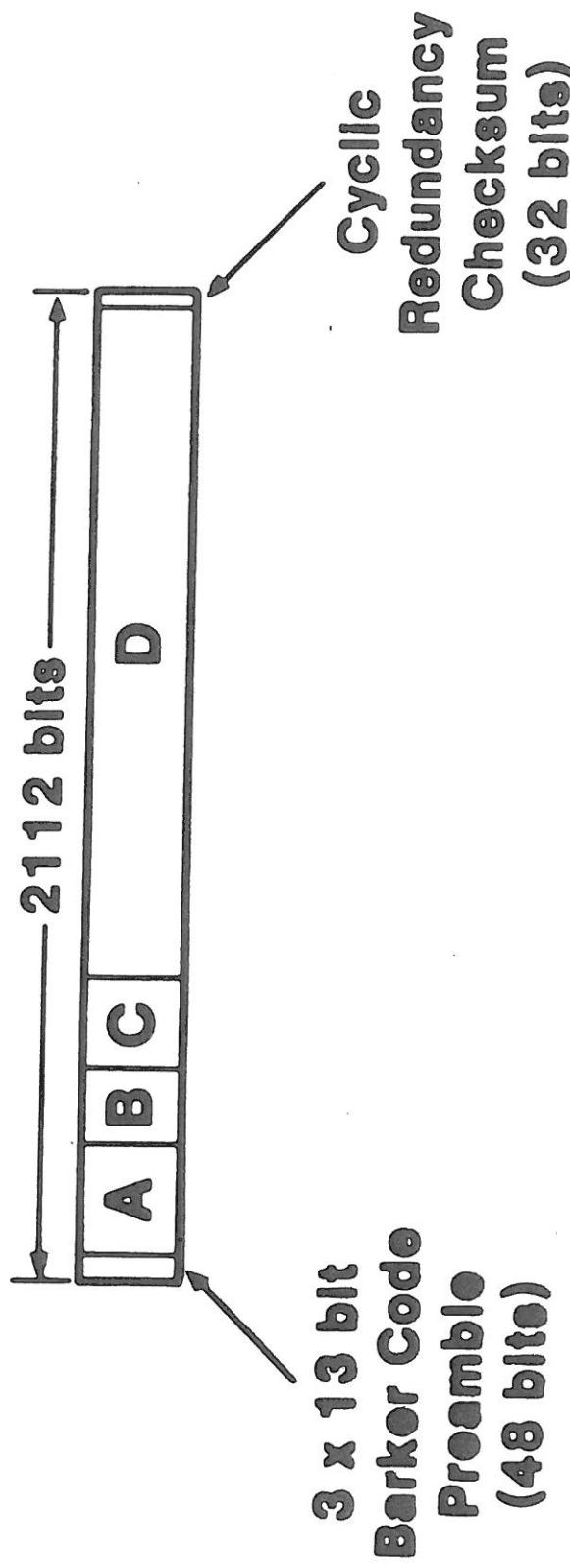
PACKETS

RADIOS

STATIONS

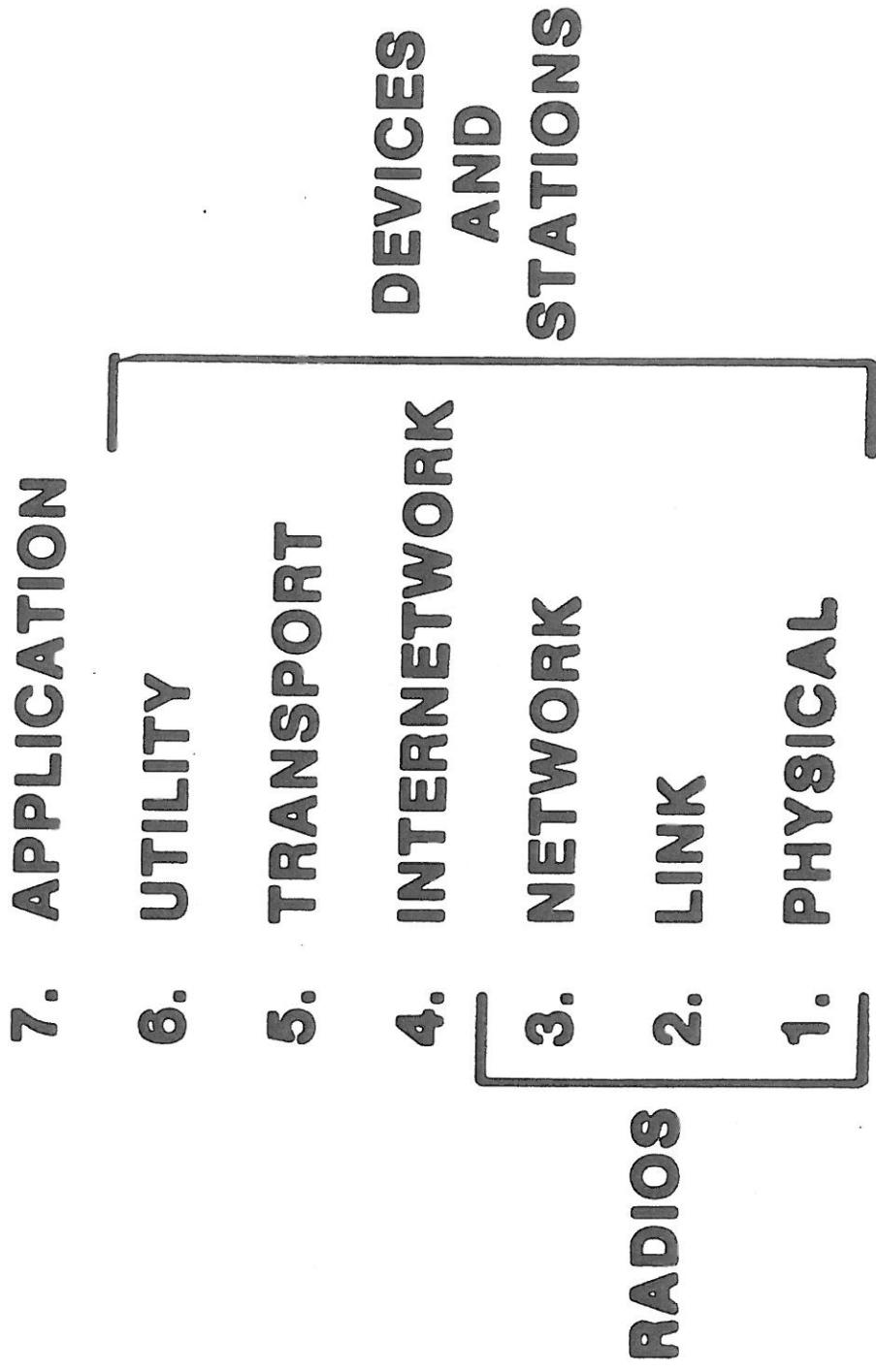
DEVICES

INFORMATION PACKET FORMAT



- A PRNET HEADER 224 bits
- B INTERNETWORK HEADER 160 bits
- C TCP HEADER 192 bits
- D DATA 1456 bits

COMMUNICATION PROTOCOL LAYERED MODEL



PACKET RADIOS

- 1 OMNI-DIRECTIONAL ANTENNA**
- 1 SS RADIO TRANSMITTER (100 or 400 Kbits)**
- 2 SS RADIO RECEIVERS (100 and 400 Kbits)**
- 1 NETWORK ACCESS PORT (1822)**
- 1 DIGITAL DIAGNOSTIC PORT (EIA)**
- 1 RADIO MAINTENANCE PORT (CUSTOM)**

FUNCTION:

- EXECUTE PRNET STORE AND FORWARD PROTOCOLS**
- PERFORM DISTRIBUTED MONITORING AND CONTROL**
- MAINTAIN BACKUP STATIONLESS CAPABILITY**
- PROVIDE BASIC PRNET ACCESS**

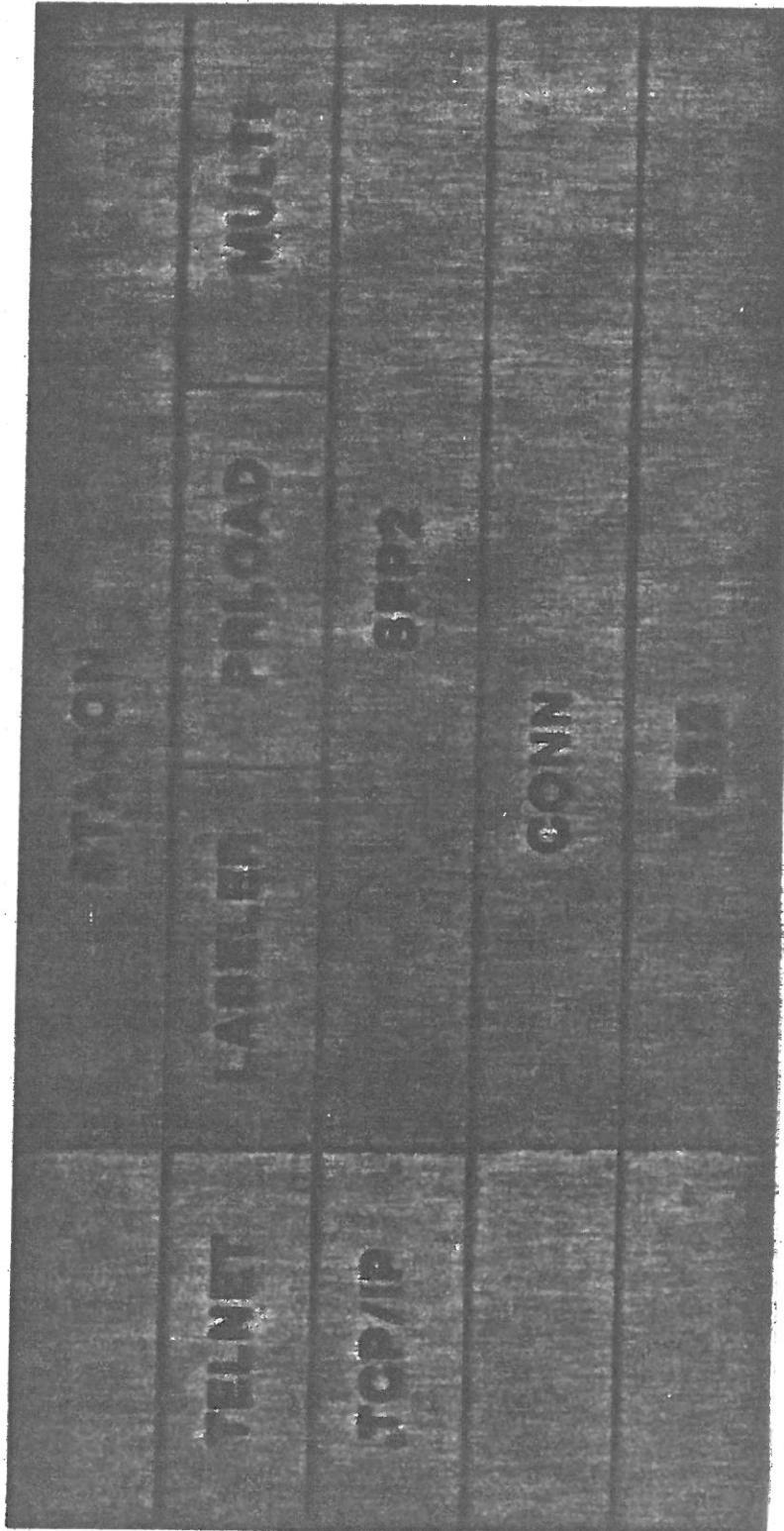
STATIONS

- 1 LSI 11/23 WITH 256 Kbytes OF MEMORY**
- 2 NETWORK ACCESS PORTS (1822)**
- PRNET**
- ARPANET (OPTIONAL)**
- 1 BUBBLE STORAGE UNIT (1 Mbyte)**
- 1 FLOPPY DISK DRIVE (1 Mbyte)**
- 4 STATION MONITORING PORTS (EIA)**

FUNCTION:

- ASSIST IN RADIO ORGANIZATION**
- PROVIDE POINT-TO-POINT ROUTES**
- MAINTAIN DEVICE-TO-RADIO ADDRESS MAPPING**
- DOWNLINK LOAD RADIO'S RAM SOFTWARE**

PRNET STATION PROTOCOL STRUCTURE



DEVICES

HOST COMPUTERS

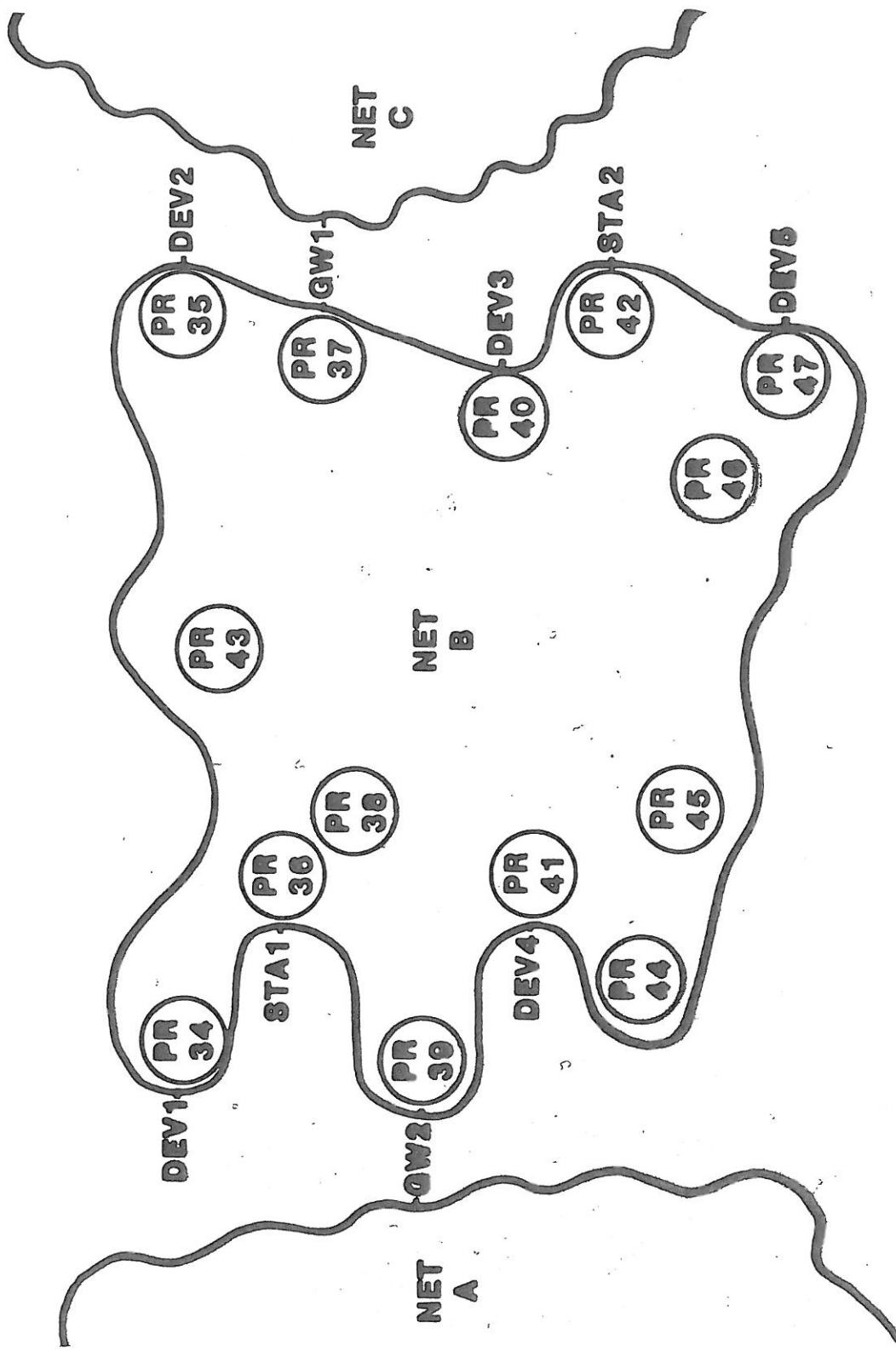
TERMINAL INTERFACE UNITS (TIU)

GATEWAYS

SPEECH INTERFACE UNITS (SIU)

**CUSTOM HOST INTERFACE UNITS
(HIU)**

PRNET COMPOSITION



3.5 Packet Radio Link Layer

John Jubin

Rockwell International

**SELECTED VIEWGRAPHS ON
THE PACKET RADIO LINK LAYER**

"FAIRNESS" IN TRANSMIT QUEUING

Radio transmit queuing discipline is basically first in, first out

However, a packet received from PR P is put ahead of a packet from PR Q if a previous packet from Q has been or will be radio forwarded before a previous packet from P - e.g.:

in the following queue,

Q1 (i.e., packet #1 from PR Q)
P1
Q2
R1
Q3

P2 would be inserted between R1 and Q3,
instead of after Q3

This "fairness" algorithm provides for a more equal sharing of a PR's:

throughput capacity

buffer resources

SINGLE THREADING

If more than one packet is queued for transmission to the same next PR, only one is (re)transmitted while waiting for the ACK

Thus, only one passive acknowledgment at a time is transmitted to previous PR(s)

However, packets addressed to different next PRs are scheduled for transmission independently

PACING

Forwarding cycle has 3 frames - receive, transmit, receive ACK

basic algorithm:

Measure forwarding delay (D) through receiving PR

Schedule transmission of next packet to that PR $3*D$
after transmission of last packet

refinements:

Smooth D measurements

Separate by $3*D$ all transmissions to same PR,
including retransmissions of same packet and
transmissions of packets from different previous PRs

abnormalities:

If retransmission(s), measure forwarding delay from time of
transmission of the copy that was forwarded by receiving PR

If receiving PR doesn't ACK, consider forwarding delay the time
that waited for ACK

RANDOMIZATION DELAY

Every transmission employs the 0-640 usec. randomization delay to unsynchronize CSMA sensing

The first transmission of a packet employs no randomization delay of packet transmission intervals:

- minimizes forwarding delay

- depends on pacing to avoid collisions from hidden PRs

Each retransmission employs an increasing range - 0-3, 0-7, ... - of packet transmission intervals, in case previous transmission collided with transmission(s) from hidden PR(s):

- decreases probability of retransmissions from hidden PRs colliding

- gets hidden PRs' pacing out of phase

TYPE OF SERVICE

Requested by user on packet-by-packet basis

"Speech" type of service selects different values of parameters:

data rate - 400 kbps only

maximum pacing delay - lower

number of retransmissions - fewer

randomization delay per retransmission

on which retransmissions alternate routing help is requested - sooner

3.6 Packet Radio Network Control

Jil Westcott

Bolt, Beranek and Newman

PACKET RADIO NETWORK MANAGEMENT

What Is a Packet Radio Network?

- A Connected Graph of PRs
- Every PR Has at Least One Neighbor
- Connectivity Changes Over Time,
Unpredictably

PACKET RADIO NETWORK MANAGEMENT (Continued)

Objectives of Network Management

- Quick Response to User Needs - Datagrams
- Survivable Operation
 - Redundant PRs, Stations, and Connectivity,
 ➡ Graceful Degradation
 - Immediate Alternatives to Failed Routes
 - Continuous Reassessment of "Best Routes"
- Guaranteed Service
 - Flow Control, Pacing Prevent Saturation
 - Special Handling for Certain Traffic
(Digitized Speech)

Solution:

- Not One, But Many Management Strategies
- Applicable to Different Situations:
 - Applied Over Different Time Scales
 - Affecting Different Geographic Regions
(In General, Longer Times Over
Larger Regions)

Some of the Strategies

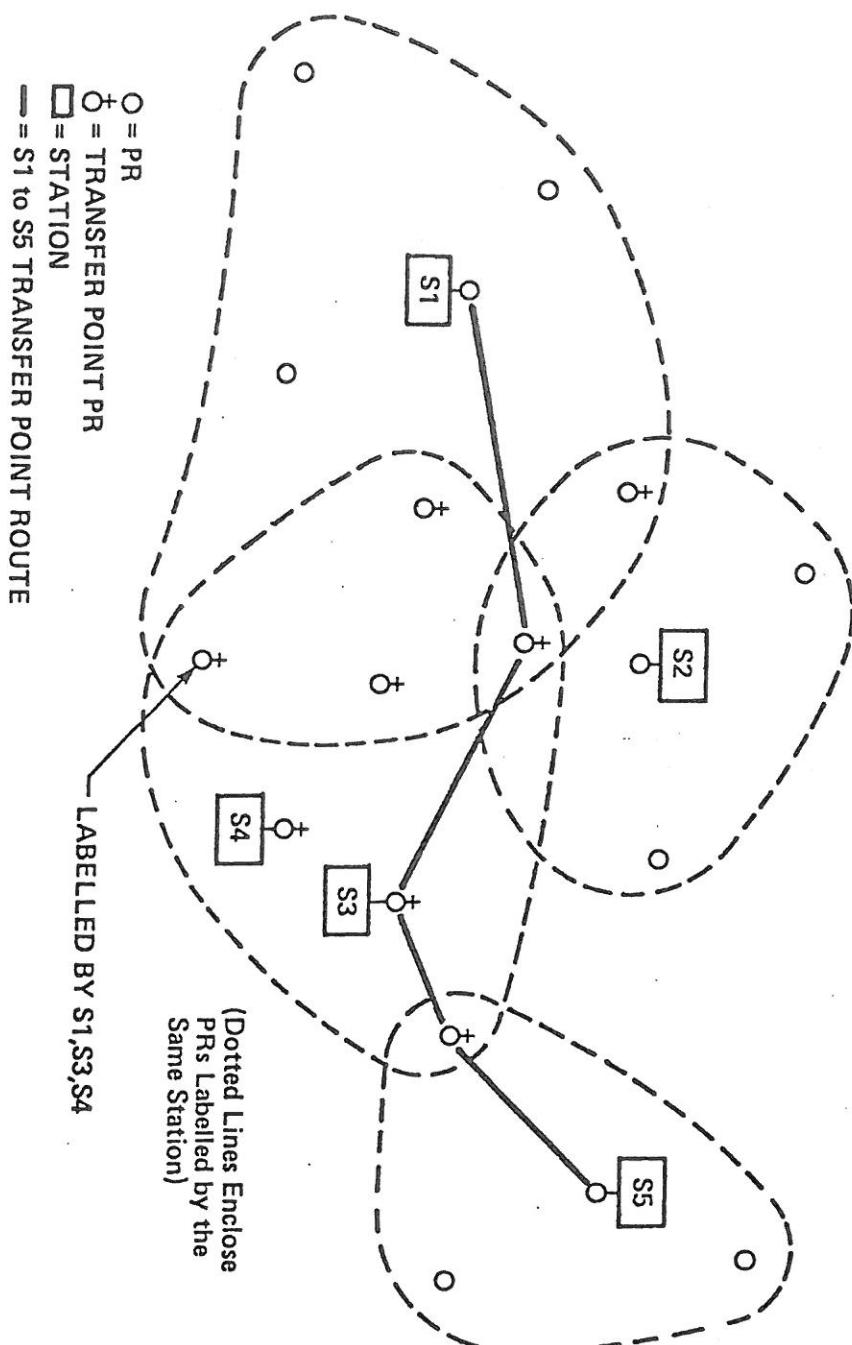
- Single Station Routing
- Alternate Routing
- Multistation Routing
- Stationless Routing

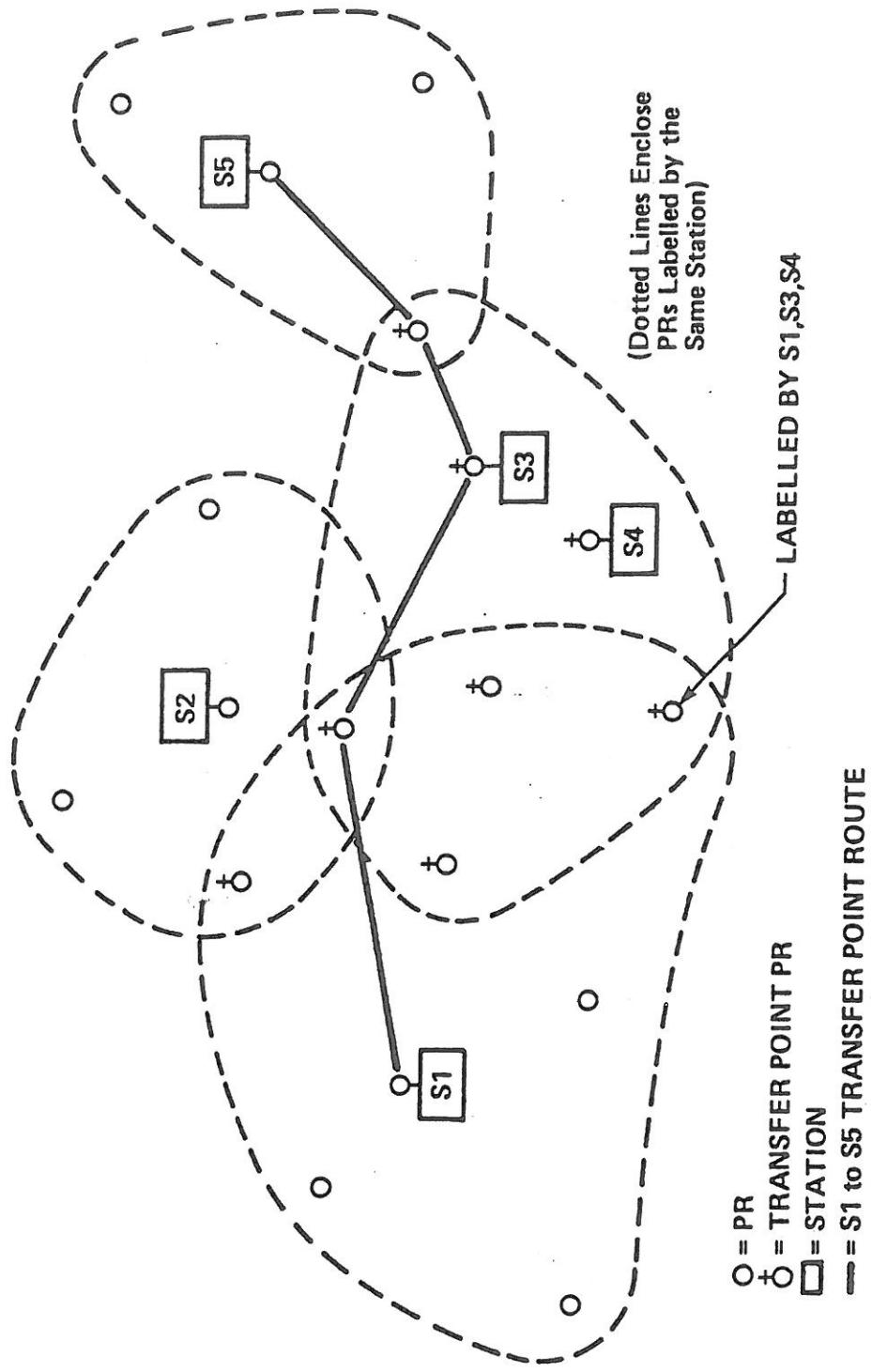
CAP6: MULTISTATION ROUTING

Background

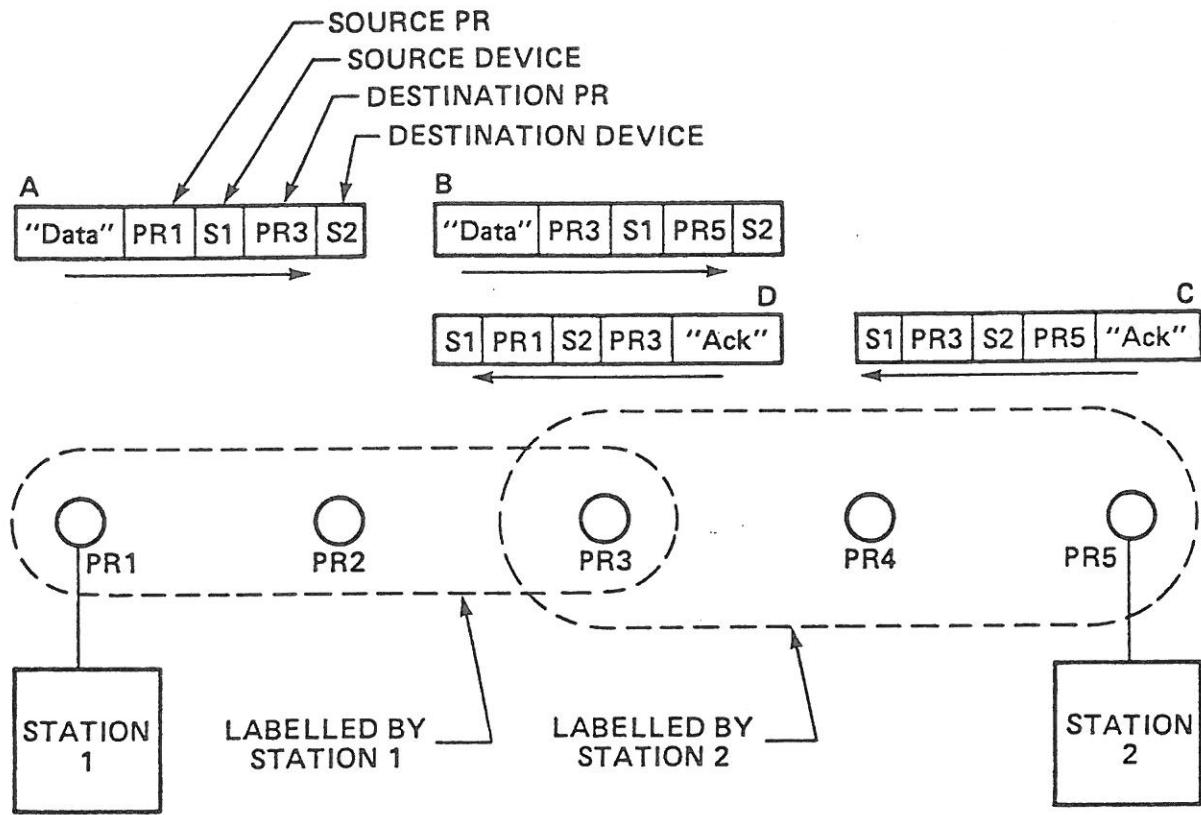
- PRs May Have Attached "Devices":
 - Terminal Concentrators
 - Gateways to Other Networks
- One Kind of Device Is a Computer - a "Station"
- A Station Attempts to
 - "Label" a Set of PRs Close to It (Its Region)
 - Monitor the Connectivity of the PRs It Labels
 - On Request, Furnish "Best Routes" Between PRs It Labels
 - Cooperate With Other Stations to Build Longer Routes
 - . . . And Provide Maintenance and Measurement Services
 - *Distributed Name Server Concept*

Define transfer points
 labeling concept "compact subnet domains"
 multi route setup
 flooding
 gather

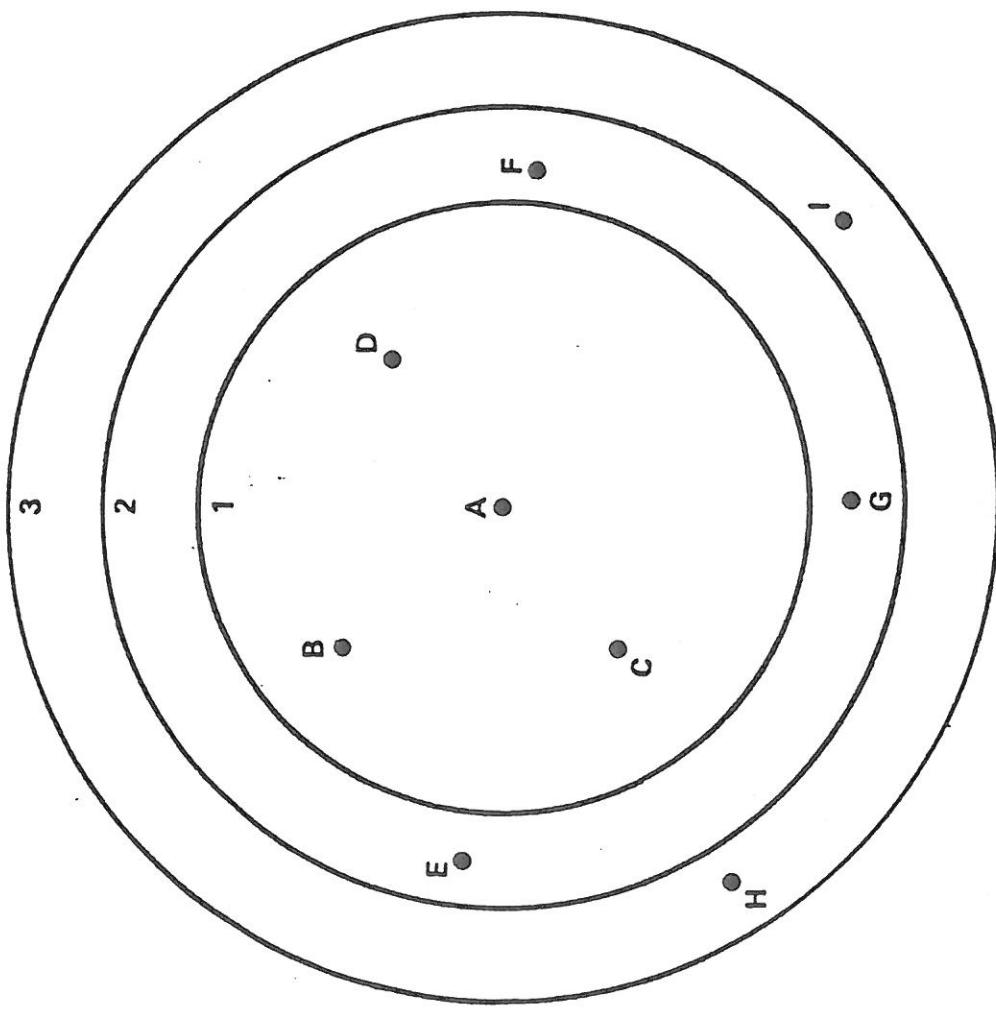




Detailed Transfer - Point-to-Point
 - only use if a lot of messages -



TIERED RING CONCEPT

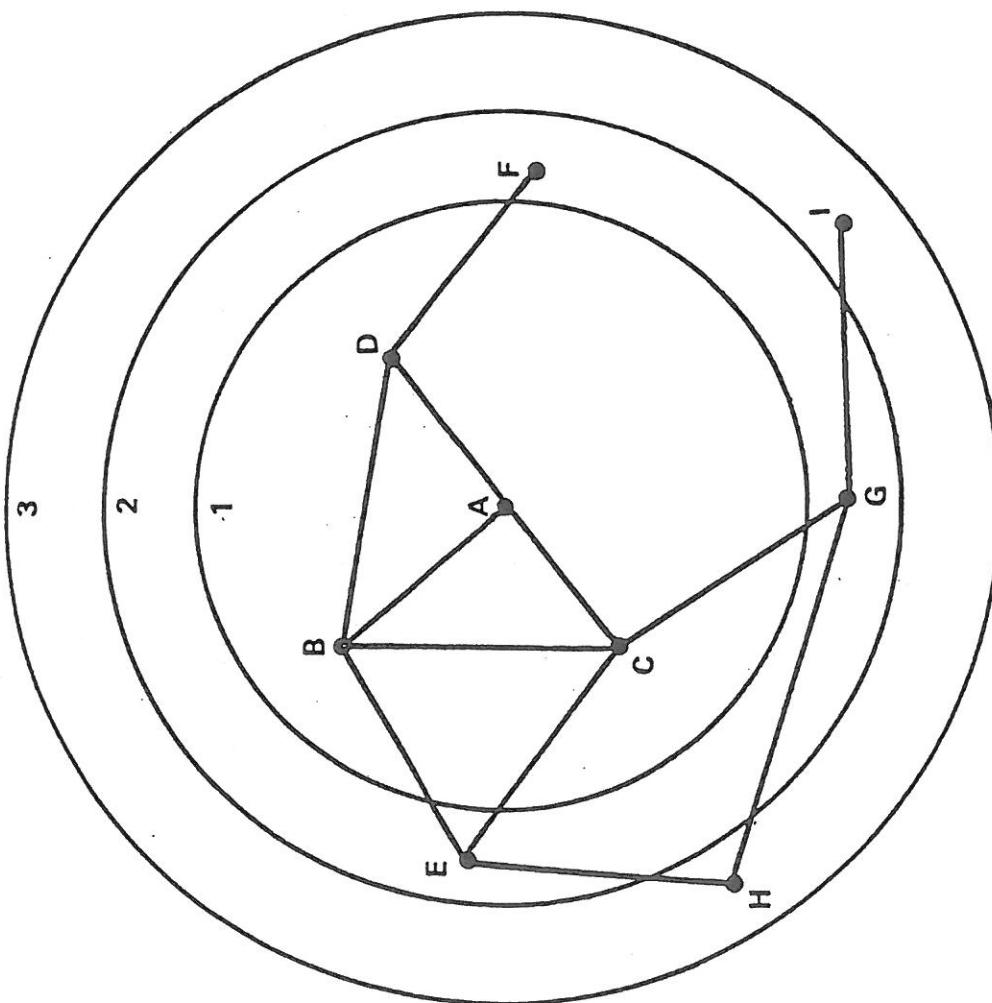


66



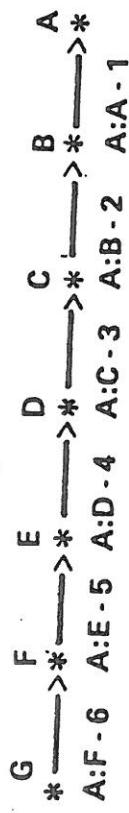
TIERED RING CONCEPT
CONNECTIVITY DIAGRAM

001



add
something about
ARPA TIER
comparison

TIER DATA FOR PR A

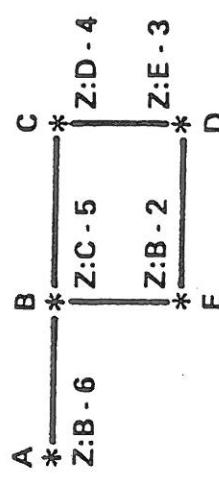


NOTATION:

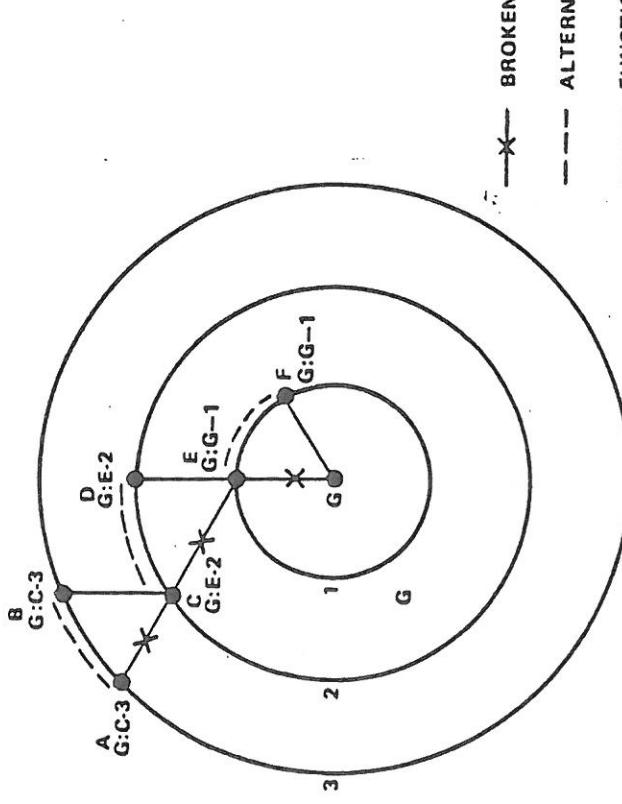
<DESTINATION PR>:<NEXT PR> - < TIER VALUE >

ROUTE LOOP DETECTION

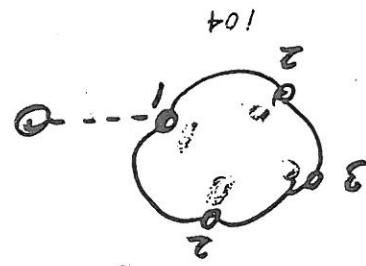
PR TRANSMISSIONS	DESTINATION-TIER VALUE
A->B	6->5
B->C	5->4
C->D	4->3
C->E	3->2
E->B	2->5



ALTERNATE ROUTING



TIERED ROUTING DATA:
A → C → E → G
PACKETS ACTUAL PATH:
A → B → C → D → E → F → G

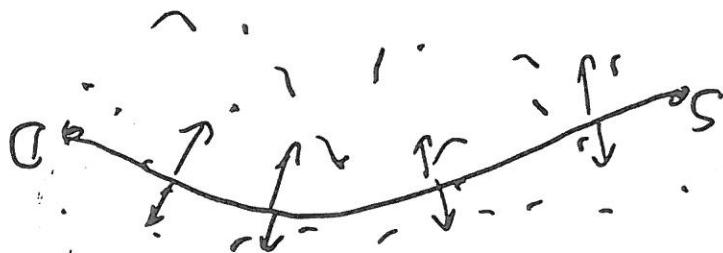


• provides ~~cyclic~~ ^{data} for dead nodes

• held down period to complete

~~until~~ ^{up by 2 or more !!!!!!!} second

+ soft delete ^{# days} ~~when~~ ^{when} insertion



• provides fast updating for route to source

• loops work after 1st pass

+ tier data in pvt header

(LRU updating) Old Allocated =

TIEP Algorithm