IEN-65

TCP Meeting Notes
14 & 15 July 1977

Editor's Remarks

In preparing these notes i have made some rearangement of the material from the actual time order of its occurance to place material under its logical agenda topic.

It must also be said that these notes are somewhat incomplete and it must be realized that sometimes they may unfortunately misreport a speakers remarks.

At the beginning of Fridays session Dave Reed distributed a draft of LCS Local Net Note 10 which attempts to describe the conclusions reached the first day and to discuss the issues and alternatives in the major unresolved area: ICP and three-way-handshake. This note has since been revised and distributed via sndmsg.

Agenda Items

1. DSP developments - Reed
2. DSP & TSP issues - Tomlinson
3. Addressing - Reed
4. Internet Plans - Cerf
5. LCS Net - Clark
6. PARC - Shoch
7. LLL - Watson
8. RCC Net - Tomlinson
9. Tops 20 - Plummer
10. TOS issues - Cohen
11. Next Meetings - Cerf

SAT
NSA-11
P-TIP

The P-TIP is a pluribus prototype TIP and is connected to RCCNET, (11) MLC lines, and the ETAM-SIMP.

The ETAM-SIMP is connected to a pdp11 gateway which is in turn connected to the COMSAT-360.

9. Tops 20 TCP - Plummer

TCP on TOPS20 is up to a degree in that it does do some test programs and a simplified Telnet. Its performance needs examination. It is about 11,000 octal words (4600 decimal). There is a problem with large core TOPS20s in that there must be 6 words of monitor tables per page of real memory. So for a 1 million word system there are 12,000 words of tables. The monitor address space is fixed at 256 K maximum. As memory grows monitor code must shrink. The NCP is 14,000 octal words. The Tenex NET: file interface is quite complicated inside and it would not be easy to convert it to use TCP sometimes.

10. TOS issues - Cohen

Editor: This topic was not discussed.

11. Next Meetings - Cerf

schedule of meetings as proposed by Cerf

Date	Place
Oct. 13-14, 1977	SRI
Jan. 30-31, 1978	ISI
Apr. 20-21, 1978	BCN
July 13-14, 1978	PARC
Oct. 12-13, 1978	LCS

Aside: Dr. Lyons indicates this recent report may be of interest:

Bochman & Goyer
"Datagrams as a Public-Packet Switched Data Transmission Service"
Department of Communication Canada
University of Montreal
March 1977

Cerf Assigns Action Items -- REPORTS DUE 8 AUGUST 1977

1. Socket ID - Uniqueness vs. Reuse

   Crocker
   Sunshine
   Reed
   Tomlinson

2. Urgent Bit vs. Urgent Pointer

   Reed

3. Separation of Control

   Postel
   Braden
   Watson
   Mathis

Cerf Designates Postel Responsible for Assigning Numbers

Net Numbers
Internet Message Types
Socket Numbers

Assigned Internet Message Types

Destination Network Identifier: 8 bits

Decimal	Octal	Network
0	0	Escape
1	1	TCP
2	2	Secure
3	3	Gateway
4	4	Measurement
5	5	DSP
6	6	UCL
7-12	7-14	Reserved
13	15	Pluribus
14	16	Telenet
15	17	Xnet

Assigned Network Numbers

Destination Network Identifier: 8 bits

Decimal	Octal	Network
0	0	Reserved
1	1	BBN Packet Radio Network
2	2	SF Bay Area Packet Radio Network (1)
3	3	BBN RCC Network
4	4	Atlantic Satellite Network
5	5	Washington D.C. Packet Radio Network
6	6	SF Bay Area Packet Radio Network (2)
7-9	7-11	Not assigned
10	12	ARPANET
11	13	University College London Network
12	14	CYCLADES
13	15	National Physical Laboratory
14	16	TELENET
15	17	British Post Office EPSS
16	20	DATAPAC
17	21	TRANSPAC
18	22	LCS Network
19	23	TYMNET
20-254	24-376	Unassigned
255	377	Reserved

Attendees:

Robert Braden	UCLA-CCN
Jerry Burchfiel	BBN
Vint Cerf	ARPA
Dave Clark	LCS
Danny Cohen	ISI
Steve Crocker	ISI
Yogen Dalal	XEROX
Jed Donnelley	LLL
Jim Forgie	LL
Jack Haverty	BBN
Robert Lyons	DCEC
Jim Mathis	SRI
Jim McClurg	SRI
Bill Plummer	BBN
Jon Postel	ISI
Dave Reed	LCS
Randy Rettberg	BBN
John Shoch	XEROX
Virginia Straizar	BBN
Carl Sunshine	RAND
Ray Tomlinson	BBN
Dick Watson	LLL
Doug Wells	LCS

< CJOURNAL, 29449.NLS;1, >, 5-AUG-77 10:35 XXX ;;;; Title: Author(s): Jonathan B. Postel/JBP; Distribution: /LLG([INFO-ONLY]) ROM([INFO-ONLY]) JBP([INFO-ONLY]) ; Sub-Collections: NIC; Clerk: JBP; Origin: < POSTEL, NOTES-TCP.NLS.25, >, 4-Aug-77 15:39 JBP ;;;;
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1. DSP developments - Reed

Dave Reed presents mainly the differences in DSP from previous descriptions. Particular small problems:

(1) Urgent into a closed window

Two stages of input processing, a preprocessor for urgent things like control-C, and a regular processor for normal input.

One idea is to transmit urgent pointer value in option field.

The current idea is to send the urgent bit with current sequence number (assume that zero window not used to arbitrarily shut the other guy off).

Cerf: Separate data and control streams?

Reed: Control stream needs flow control too

Crocker: No, control stream only is setting parameters so no flow control is needed.

(2) Allocation & Buffering

Letters - means this is a complete unit but data stream itself should be self parsing. Model is ring buffer like, but some systems prefer block buffers. If data comes out of order then one doesn't know if data that arrives early should be placed at the end of one buffer or the beginning of the next. [TCP has additional problem of controls in sequence space, but DSP has none of that.] Two proposals:

1. (Strawman) Put the data in as it arrives. If later found to be out of order, move it.

2. Transmit gaps - [the sender has to know how big the buffers are]. Note in header says x bytes following this are a gap. The gap uses up allocation space. Start in ring mode then negotiate buffer size to continue. To include buffer size in TCP initial exchange is not much cost.

(3) ICP for DSP

Sockets are uniquely chosen except for well known "sockets". This use of a socket is distinguishable from any other use [no resynchronization, sequence numbers start at zero]. Well known socket is susceptible to spoofing by reply so doesn't do anything that cannot be harmlessly repeated.

1. User calls well known server socket.

2. [optional] Well known socket replies.

3. Well known socket creates server instance with a new socket. new socket sends data to user socket.

4. Communication is open.

Well known socket must not do anything that can't be undone or can't be done N times without harm.

Socket created is in initial state and either reuseable (= well known) or not.

Discussion of model of security & spoofing model of how secure and how much is dependent on it being a gentlemans club.

Discussion of DSP initial connection procedure and especially the errors in face of duplicates that arrive at well known socket.

Security is handled in encryption. [Questions about how much the encryption is relied on to protect against other than security problems.]

2. DSP & TCP issues - Tomlinson

How to take advantage of DSP work and to solve problems in TCP. Assumption: No radical changes to TCP philosophy.

Problems:

1. Control Information in Sequence Space.

2. EOL Interpretation.
   Buffer Management

   Flow Control (fluctuating window)

3. DSP Ideas to Not be Adopted.

   Continuous Checksums
   ICP

(1) Control Information in Sequence Space.

The controls that take up sequence space are: SYN, FIN, ARQ, RSN, and INT.

SYN

At begining of stream so no real problem.

FIN

At end of stream so no real problem.

ARQ

Window sending (reliable) schemes using it have not been good. Ray wants to eliminate ARQ by having low rate of retransmission. Cerf is concerned about effects on shared resources. Reed thinks that is a congestion control issue.

Watson: Sending control into zero window?

Tomlinson: Keep retransmitting (slowing down).

Cohen: Telenet has a solution -> pay for each packet.

RSN

Sequence number reassignments imply buffering issues.

Crocker: It comes down to time constant. If time constants are chosen right probability of failure can be reduced.

Proposal is to ignore RSN

A reasonable value for maximum packet life time is 2 minutes. If parameters of transmission rate and packet life time require then go to a 64 bit sequence number.

Reed: Do it now because we won't be able to do it later.

If packet lifetime is short enough (say <30 sec) then if you crash then just don't come up for 30 sec (that time).

Cohen: Should design in robustness. Look out for the "add x bits to field y" as a band aid rather than careful design.

Watson: Method of choice of initial sequence number could be what ever that hosts want to do.

Everybody thinks its ok.

Size of sequence field is now 32 bits may grow at a later time to 64 bits.

INT

Slightly mysterious, do it like DSP's "urgent."

If nothing going on the UP (urgent pointer) = LE (left edge).

If urgent comes then send UP in each pocket transmitted or retransmitted as an option. UP = sequence number of last by byte of urgent data

Donnelley: Why not separate connection for controls?

Crocker: Model for control is the passage of values of parameters to update the parameters shared between the protocol modules, data flow is secondary.

Reed: For efficiency and as a hook for common applications.

Crocker: What is the minimal amount of control? Then put all other controls on a second connection. Each side has a model of the state, and the sender sends an update to the state, and the reply is the current state, if it is not close enough then go arround again.

Tomlinson: Urgent pointer to one past the urgent data byte. If UP = LE then not urgent.

Reed: Efficiency of the updating - reduce the Ack to just the LE.

Reed: Model of speech data processing is to always Ack the highest sequence number read.

We all believe that urgent pointer works, does urgent bit work? LCS will explore and try to convice Tomlinson (presumably as a representative of the skeptics).

Flushing - higher level issue not part of TCP.

(2) EOL Interpretation.

Delimits streams of useful information

1. Buffer quantization, default = 1 byte. Sending an EOL never consumes receiver buffer space (really sequence space). Right edge never gets moved left.

2. Option of setting buffer size.

Cerf: What happens in non-reliable delivery? If you get only part of a letter how do you parse it? Don't deliver it at all?

Cohen: Only user above TCP knows what letter means.

Reed: TCP should take no responsibility for remembering all letter boundaries only the last (most recent) one. We should be concerned with conceptual TCP-USER interface.

Watson: What if buffer space less than letter size?

Reed: Never deliver a non-letter to user.

Tomlinson: No EOL significance (telnet model).

1. User (sender) declares to his TCP in OPEN call "No EOL significance".

Cerf: There are the following EOL issues:

1. Identify that meaningful data is now available.

2. Frames users data.

3. For non-guaranteed modes of transmission, allow TCP's to deliver only "useful" data (as specified by source).

4. Allows better buffer management.

5. Is it permissible for a connection to never have an EOL?

Tomlinson: There are some cases:

Case A - Receiver knows the most recent letter mark only.

Case B - Receiver knows the begin and end of every contiguous block of letters.

Case C - Receiver knows the begin and end of each letter.

Case D - Receiver knows boundaries all letters and buffers, but does not know what they represent.

Wake up process when a buffer is full or when EOL is present.

Choice is between B & C, and if the receiver chooses D too.

Reed: We should not support high level protocols that can not recognize boundaries between meaningful units.

Tomlinson: There is a transaction processing example where the issue of buffering is critical.

Clark: Places in the stream that are resynchronization points, thus what we really want is Begin of Letter.

Reed:

Beg of Letter - Synch point
End of Letter - Wakeup point

Postel: Synch points not necessary in host level protocols.

Tomlinson: So this is an important efficiency issue.

Reed: It costs us something to keep this extra information in model C over model B.

Tomlinson: Thinks it is cheap to keep extra pointers.

Some feel it calls for extra data structures in their inplementation.

Wells: Suppose user has timer that can remind him that he has not gotten data recently. Suppose there is a value for bytes in a buffer that means "no data here".

Generally thought to be a bad thing! Equivalent to keeping extra data about data stream.

Sending TCP can send at any time, and will send at EOL.

TCP carries begin of letter and end of letter.

user -> TCP: User says EOL when he wants.
TCP -> TCP: carries both marks.
TCP -> user: lets user know about begin and end of letter.

Cohen: Wake up bit.

Beginning of meaningful data.
Ending of meaningful data.

Rettberg: Since it is important for the user sending to put the marks on it is important for all the marks to be delivered.

Crocker: So maybe everything should be time stamped because sending it at minute one is different from sending it at the next minute.

Tomlinson: What is the cost of keeping all the synch information?

Donnelley: It can't be optional either all have to do it or none can rely on it.

Braden: Extra data structure if you didn't need it in the reliability case.

Clark: High level protocol (HLP) requires the letter bit on every semantic unit and that the high level protocol also provide a way to parse data. HLP's don't depend on letter boundaries but TCP's may report them all to destination processes.

Tomlinson: Destination TCP will put only one letter in a buffer so this is ok.

Letter boundary

Rubber bit on EOL

1. Sending user knows.

2. Sending TCP knows buffer size.

   (could send one letter before knowing size) finds out from receiver TCP (that found out from receiving user on open) on SYN, default = 1 byte, SYN has buffer size option.

3. Sending side doesn't know.

Editor: seems to be agreement on a rubber EOL of type 2.

(3a) Continuous checksums:

Do Gateway's have to recompute checksums?

Reed says no
Tomlinson thought yes

Editor: Dave Reed explained continuous checksumming but the notes are confused here (perhaps the editor is confused). As the editor understands it the overall idea is that if there is a checksum C1 of everything up to a point A in a data stream then the checksum C2 of everything up to a later point B in that data stream can be computed from a function C2=f(C1,delta) where delta is the computed checksum of the stream between points A and B.

Can't validate anything out of order. (In reliable system, we have an unreliable system too.)

Sunshine: What is advantage?

Reed: The good point is that the transmitter can change his mind where to checksum. That is packet boundaries can change on retransmission. The transmitter only has to compute a new checksum.

Plummer: The trade off is that DSP lets one send larger packets on retransmission without redoing checksum. While TCP allows verifying blocks out of order.

Reed: Here is how to do unreliable delivery under continuous checksums:

Use a checksum synchpoint, then one can restart at any synchpoint.

Is being of letter a synchpoint?

Shoch: How is checksum thru synchpoint different from block checksum for speech.

Not different.

Tomlinson: Drawback of continuous checksum is that one can't look at ACK and window information of just arrived segments to use this most up to date information.

Cerf: We don't seem to gain enough by continuous checksumming.

Plummer: The ability to use ACK window information from "packets from the future" is very important.

Cerf: Propose that TCP proceed with block checksums then LCS to explore tradeoff between continuous checksum and block checksum.

(3b) ICP and Unique Sockets

Clark:

1. ICP use something (3 way handshake) to confirm identity of the parties.

2. Synchronize sequence numbers.

Cerf: Do two well known sockets need to talk to each other?

Clark: The reuse of the same socket is really for authentication. Sockets are a very weak form of authentication.

Crocker: Real World examples: Detatch-Attach in Tenex and Tenex re-enter. The proposed mechanism may be too shallow. If user tries again then may get rejected cause "half-open" then other end clears and re-establishes connection.

Cohen: Analogy with telephone calls between businessmen with multiextensions.

Sunshine: Guy who wants to reconnect needs a unique handle to get back his state either socket number or higher level (e.g. tenex job number).

Mathis: User may know only socket number 1 not the socket resulting from the ICP.

Donnelley: Why are we talking about this - is it not a host issue?

Forgie: In internet case it is not clear a host is going to be notified of a crash in some other part of the network.

Crocker: Attach to Job number not TTY number, is socket like Job number or TTY number?

Mathis: ICP is part of TCP?

Clark: Cerf was trying to present a scenario for reuse at both sockets, Clark model is asymetric.

Clark: I amnot bothered by asymetric model, user is active while server is passive.

Crocker: That's the same as telephone etiquette, the guy who placed the call should replace call.

Cerf: If we are allowed to have reused both U and S then also need 3-way handshake too.

Reed: ICP has taken place of three-way handshake, CONN call is a degenerate form, defer let us decision until people can read LNN Note 10.

Sunshine: Difference between DSP &TCP?

Reed: DSP will create a server that never gets used.

Clark: TCP needs a mechanism to guard against replay, DSP has an optional exchange of unique number.

Tomlinson: Everything has a three way handshake.

Reed: Your (Cerf) scheme is same as DSP except that you require the final ACK.

Clark: We trying to get rid of 3-way handshake.

Editor: There was much drawing of diagrams during this discussion which unfortunately can not be adaquately included in this record.

3. Addressing - Reed

Reed: Addressing is an internet problem not strictly a TCP problem.

- packet routing (logical)
- header

The 8 bits now available is too small for net address. Propose that an arbitrary interpretation be placed on the address bits.

There is an assumed 2 level hierarchy:
Gateways
Hosts

Assume host is hardware port. Distinction between internet address and sockets, but sockets are a routing function too.

- Ease of Extension

"There is always another network", "Who's on top", also provision for temporary optimizations.

- Autonomous Gateway

Do all gates have to know about all other gates (at their level), can there be gates that don't participate in all gate to gate procedures.

- Hiding a Network behind a Host [or Host within a Host]

- Broadcasting/Multi-destination

  Broadcast starts at a source and is copied to all destinations that have an address that belongs to a generic address field.

- Source Routing or Path Routing or Extensible Addressing

  Address is a variable length string of bits. Logical path name relative to source of packet. Emphasis that "links" and "routes" and "switch points" are logical.

Naming scheme -

Pick a fixed point, publish a list of the routes from that point to all points, each point knows how to get to the central point, then the contatination is a route (perhaps not optional).

Rettberg: What if the something changes? If route is B.C.D can C be replaced by E so route becomes B.E.D? This is a different place. Problem is same as current problem with reassigning names to hosts.

How is this scheme mapped onto the physical world?

Suppose we have a hierachial organization with a gatenet at the top and down from that local nets, and down from them hosts and down from them processes. Then an address to get from process 1 in host A on local net I to process 2 in host B in local net II could be 1.A.I.II.B.2. Or if address 0 is defined to mean up the address could be 0.0.0.II.B.2.

Rettberg: Addresses get longer toward the middle of the network. If this is now to be used physically as well as logically, why is there not a problem with hosts coming and going and changing their addresses?

Crocker: Note that at each point (node) some portion of the name space should be reserved for extensions. Given a standard chunk size the waste bits increase with chunk size in larger chunks, but increase with number of chunks in smaller chunks. Looking at some numbers indicated that 4 bits is a desirable chunk size.

Reed: Broadcasting can be supported by using pseudo-addresses or generic addresses that cause copies to be made at the appropriate routing points.

How do we get from the current TCP to a Source Routing TCP? Make use of the version number in the header. Show how the current addressing fieds map into a source routing scheme.

Is checksumming of changing address a problem? There may be ways of dealing with this. Crocker suggests an incremental modification of checksum that goes in parallel with the address modification.

Editor: There may be more to this, but your editor had to catch a plane.

4. Internet Plans - Cerf

FY78 INTERNET PLAN

TCP Development

- UCLA: TCP on 360-91
- MIT(LCS): TCP on Multics (& others?)
- BBN: TCP on Tenex, and TOPS 20, and TCP on UNIX
- SRI: TCP on LSI-11

Type of Service (TOS)

- ISI: Type of Service issues Study (Cohen)
- SRI: Impact of TOS on PR net (Craighill)

Network Development

- BBN: ARPANET changes for broadcast conferencing including multi-destination addressing and imp level changes (McQuillian)
- LCS: LCS net
- PARC: [PARC on PR net] (Shoch)

Packet Radio

- Collins: multi destination addressing in radio
- BBN: multi destination addressing in station
- MIT: minimal spanning trees (Gallager)

Gateways

- BBN: Packet Radio - PR/ARPA & Satellite - PS/ARPA

- PARC: PR/Ethernet (?)
- UCL: EPSS/ARPANET or and x.25 interface EPSS/PS

Gateway Design

- ISI: Translation Gateway for DCA (NCP/TCP) & Fast Deployment and Interconnection and Self Authentication for ARPA
- BBN: RCC & PR & PS
- MIT: Routing (MIT focus on Reliability)
- UCLA: Flow Control & Congestion Control (UCLA focus on Performance)

Working Groups

INTERNET
TCP
PACKET SATELLITE
PACKET RADIO

Internet Systems

- BBN: Gateway Control Center
- UCLA: Internet Measurement Center (Wes Chu)

Discussion:

Should Gateway be visible to a control center? Some visible and some not?

Clark: Will there be a TCP in TIPs?

Cerf: We may never have a TIP TCP.

Reed: Higher level protocols standards for use with TCP?

Cerf: This is open, there is no specific plans.

Regular use needed to get bugs out.

Synchronized Protocols: voice, display, conferencing.

Cerf: Phase out of ARPANET by replacing the crosscountry sections by Autodin II, leaving (for a while) regional ARPANETs in the Boston, Washington, Los Angeles, and San Francisco areas. These regions connected to Autodin II (and thus each other) via gateways.

Reed: The unifying force will be mail.

Wells: Where is the directing force to get high level protocols e.g. Telnet & FTP standarized for use for TCP?

Sunshine: I volunteer to say something about higher level protocols.

Reed: Is it time to change higher level protocols?

Cerf: Telnet is ok.

Reed: How do we fix bugs?

Tomlinson: Use same procedure as before.

Cerf: Postel coordinates protocols.

5. LCS Net - Clark

LCS is building a local network. A host (computer or terminal) is connected to the network by a Local Network Interface (LNI). The LNI is based on the interface developed by Dave Farber at UC Irvine. Three LNI units are to be delivered to LCS in August, and 10 more by December. The units are inexpenisive (currently $2000. with dma). Expect that by the end of the year there could be five or six PDP-10s, several printers, and several terminal concentrators on the LCS network. Goal: cost of local interface should be cheap enough to use 1 per terminal. LNI can be modified to be Ethernet interface. Local Net - PDP-10 interface to be built in house.

The protocol (DPS) was initially designed toward the local environment. A high data rate is a key element in this net. Distributed active naming mechanism. Thoughts about using fiber optics for transmission. Thoughts about supporting bit map displays over the net. Planning on using Encryption for privacy (not red/black security).

Two implementations of DPS are underway:

Motorola 6800 [1300 bytes so far]
PDP-11 UNIX [Mathis reports that his LSI-11 TCP is 1700 words]

Bridge is an interface between network subcomponents (does no address translation, may filter). Multics may not be on local net but reachable via ARPANET/LN gateway.

Some names used for various interconnecting devices: Repeater, Coupler, Bridge, Gateway.

LCS vs CHAOS

Chaos is an Ethernet to connect 10's and 11's and ersatz 11's planned by the MIT-AI people (Tom Knight). Maximum packet size is smaller than a TCP header. All packets are 256 bits, and carry 16 bits of address. LCS/CHAOS net interface is under consideration.

6. PARC - Shoch

Status Report on Xerox Networking

Local computer networking: Ethernet

An Ethernet is limited to about 1 km and 256 stations. It is a shared broadcast facility. Ethernets can be plugged together but there are physical size and addressing problems. At PARC a second Ethernet is connected via a gateway.

Ethernet supports many Personal Computers, pseudo PDP-10s, a Tape station, a Disk station, and a Printer station.

PARC has 5 differtent types of networks with peices in Palo Alto, Los Angeles and various places on the East Coast. Approximately 14 different networks, approxamately 300 hosts connected.

Involved with ARPA to work with Packet Radio. Interested in mobile terminals. There should be work on Media Gateways, Translation Gateways. Also on Internetwork Telnet & FTP.

7. LLL - Watson

Livermore is a place about 1 mile by 1 mile and has for local users a computer center. This center has as worker computers (4) 7600s, (2) STARs, and (1) CRAY. The center has as concentrators (34) pdp11s and pdp8s. There are about 1000 terminals connected to the collection of concentrators. Most of the concentrators are connected to most of the workers via high speed point to point lines. It is a mess.

Livermore also operates the Magnetic Fusion Computer Center. This center has as worker computers (2) 7600s, (1) CRAY, and (1) 6400. The worker computers are connected to the ARPANET via a pdp11/70. The workers are connected to another network made up of pdp11 nodes and 50 KB lines using DECNET protocols. The other two locations on this network are Princeton and [someplace] where there are pdp10s.

Dsigning a replacement for the point to point lines in the Livermore Center. Probably will leave the existing lines in place but put new uses on the new system. Since the system is called Octopus we have Octo[x] where x = net, bus, port, ...

Looking at very high speed systems like a 50 MB bus. Put things called Octoports on the bus. Could have up to 128 lines into an Octoport at 6 MB each. An Octoport talks to the bus at 40 MB. Also looking at using an Octoport for a gateway to LASL (Los Alamos).

Protocol ideas: clean up the situation. Now each function has own protocol, no layers. Could use TCP if it is right for this environment. One issue is "fast single message".

Protocol

open, assure, arg, close1, close2,

Plan to close out in delta-t. Remember sequence number delta-t. If send again before delta-t then use next sequence number else send an original message. One combination might do 3 way handshake. Trying for flexibility to see what gets used. The TCP world has not been a source of assurance that all problems are solved. The delta-t idea trades remembering state for messages.

8. RCC Net - Tomlinson

Status Report on RCC Net

Tomlinson drew a diagram of the RCC network and associated stuff at BBN. An approximate description follows:

ARPANET IMP 49 has hosts BBNB, BBNC, BBND, and Speech-11.

ARPANET IMP 3 has hosts BBNA, BBNE, T-11, and GATEWAY.

There is a box labeled "RCC NET IMPS 5, 44, 62, x", which is connected to GATEWAY on IMP 3 and to the following:

(378) terminal lines
TNET-11 (which is connected to Telenet)
LPT-11
PR-11 #1
PR-11 #2
KBC-11
via BCR to same KBC-11
via BCR to LSI-11