Network Working Group
Request for Comments: 898

R. Hinden (BBN)
J. Postel (ISI)
M. Muuss (BRL)
J. Reynolds (ISI)
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GATEWAY SPECIAL INTEREST GROUP MEETING NOTES

STATUS OF THIS MEMO

This memo is a report on a meeting. No conclusions, decisions, or policy statements are documented in this note.

INTRODUCTION

This memo is a report on the Gateway Special Interest Group Meeting that was held at ISI in Marina del Rey, California on 28 and 29 February 1984. Robert Hinden of BBNCC chaired, and Jon Postel of ISI hosted the conference. Approximately 35 gateway designers and implementors attended. These notes are based on the recollections of Jon Postel and Mike Muuss. Under each topic area are Jon Postel's brief notes, and additional details from Mike Muuss.

The rest of this memo has three sections: the agenda, notes on the talks, and the attendees list.

MEETING AGENDA

Tuesday, February 28

9:00 Opening Remarks -- BBN - Hinden
9:15 Opening Remarks -- ISI - Postel
9:30 The MIT C Gateway -- MIT - Martin
10:00 The Butterfly Gateway -- BBN - Hinden
10:30 Break
11:00 The EGP C Gateway -- ISI - Kirton
11:20 The BRL Gateway -- BRL - Natalie
11:40 The CMU Gateway -- CMU - Accetta
12:00 Lunch
1:30 The Wisconsin BITNET/CSNET Gateway -- UWisc - Solomon
2:00 LAN to X.25 Gateway -- Computer Gateways Inc. - Buhr
2:20 ISI-UCI Gateway -- UCI - Rose
2:40 FACC Gateway -- FACC - Holkenbrink
3:00 Break
3:30 Lincoln IP/ST Gateway -- LL - Forgie/Kantrowitz
3:50 Minimal Stub Gateways -- MITRE - Nabielsky
4:10 Discussion

Wednesday, February 29

9:00 Opening Remarks -- BBN - Hinden
9:10 SPF routing -- BBN - Seamonson
9:35 Multiple Constraint Routing -- SRI - Shacham
10:00 FACC Multinet Gateway Routing -- FACC - Cook
10:30 Break
11:00 Metanet Gateway -- SRI - Denny
11:20 Address Mapping and Translation -- UCL - Crowcroft
11:40 Design of the FACC Multinet Gateway -- FACC - Cook
12:00 Lunch
1:30 SAC Gateway -- SRI - Su/Lewis
2:00 EGP -- Linkabit - Mills
2:30 Congestion Control -- FACC - Nagle
3:00 Break
3:30 A Gateway Congestion Control Policy--NW Systems - Niznik
4:00 Discussion

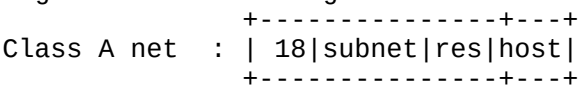
NOTES ON THE MEETING

The MIT C Gateway -- MIT - Martin

Postel: A description of the gateway implemented at MIT. The gateway was first developed by Noel Chiappa. It is written in C. The MIT environment has 32 internal networks which are treated as subnets of the MITNET on the Internet. The MIT gateways then do subnet routing in their interior protocol. The subnet routing scheme is similar to GGP. Liza has added an EGP implementation to this gateway.

Muuss:

Campus network/project Athena
Dynamic routing
Congestion control - grad student



"Bridges" forward between subnets.

Campus Network and Project Athena 65 VAX 750s, 200 IBM PCs.

Hosts: Now = 400, 1986 = 3,000, 1990 = 10,000

Subnets: Now = 42, 1985 = 60, 1990 = 200, (4 subnets/building)

Protocols: Internet, DECnet, Chaosnet

FiberOptic spine between campus buildings.

MIT gateways:

11/03s and 11/23s
68000 on Abus
6800 on Multibus (Bridge communications)

MIT C gateway -
Runs under MOS, bridge OS, homegrown OS. Multiple protocols, multiple interfaces.

11/03 - 100 packets/sec.
11/23 - 180 packets/sec.

GGP - Gw/Gw
EGP - Exterior Gw
IGP - Interior Gw

EGP: Autonomous systems

EGP:
- Neighbor acquisition
- Hello/I heard you
- Net reachability poll
- Net reachability message

MIT IGP:

IP header on EGP protocol
Dest: net number, subnet number, 0, 0377 (broadcast address)

IGP header:

Autonomous system number
Sequence number
Tasks:
- Propagate exterior and subnet routing.

Packets
Ext route request, and update Routing server
- Default gateway
- Exceptional gateways
- Nets reached

MIT - Gw broadcasts initial routings when it comes up, and again on each change, net is flooded on each change several times. Each bridge can ask for help.

Future: Wideband net gateway from BBN will also sit on net 18, and an MIT routing server to acquire routing information. Trick - BBN-Gw will be on an Ethernet, and a modified ARP will be used by the bridges to "fool" the BBN gateway into acquiring the routes.

Subnet Routing - inspired by PUP and CHAOS
- Neighbor Bridge
  - Net I/F
  - Bridge address
  - Latest seq number
  - Aging value
- Route to subnet
  - Distance
- Packets
  - Request
  - I'm up
  - Route update
    - Distance vector (256 bytes)
      - 0 - Direct
      - 1 -127 - hop count
      - 128-255 - "Interface used for next hop" to subnet and hop count
      - 255 - Unreachable

Problem -
- Many neighbors --> too much time and traffic needed for processing.
- 3 level addressing and routing strategy
- Ext Gw:
  - Routing server
  - Default Gw
- Subnet routing
  - Small but rich subnet routing updates.

The Butterfly Gateway -- BBN - Hinden

Postel: A description of the butterfly hardware and a discussion of the plans for the new gateway software to be implemented on it. The butterfly machine is a multiprocessor (MC68000's) interconnected with a funny switch. The new software will incorporate the so called "Shortest Path First" or SPF routing algorithm.

Muuss:

Replacement for existing 30 PDP-11 "core" gateways.
Problems to be solved.

- Replace GGP
  - Routing updates filling up
  - Neighbor probes (N**2)
  - Few buffers

- Present GGP updates only hold 70 net numbers, repacking data will increase that to approximately 100 nets, but this is just short term.

Features of Butterfly -
- 1000's of nets
- Partitioned nets
- Type of service routing, access control
- Flow control
- Large and small gateway configurations

New functions -
- Routing
- Neighbor discovery
- Reduce neighbor pinging
- Access/departure model
- Connect gateways with point-to-point lines

Routing -
- SPF - shortest path first
- Gateway based routing (opposed to network routing)
- Routing updates
  Gw ID
  <nets directly connected>
  <neighbor, distance>
- Updates flooded to other gateways

Next-door - Neighbors
- Neighbor gateways closest to gateway
- Ping next-door-neighbors only
- For up/down acquisition, partition into rings. Reduces pinging.

Access/departure model

First Gw (entrance) picks exit gateway

First Gw adds Gw - Gw header

Butterfly gateway

Processor nodes and switch nodes

4-legged switch nodes, decision is simply UP or DOWN. 2 inputs
and 2 outputs.

Processor: MC 68000
Memory management Unit
Processor node controller - 2901 bit slice
PVC is the memory controller.

Butterfly -
32 M bps/path
Bandwith: approximately N - speed
Size: approximately N/2 log N 2

Butterfly will support multibus interface; 1822, HDLC, Ethernet, Ring

Terminal and load device will be a personal computer

Small Gw for ARPA is approximately $20K

New Gw processor structure

Buffer Management
- o Scatter/gather buffers minimum size and extensions
- o Buffer pool on processors with I/O
- o Primary and secondary collections per device
  ==> guaranteed minimum service per device
  (implemented w/counts)

The EGP C Gateway -- ISI - Kirton

Postel: A user process was installed in Berkeley 4.2 Unix to do EGP protocol functions leaving the normal router kernel function in charge of forwarding datagrams. The EGP user process may do system calls to update the kernel routing data. Based on the work of Liza Martin.

Muuss:

EGP under 4.2

Elimination of nonrouting gateways

Design -
- Forwarding done in kernel
- Kernel does not send redirects
- EGP user process for route updates
- Written in C
- EGP based on Liza Martin's code

Routing Tables
- Kernel
- EGP Process

EGP Process Table -
- External updates
- Internal information

Facilities -

Configuration file-
- Trusted neighbors
- Internal non - routing gateways

Acquisition -
- Predetermined number of core gateways are EGP'd to
- Only accept from trusted neighbors
- Cannot acquire neighbors indirectly, for now

Unix Interfaces -
Reuse IP socket (problem with protocol number)
Listening to ICMP for redirects
System calls for -
- Route updates
- I/F config reading
- I/F status check

Performance -
- 60 ms/packet pair (CPU time)
- Typically 1% of CPU for 1 minute polling

Protocol function going
Routing updates being implemented

Should be all going in April.

The BRL Gateway -- BRL - Natalie

Postel: This was a description of the BRL dumb gateway. More interesting was the description of the BRL complex and the inteconnections between machines. The gateway is written in C (and derived from the MIT C-Gateway) and based on a simple multiprocess operating system called LOS.

Muuss:

BRL history

LOS design
- Message passing
- Memory Management
- No copying of data, buffer size

The CMU Gateway -- CMU - Accetta

Postel: This was a description of the CMU dumb gateway.

Muuss:

History -
- o "Logical-Host" multiplexor (March 81)
- o Gateway (Oct 82) remote debugger and monitor
- o Router (Oct 83)
  - Modular device and protocol support
  - Stub IP dynamic routing
  - Local inter-network cable routing.
- o Written in "C"

Uses low memory for buffers (maximum 32K)!
(autoboot of 3M bps Ethernet)
Auto-configuration of devices
Individual stack contents
Round-robin scheduler
Dynamic memory allocation

Device driver
- Network interfaces
- Auxiliary support devices

Does IP, ICMP, UDP

Splicing through of PUP and CHAOS on chaos net, uses ARP.

Configuration testing protocol (as in Ethernet Spec).

IP Processing-

- o Consistency checks
- o Redirects does not forward misrouted packets
- o Fragmentation - ICMP dest unreach If DF Set
- o Access list for who can pass through

No GGP, no EGP, Uses known gateways

Ordinary devices and PDP-10 and PDP-20

The Wisconsin BITNET/CSNET Gateway -- UWisc - Solomon

Postel: This was a discussion of a mail relay between the Internet and BITNET to be installed at Wisconsin.

Muuss:

WISC-IBM (192.5.2.24) will connect to BITNET

Mail gateway, BITNET uses RFC 822 headers!

LAN to X.25 Gateway -- Computer Gateways Inc. - Buhr

Postel: This was a description of a protocol translation device between an X.25 world and the DATAPOINT ARCNET world.

Muuss:

ARCNET to X.25 Bridge

ARCNET - from Datapoint,
Baseband coax, 2.5 mbps
Token passing
Reserve/send/wait/ack protocol
RIM chip implements this

"The OSI models seem less clear than the Internet models, perhaps because they are less well developed."

Wraps the subnetwork in an enhanced subnetwork layer.

Every pair of subnetworks must be connected in this design - hence a bridge not a gateway.

Bridge is a network layer RELAY.

ARCNET address is sent as X.25 data

ISI-UCI Gateway -- UCI - Rose

Postel: This was a description of the UCI dumb gateway. This one is made up of two hosts (VAX 750s) 50 miles apart. The VAXs are connected via a 9.6 Kbs leased line. One is interfaced to the ISI-NET (an Ethernet) and the other to UCIICS net (also an Ethernet). The VAXs run Berkeley Unix 4.1. These VAXs run as regular hosts too.

Muuss:

MTU is 512. Effective bandwidth of approximately 6000 baud over 9600 baud line.

FACC Gateway -- FACC - Holkenbrink

Postel: A description of a gateway designed by Ford. The gateway is based on a MC68000 multiprocessor and a VME bus. An interesting question that came up during this presentation was "What is the least information a host (or gateway) must have when it comes up, and how can it acquire the rest of what it needs to go into full operation from the environment?"

Muuss:

Inter-segment Processor. M68000 CPU with various co-processors. 68000 IOPS, 1822, IOP Ethernet IOP. 1 cpu does IP, routing. Multi-cpu version of MOS

Lincoln IP/ST Gateway -- LL - Forgie/Kantrowitz

Postel: This was a discussion of the design of the Lincoln gateways used primarily in the WBCNET for speech transmission research. This gateway uses special I/O interfaces to promote a high packet processing rate. The gateway implements both the regular IP, and the ST protocol which permits resource reservations to minimize the variation in transmission delay. These gateways can, of course, act as regular internet gateways, and have achieved very good performance in terms of datagrams per second.

Muuss:

Packet voice experiments, wideband SATNET. Concentrate traffic from local nets to trunk net. Needed enough performance to load WBSATNET. 11/44 and ACC IF11 (Z-80). T1 trunk protocol converter. (voice T1 <--> datagram)

IP problems -
- Congestion
- High packet header overhead
- No support for conference call

ST -
- Virtual circuit
- Know capacity in advance, schedule channel
- Abbreviated header

11/44 - 900 to 1000 pkts/sec.

Port processor:
Sync low speed: 600K bits/sec.
Packet processing: 500 pkts/sec. average
20-talker LPC voice loop, 28 data bytes/pkt, 50% duty cycle
Data handling
4 pcm voice stream loop 64K bps
184 data bytes/pkt, 100% duty cycle

Dispatcher Requirements
- Timely do ST
- Utilize rest of circuit for IP
- Performance measurement

Reservations on the SATNET: Each host makes a reservation for Nbytes of M messages every INTERVAL. Reservations are absolute.

ST and IP for each distant run = MPP multipurpose packets.

12,000 lines of C code in 11/44 portion.

Minimal Stub Gateways -- MITRE - Nabielsky

Postel: This was a more abstract discussion of how stub gateways could interact and acquire information about the topology of the Internet.

Muuss:

Ethernet stub to Internet
Inexpensive, single-band ISBC 186/51 Intel @ $3000
High performance. EGP?

128K bytes/board

The Internet forest

Alternative to ARP using Multicast

SPF routing -- BBN - Seamonson

Postel: This was a fine presentation of the principles of the "Shortest Path First" (SPF) routing procedures with some remarks on how it is tailored to the Internet gateway situation. One point that was impressed on me was that when using SPF in a set of gateways (say, the core autonomous system) the procedure will do routing to an "exit" gateway. Somehow I had not thought about it in those terms before, but (obviously) just as there is a source and a destination IMP in the ARPANET there will be an entrance and an exit gateway in an SPF autonomous system.

Muuss:

Features -
Metric, update procedures, path calculation, forwarding

Current GGP problems -
- Counting to infinity
- Not enough topology information in each Gw
- Updates potentially very large

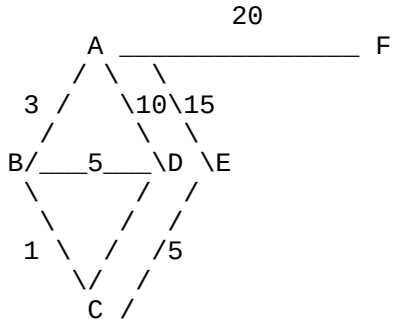
SPF in ARPANET
- Single path (not optimal) - no split of flow
- Delay based, to minimize delay
- Global knowledge of connection topology and delays

Metric used -
- Delay, delay of each packet averaged
  (queueing plus transmission plus propagation)
  arrival-to-arrival time.
- Average delay on each trunk computed every 9.6 seconds.
  Report large changes in delay, fast

Update procedure -
- Updates report delay to each neighbor
- Update triggered by topology change, significant delay change, or 1 time/minute.
  Decay of threshold to direct to send update
- Sequence numbers
- Flooding on all trunks sent out on all lines
- Receipt of echo is acknowledgement
- Retransmission
- Aging of information
- Updates are 2*n*l packet growth. n = number imps, l = number lines

- When lines goes up, rather than dumping routing table,just waits one minute until all updates have been heard.

Path calculation
o Dijkstras Algorithm



1. A B(A, 3), D(A, 10), E(A, 15). F(A, 20)

2. A C(B, 4), D(B, 8), E(A, 15), F(A, 20)
   |
   B

4. A E(C, 9), F(A,20)
   |
   B
  / \
 C D

5. A
   |
   B
   |
   C
  /
 E

Then tree is inverted into a "go here to get to this destination."

For Internet -

Similar algorithm, needs special packet header to indicate "exit" gateway to get to destination network.

Update procedure -
Neighbor interface, neighbors, and delay to neighbor.

"Next door neighbors" for minimizing traffic.
Ability to package multiple updates in one average
explicit Acks.

Path calculation -
- Possible to build different trees based on type of service.

Forwarding -
- Exit Gw
- Consistent databases are important.

Multiple Constraint Routing -- SRI - Shacham

Postel: This was a clear presentation of some of the consequences of the idea of type of service routing. The level of complexity of the routing procedure is determined to depend on how many catagories of service there are and how many selections there are in each catagory. A few examples were discussed including the current type of service parameters of IP.

Muuss:

Both current and proposed ARPANET algorithms provide "best" path under single constraint (number of hops, delay).
Internet will have diverse characteristics, it would be nice to consider more than one constraint.

- Determine a set of measures.
- Represent each measure as a single number.
- Determine range of values. (complexity 0(c**n) range of n)
- Define path measure as a function of measure of length.
  sum (delay, cost)
  min/capacity, length, security)

If just one cost is used, then SPF (or whatever) can be used for each cost. However, under multiple constraints there is a more difficult problem. e.g.: minimum delay with packet size of at least 1000 bytes.

RUMC has been shown to be in the NP complete family.

RUMC needs bigger tables, more processing and routing overhead.
Its not awful for 2-choice TOS, like in IP.

Table size is random, we have to be prepared for the worst case.

Possible strategies: flood a "search packet," dropped when

constraints are not met, see if it makes it though. Good only for virtual circuit. Weighted sum (VC only) works only with some probability.

TOS is needed for Internet, but the algorithms are costly. Complexity for providing TOS IP style is not too high.

FACC Multinet Gateway Routing -- FACC - Cook

Postel: This approach considered hop count to be an inadequate metric for routing decsions in a system of different types of networks (e.g., Ethernets, ARPANETs, 2.4Kb lines). Delay was selected as the metric to use. There are some interesting issues in the measurement of delay for some types of networks. Also, the design considers the use of multiple paths when they are avaiable, and routing to provide connectivty between the parts of partitioned networks.

Muuss:

Routing with a single constraint.
A network of gateways Access, Transport, or Dual networks.
Some networks are used as backbones between gateways only.

Routing updates
  Variable length
  Broadcast routing updates

Unitary ends - A - Gw - B - Rest
   Routing for A is really just routing to B
   Neighbor Gws, nets
   Lots and lots of tables

Metanet Gateway -- SRI - Denny

Postel: This is a project to invent several new addressing features for gateways. In particular, there is a scheme to use an option much like the source route option to do multi-addressing of IP datagrams. It seems as if the gateways that implement this option will have to know which other gateways do and don’t implement it. Also, there was discussion of a gateway to a network that is in radio silence, and how to keep TCP connections going with hosts that can’t talk. This project is also concerned about network reconstitution, security, survivability, congestion control, and supporting multimedia data (voice, bitmaps, etc.) in applications. A gateway is being developed in ADA for a MC68000 machine (SUN), and the initial version of the gateway is to be up in May 84.

Muuss:

Navy internet
Multimedia mail and conf.
Radio silence (EMCON)
Security and Survivability.

EMCON - Causes special problems for EGP and IGP one way nonTCP mail delivery. No Acks. Uses name screen to redirect mail to special one-way mail catcher, who then forwards using ordinary methods.

Security and survivability
Access control - "capability" - 32/64 bit key which changes frequently (every hour or so)

Reconstitution - Partitioning, coalescing, mobile host
Test and monitoring - HMP

Gateway target - 68000 in ADA. Telesoft compiler

Address Mapping and Translation -- UCL - Crowcroft

Postel: This was a discussion of some of the issues in interconnecting networks of different types including the Internet and networks in England such as the Universe network. The Universe network is made up of Cambridge Rings at several sites linked via a satellite channel.

Muuss:

ARPA - SATNET - NULLNET - UCLNET UNIVERSE Satellite, 3 UCL rings

SAM -
- IP switch to several 1822 hosts
- IP/universe mapper, overlays UCLNET on universe
- Mask and match
  128. 11. code. host

Three types:

1. Direct: code --> subnet
2. Redirect: 2nd lookup (for multihoming)
3. Logical: Logical address into a table of universe names.

Name lookups give addresses and routes.

IP tunnels through X.25

BBN Van gateway PSS - IPSS -Telenet - for hosts that can't use SATNET.

SAM does access control and multihoming. Clever Multihoming gives host a second address and sends an ICMP/Redirect to force TCP connection to go through a different route, but wind up at same place!!!

Wrote EGP in ADA. It didn't help at all.

Design of the FACC Multinet Gateway -- FACC - Cook

Postel: This is a distributed multiprocessor machine using a special bus network for the interprocessor communication. The softaware is written in C. The gateways is in an early test phase.

Muuss:

RADC program

Started with AUTODIN II, switched to DDN.
Small to large switching devices.
DoD uses of PDNs, and partitioned network problems.

Distributed processing architecture -
Parallel contention, 90M bps bus, 22 wires. Each node has cpu, memory, optimal comm line. Wire - OR presentation of address, contention happens each time bus becomes free, all requestors put out type of msg, pri, and address. Reads back wire - OR of result, and highest gwy wins, sorted by (pri, type, higher addr).
Bus was originally designed for our FAA fail-soft application Z-800l w/MMU. Not binary addressing, but unitary (base1)
One element resolved per bus transaction.
Boards may be plugged in while running.
Inherent parallelism in layered protocols.

Interface connector clues board to modem levels and date rate. Up to 100K bps now, soon up to T1 rate.

Multiprocessor approach allows routing calculation to take place out-of-band from the measurement of delay and traffic, and allows use of more compute power for routing.

Mostly written in C, with some assembler. Multiprocessor operating system, designed from scratch.

SAC Gateway -- SRI - Su/Lewis

Postel: This was a presentation of the design for the gateways to be used in the advanced SAC demo experiments on network partitioning and reconstitution, and communication between intermingiling mobile networks. Much of these demonstrations will be done with packet radio units and networks. Some of the ideas are to use a gateway-centered type of addressing and double encapsulation (i.e., an extra IP header) to route datagrams.

Muuss:

Network dynamics due to component mobility or failure.
Mobile host, reconstitution, partitioning.
H/W: 11/23
S/W: Some "C" gateway
OS: VMOS (SRI)

Gateway-centered addressing, rather than network.
Gw host instead of net.host.
Double encapsulation: additional IP header.
TCP uses addr as an ID, IP uses it as an ADDRESS (-> route)
Need to separate these dual uses of this address field.
Incremental Routing (next-hop indication)

EGP -- Linkabit - Mills

Postel: A presentation of the EGP design. EGP has three major aspects, neighbor acquisition, neighbor reachability, and network reachability. The autonomous system concept was discussed.

Muuss:

Background, Implementation, Experience, Disparaging Remarks

Design goals -
- Established demarcations
- Decouple implementations
- Confine routing loops
- Exchange reachability information
- Provide flow control for connectivity information
- Medium-term lifetime

Non goals Not trying to do these!
- Flexibility of topology
- Rapid response Very slow update

- Adaptive routing
- Common routing metric No agreement at all
- Load sharing or splitting

"Good news travels fast and bad news travels forever."
Not for routing, but only provides reachability

RFC827 initial mode, RFC888 stub protocol

Neighbor acquisition protocol
- 2-way shake
- Flow - rates
- Explicit acquisition/cause

Neighbor reachability protocol
- Periodic polling
- Parasitic information
- Reachability algorithm Network reachability protocol
- Periodic pulling
- Remote information
- Direct and indirect neighbors
- Indirect internal and indirect external neighbors
- Distance information

EGP neighbors do not need to peer with more than one CORE gateway, but you may peer with anybody you wish.

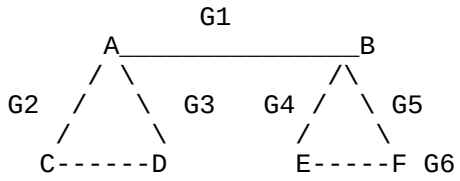
Shortcomings -
- Slow reaction due polling
- Tree-structured routing constraint
  - Rigid topology
  - Administrative resistance to odering
  - Lack of adaptive connectivity
- Neighbor acquisition incomplete.

Loops between autonomous systems will last a long time, and are a real no-no.

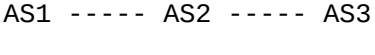
System models -
- "Appropriate first hop" criterion
  - Not useful for implementation
  - Requires global information
  - Inadequate for verification
- Graph models
  - N-graph shows net connectivity
  - T-graph shows system connectivity

- T-acycloc criterion insures loop-free
  - o Derived features
- Induces spanning tree

N-graph



AS1 = G2, G3, G6
AS2 = G1
AS3 = G4, G5



T-graph

Test: to ensure that there are no cycles

Spanning subtree

Specification effort - Status report State machine designed

Remaining issues -
- o Remove extra hop in core system
- o Expand tables
- o Test backdoor "GGP"
- o Resolve specification issues
- o Resolve full gateway configuration
  - Back door connectivity guidance
  - can only advertise 1 path at a time.
  - APF rule guidancee
  - Self organization issues
- o Implement and distribute for operational systems.

Congestion Control -- FACC - Nagle

Postel: This was a discussion of the situation leading to the ideas presented in RFC 896, and how the policies described there improved overall performance.

Muuss:

First principle of congestion control:

DON'T DROP PACKETS (unless absolutely necessary)

Second principle:

Hosts must behave themselves (or else)

Enemies list -

1. TOPS-20 TCP from DEC
2. VAX/UNIX 4.2 from Berkeley

Third principle:

Memory won't help (beyond a certain point).

The small packet problem: Big packets are good, small are bad (big = 576).

Suggested fix: Rule: When the user writes to TCP, initiate a send only if there are NO outstanding packets on the connection. [good for TELNET, at least] (or if you fill a segment). No change when Acks come back. Assumption is that there is a pipe-like buffer between the user and the TCP.

The source quench problem Rule: When a TCP gets an ICMP Source Quench, it must reduce the number of outstanding datagrams on relevant TCP connections.

Rule: When a gateway nears overload, before starting to drop packets, send a Source Quench.

Node capacity: Each node ought to have one buffer for each TCP connection, plus some for overload.

Both fixes really need to be done together, although the first one is often helpful by itself. Side effect: FTPs start off "slowly," until the first Ack comes back Dave Mills thinks this will increase the mean delay for medium-size interactions. This probably will not work so well for SATNET.

Problems about propagation time of links biasing the validity of this result!!

A Gateway Congestion Control Policy--NW Systems - Niznik

Postel: This talk was (for Postel) hard to follow. There were a number of references to well known results in queuing theory etc, but I could not follow how they were being used.

Muuss:

Replacements for IMP SPF
Topological observations
Nodal congestion control policy
  GMD - control application [from German network]
  RPN - relational Petri net
  DCT - dynamic congestion table
NCCP performance evaluation
Planned GCCP: Gateway congestion control policy

Lots of diagrams and figures.

Better throughput than SPF, but somewhat higher delay.

Cubic structure of table.

DISCUSSION (Postel's personal comments)

There was very little organized discussion during the meeting and not really very much question and answer interaction during the presentation. There was a lot of discussion during the breaks, and at lunch time, and at the end of each day.

Some things that occured to me during the meeting that may have been triggered by something someone said (or maybe by the view out the window):

Don't design a protocol where you expect to get a lot of messages from a lot of sources at the same time. For example, don't ask all the hosts on an Ethernet to send you an ack to a broadcast packet.

Has anyone worked out in detail the routing traffic costs for the GGP vs the SPF procedures for the actual case of the Internet?

How will the fact that thinking of the routing in the core autonomous system is cast in terms of an entry and an exit gateway effect other things? Will there be special

arrangements between the entry and exit gateway? Will an autonomous system become a circuit switch connecting pairs of entry/exit gateways?

Is TOS routing worth the cost?

Should we allow (as a new type of ICMP message) redirects to Gateways?

Does making memory larger ever hurt? If a gateway's memory is full of inappropriately retransmitted TCP segments would it be better if there were less memory?

Is there something reasonable to do with source quench at the TCP? Re: RFC-896.

If there are links (or networks) of vastly differing delay and thruput characteristics what impact would an IP level load splitting (say by gateways) have on TCP connections (some of the segments of the connection go one path and others go a different path)?

Are any problems avoided (either way) by using double IP headers vs a "source route like" IP option to separate the IP level addressing and routing function from the TCP level end-point naming function of the IP addresses.

What bad things could happen from the proposed IP multidestination routing option?

MEETING ATTENDEES

Mike Accetta - CMU
R. Buhr - Canada
J. Noel Chiappa - MIT
Paul Cook - Ford
Jon Crowcroft - UCL
Barbara Denny - SRI
Jim Forgie - LL
Steve Groff - BBN
Phill Gross - Linkabit
Kjell Hermansen - NTA
Robert Hinden - BBN
Patrick Holkenbrink - FACC
Ruth Hough - AIRINC
Willie Kantrowitz - LL
Paul Kirton -ISI
Mark Lewis -SRI
Liza Martin - MIT
Doug Miller - MITRE
Dave Mills - Linkabit
Mike Muuss - BRL
Jose Nabielsky - MITRE
Ron Natalie - BRL
John Nagle - Ford
Carol Niznick NW Systems
Jon Postel - ISI
Joyce Reynolds -ISI
Marshall Rose - UCI
Joe Sciortino - AIRINC
Linda Seamonson - BBN
Nachum Shacham - SRI
Alan Sheltzer - UCLA
Marvin Solomon - WISC
Zaw-Sing Su - SRI
Mitch Tasman - BBN