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IDENTIFICATION
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INTERCONNECTION OF PACKET SWITCHING NETWORKS

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KEYWORDS
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CATENET, GATEWAY, SUBSCRIBER, INTERNATIONAL, HEADER.

CONTENTS
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1 - PURPOSE
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THIS NOTE IS DIRECTED TO THE PROBLEM OF CARRYING MESSAGES ACROSS SEVERAL NETWORKS OPERATING ON THE PRINCIPLES OF PACKET SWITCHING. WE WILL EXAMINE SPECIFICALLY WHAT MECHANISMS ARE NECESSARY TO ESTABLISH INTER-NETWORK COMMUNICATIONS WHILE PRESERVING AUTONOMY OF OPERATION WITHIN NETWORK BOUNDARIES.

2 - INTRODUCTION
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PACKET SWITCHING NETWORKS ARE GROWING. SOME HAVE BEEN DEVELOPPED AS SUB-NETWORKS PROVIDING SPECIALIZED SERVICES WITHIN A LARGER SYSTEM (ARPANET, TYMNET, CIGALE). OTHERS ARE DESIGNED AS STAND-ALONE NETWORKS TO BE OFFERED AS MESSAGE CARRIERS TO SOME SEGMENTS OF THE USER MARKET, (SITA, EPSS, PCI). ACTUALLY THE DIFFERENCE IS MORE IN TERMS OF COMMERCIAL EXPLOITATION THAN TECHNICAL CONCEPTION. ALL PACKET SWITCHING NETWORKS ARE ACTUALLY STAND-ALONE SYSTEMS, CAPABLE OF BEING OPERATED INDEPEDENTLY FROM THEIR PRESENT USERS (HOSTS OR TERMINALS).

LARGE CORPORATIONS, USER GROUPS, PTT'S, ARE PRESENTLY EMBARKING UPON NETWORK STUDIES. A SIZABLE PROPORTION OF THESE STUDIES WILL BE PURSUED THROUGH ACTUAL IMPLEMENTATIONS. THERE IS LITTLE CHANCE IF ANY THAT ALL THESE NETWORKS WILL ADOPT IDENTICAL TECHNICAL SPECIFICATIONS. AT BEST, THEY WILL BE SIMILARITIES BUT NOT IDENTITY AT THE EXTERNAL INTERFACE. INTERNAL IMPLEMENTATIONS WILL BE AS AKIN AS TWO FORTRAN COMPILERS. AS A RESULT, NETWORK INTER-CONNECTION WILL HAVE TO WORK AROUND PECULIAR, POSSIBLY WEIRD FEATURES, EMBEDDED IN LOCAL ARTWORK. OF COURSE, EVERY ONE OF THEM WILL BE JUSTIFIED, AT LEAST IN AUTHOR'S MIND, BY UNDEBATABLE INITIAL ASSUMPTIONS, AND UNLIKELY TO BE REVISED.

CONSEQUENTLY, THERE ARE GOOD CHANCES THAT THE SET OF COMMON PROPERTIES ACROSS NETWORKS WILL BOIL DOWN TO THE ONLY UNQUESTIONABLE ONE, I.E. MESSAGE TRANSFER. BUT EVEN THAT IS NOT SPONTANEOUSLY COMPATIBLE, AS WE SHALL SEE.

THE OJECTIVE OF INTERFACING NETWORKS SO THAT MESSAGES CAN CROSS OVER BOUNDARIES AND REACH THEIR DESTINATION THROUGH FOREIGN NETWORKS, IS PER SE QUITE OF A CHALLENGE. ONE SHOULD NOT ATTEMPT TO LOAD THE PROBLEM WITH ADDITIONAL REQUIREMENTS THAT ARE NOT DEMONSTRATED AS BEING OF COMPELLING NECESSITY. ASSUMING THAT THE MOST SUCCESSFUL DESIGNS WILL EVENTUALLY EMERGE, NETWORKS WILL TEND TO CONVERGE TOWARDS GENERALLY ACCEPTED MODELS. THEN MORE FUNCTIONS COULD BE STANDARDIZED, TO ALLOW MORE INTIMATE INTERFERENCES.

3 - TERMINOLOGY
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A - PACKET SWITCHING NETWORK, (PSN)
----------------------------- A SET OF COMMUNICATION COMPUTERS (NODES) CONNECTED VIA PHYSICAL CIRCUITS, AND CARRYING BIT STRINGS USING A STORE AND FORWARD TECHNIQUE.

B - PACKET
------ A BIT STRING EXCHANGED BETWEEN NODES OF A PARTICULAR PSN.

C - MESSAGE
------- A BIT STRING EXCHANGED BETWEEN A PSN AND AN EXTERNAL DEVICE, HOST COMPUTER, OR ANOTHER PSN.

D - HOST
        ---- A SET OF RESOURCES, USUALLY HOUSED IN A COMPUTER, CAPABLE
OF EXCHANGING MESSAGES WITH OTHER HOSTS, USING ONE OR SEVERAL PSN,S
AS MESSAGE CARRIERS.

E - GATEWAY
        ------- A PARTICULAR NODE CAPABLE OF EXCHANGING MESSAGES WITH
AN EXTERNAL DEVICE, HOST OR PSN.

F - CATENET
        ------- AN ABSTRACT PSN RESULTING FROM THE JUXTAPOSITION OF
SEVERAL PSN,S.

4 - EXPECTED SERVICES
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    A - THE MINIMUM SERVICE TO BE EXPECTED IS THE CAPABILITY TO SEND
A MESSAGE TO A RECEIVER, GIVEN SOME SORT OF GLOBAL ADDRESS, WHICH
CAN BE UNDERSTOOD BY THE TRAVERSED NETWORKS. THE MESSAGE SHOULD NOT
BE ALTERED IN ANY WAY BETWEEN RECEPTION FROM ITS SOURCE AND DELIVERY
TO ITS DESTINATION.

    B - SOME CONTROL SERVICES ARE HELPFUL, SUCH AS TRACING, ECHOING,
TIMING, ETC..., OR ACCOUNTING, STATISTICS. BUT THIS AN AREA WHERE
THERE ARE LIKELY TO BE VARIATIONS DUE TO INTERNAL NETWORK STRUCTURE
AND IDIOSYNCHRASIES. ALTHOUGH STANDARDIZATION MAY BE DESIRABLE,
IT WILL PROBABLY NOT MATERIALIZE UNTIL SOME YEARS OF OPERATION HAVE
BUILT UP PRESSURE, AND FORCED A COMMON AGREEMENT. IN THE MEANTIME,
THESE SERVICES WILL BE AVAILABLE ON A MUTUAL AGREEMENT BASIS.

    C - ADDITIONAL SERVICES MAY BE OFFERED BY SOME TYPES OF NETWORKS,
E.G. VIRTUAL CIRCUITS, FLOW CONTROL, SHORT ADDRESSING, HOT CIRCUITS,
BROADCASTING, MAILBOXES, ETC. IT IS NOT OUR INTENT TO DISCUSS THE
APPROPRIATENESS OF ANY PARTICULAR PROPERTY ENCOUNTERED IN EXISTING
OR PLANNED NETWORKS. BUT SINCE THEY ARE LIKELY TO BE JUST A LITTLE
DIFFERENT FROM ONE NETWORK TO ANOTHER, AT BEST, THEY SHOULD BE
CONSIDERED AS LOCAL PROPERTIES TO BE IGNORED WHEN DEFINING A GENERAL
TRANS-NETWORK SERVICE. OF COURSE, THE FACT OF NOT USING THEM MUST
NOT REQUIRE ANY PECULIAR SET UP, FROM THE EXTERNAL USER STANDPOINT.
PRACTICALLY SPEAKING, IT IS MORE REALISTIC TO SEEK A MULTI-NETWORK
AGREEMENT BASED ON A MINIMUM SERVICE, RATHER THAN A MAXIMUM.

5 - LOCAL NETWORK CONTROL
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        TO TRANSFER A MESSAGE, EACH INTERMEDIATE NETWORK MAY CHOSE
DIFFERENT TECHNIQUES, AS LONG AS THEY DO NOT PUT SPECIFIC CONSTRAINTS
ON A NEIGHBOR NETWORK, OR END USERS. E.G.

    - FRAGMENTATION FOLLOWED BY REASSEMBLY.

- ASSEMBLY FOLLOWED BY FRAGMENTATION.

- FIXED OR ADAPTIVE ROUTING.

- INTERNAL CIRCUIT SET UP AND CLOSE.

- END TO END ACKNOWLEDGEMENT.

- SOURCE-DESTINATION SEQUENCING, (WITH OR WITHOUT CIRCUITS).

- CONGESTION CONTROL.

- ERROR DETECTION AND RECOVERY.

PRESUMABLY, SOME LOCAL USERS WILL RELY UPON LOCAL NETWORK PROPERTIES IN DESIGNING THEIR PROTOCOLS AND ACCESS METHODS. THIS APPROACH CARRIES THE UNDESIRABLE EFFECT OF TYING UP USER AND NETWORK OPTIONS. SHORT TERM SAVINGS TURN UP LONG TERM INADEQUACIES, WHEN NEW NEEDS AND A BETTER UNDERSTANDING OF NETWORK PROBLEMS CALL FOR A REVISION OF PROTOCOLS.

WHEN SEVERAL NETWORKS ARE INTER-CONNECTED, ONE CANNOT EXPECT FUNCTIONS SUCH AS THOSE LISTED ABOVE TO BE EXTENDED SO THAT THEY GIVE EACH USER THE IMPRESSION OF HAVING AN ENLARGED LOCAL NETWORK. BARRING TECHNICAL HURDLES, THIS WOULD RESULT IN END USERS BEING UNABLE TO EXCHANGE MESSAGES, SINCE THEY WOULD NOT USE MATCHING PROTOCOLS.

6 - ON GATEWAYS
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WHEN IT COMES TO LINK NETWORKS, ONE APPROACH, WHICH IS OFTEN ADVOCATED, CONSISTS IN SHIPPING MESSAGES THROUGH GATEWAYS IN CHARGE OF INTERFACING BETWEEN NETWORKS.

GATEWAYS WOULD LOOK LIKE A HOST FOR EACH NETWORK, I.E. RECEIVE AND FORWARD MESSAGES, EXCHANGE ADEQUATE SIGNALING INFORMATION, PERFORM SOME ERROR AND FLOW CONTROL, ACCOUNTING, ETC. IN OTHER WORDS, A GATEWAY COULD BE VIEWED AS TWO HOSTS FACE TO FACE. (FIG. 1).

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                                                          ++++
                 ++++++                              ++      ++
             ++        +       ******     ******    +          ++
          +              +     *     *    *     *   +
        +     PSN=1    +=====*    *=====*    *=====++    PSN=2    +
          +              +     *   *      *    *    +              +
            +              +     ****** *   ****** *   +            +
             ++        ++                             +    +++
                ++++            GATEWAYS                ++++
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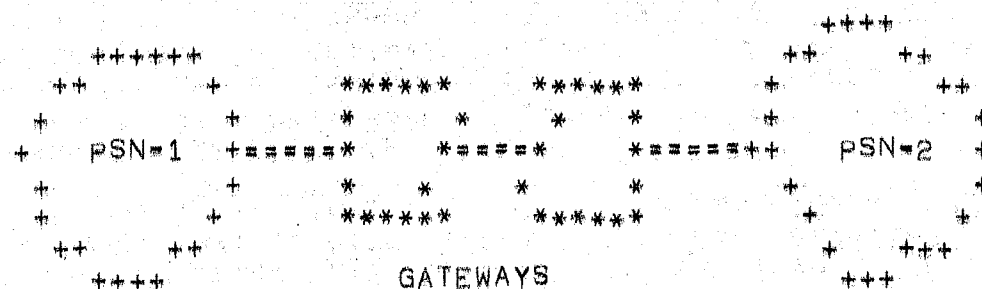
FIG. 1

A CURSORY EXAMINATION MAY SUGGEST THAT THIS IS THE WAY TO GET AROUND NETWORK PECULIARITIES, BY BURYING THEM WITHIN GATEWAYS. BUT A CLOSER LOOK REVEALS THAT THIS IS NOT SO.

FOR EXAMPLE WE MIGHT HAVE NETWORK-1, WITH VIRTUAL CIRCUITS, END TO END ACKNOWLEDGEMENT, AND SEQUENCING, WHILE NETWORK-2 HAS NONE OF THESE FEATURES. IF WE WANT NETWORK-1 PROPERTIES BE EXTENDED ACROSS NETWORK-2, THEN GATEWAYS ALL OVER MUST IMPLEMENT VIRTUAL CIRCUITS, END TO END ACKNOWLEDGEMENT, AND SEQUENCING, ON THE SAME WAY AS NETWORK-1 DOES. AS A CONSEQUENCE, ALL GATEWAYS WOULD HAVE TO IMPLEMENT ALL NETWORK PROPERTIES, WHICH IS CLEARLY UNREALISTIC.

ON THE OPPOSITE, WE MAY WANT NETWORK-1 PROPERTIES TO BE ENTIRELY MASKED OUT, SO THAT NETWORK-1 APPEARS AS NO DIFFERENT FROM NETWORK-2. ONLY GATEWAYS TO NETWORK-1 WOULD BE DEPENDENT ON NETWORK-1 PROPERTIES, WHICH IS UNDOUBTLY MORE SATISFACTORY. BUT THIS IS ONLY POSSIBLE TO THE EXTENT THAT NETWORK-1 USERS DISREGARD ALL NETWORK-1 PROPERTIES THAT ARE NOT MATCHED BY NETWORK-2, I.E. VIRTUAL CIRCUITS, END TO END ACKNOWLEDGEMENT, AND SEQUENCING. IF NETWORK-1 INTERFACE DOES NOT ALLOW SUCH A SIMPLIFICATION, THEN A LOCAL GATEWAY MUST BE INTERPOSED BETWEEN NETWORK-1 AND ITS USERS THAT WANT TO ACCESS NETWORK-2.

PRACTICALLY, IT IS NOT REALISTIC TO EXPECT USERS TO ADJUST THEIR PROTOCOLS ACCORDING TO WHICH NETWORKS THEIR MESSAGES ARE TO CROSS. THEY MAY NOT KNOW IT, AND PROPERTIES MAY CHANGE. ON THE OTHER HAND, EVEN IF GATEWAYS ARE PROVIDED FOR USERS, THEIR DESIGN CANNOT TAKE INTO ACCOUNT ALL COMBINATIONS OF NETWORK PROPERTIES THAT REQUIRE SOME MASKING.

WE GRADUALLY COME TO THE CONCLUSION THAT USERS AND GATEWAYS CANNOT ASSUME ANYTHING ABOUT OTHER NETWORKS BUT THE SIMPLEST POSSIBLE PROPERTIES. THE REASON IS THAT GATEWAYS CANNOT GIVE TO NETWORKS PROPERTIES THAT THEY DO NOT HAVE. THEY CAN ONLY SCREEN OUT UNDESIRABLE OR UNUSABLE ONES.

ONE MIGHT ALSO THINK OF GATEWAYS AS NODES OF A SUPER-NETWORK, IN WHICH TRANSMISSION LINES HAPPEN TO BE LOCAL NETWORKS. THEN, ONE COULD IMPLEMENT WITHIN GATEWAYS WHATEVER PROPERTIES SHOULD BE DEEMED FIT FOR INTER-NETWORK COMMUNICATIONS, USING MORE OR LESS OF THE LOCAL FEATURES TO CARRY MESSAGES BETWEEN GATEWAYS.

ACTUALLY, THIS LAST APPROACH BOILS DOWN TO THE CONSTRUCTION OF YET ANOTHER NETWORK, AND ULTIMATE AT THAT. THE VERY FEASIBILITY OF SUCH AN OBJECTIVE CAN BE SERIOUSLY IN DOUBT. SHOULD NETWORK INTER-CONNECTION DEPEND ON A UNIVERSAL NETWORK, SCHISMS WOULD INDEFINITELY RAISE THE PROBLEM ONE LEVEL UP.

THIS IS NOT TO SAY THAT A GENERAL INTER-NETWORK AGREEMENT WILL NEVER HAPPEN, BUT THAT IT WILL HAPPEN GRADUALLY, STARTING WITH A FEW RECOMMENDATIONS ON FUNDAMENTAL ISSUES, RATHER THAN A WHOLE NETWORK.

7 - CATENET STRUCTURE
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AS IT HAS BEEN SUBSTANTIATED PREVIOUSLY, GATEWAYS WILL TEND
TO REDUCE PSN'S TO THEIR BASIC COMMON PROPERTIES. THUS, WHY BOTHER
TO IMPLEMENT SOPHISTICATED FUNCTIONS IF IN THE END THEY TURN INVISIBLE.
AND WHY GATEWAYS IF THERE IS NOTHING TO FAKE UP. MANY AN OPERATING
SYSTEM ILLUSTRATES THE STORY OF LAYERS OF SOFTWARE (AND OVERHEAD)
TO PROVIDE JUST SIMPLE GET & PUT FUNCTIONS ON TOP OF A HODGE-PODGE
OF SYSTEM PRIMITIVES, FOR WHICH NO ONE CAN FIND ANY SENSIBLE USE.

THE CASE HERE IS TO SHOW THAT PSN'S WITH VERY FEW BASIC PROPERTIES
MAY INTER-CONNECT THROUGH QUASI-REGULAR NODES, AND CONSEQUENTLY
ARE IN A BETTER POSITION TO REACH MULTI-LATERAL ACCEPTANCE, AND
TO FOSTER COST-EFFECTIVE IMPLEMENTATIONS.

WE CALL <CATENET> A PSN MADE UP FROM A MERE JUXTAPOSITION OF
LOCAL NETWORKS. IT HAS NO HIERARCHICAL STRUCTURE, AND GATEWAYS ARE
ALL BUT REGULAR NODES, SAVE FOR I/O FUNCTIONS PERFORMED IN CONJUNCTION
WITH ANOTHER PSN, RATHER THAN LOCAL HOSTS. AS A WHOLE IT HOLDS
THE BASIC PROPERTY OF CARRYING INDEPENDENT MESSAGES ACROSS SEVERAL
LOCAL PSN'S. EACH LOCAL PSN IS ASSUMED TO HAVE ONLY THIS VERY SAME
BASIC PROPERTY. IN OTHER WORDS, THE CATENET STRUCTURE IS RECURSIVE.
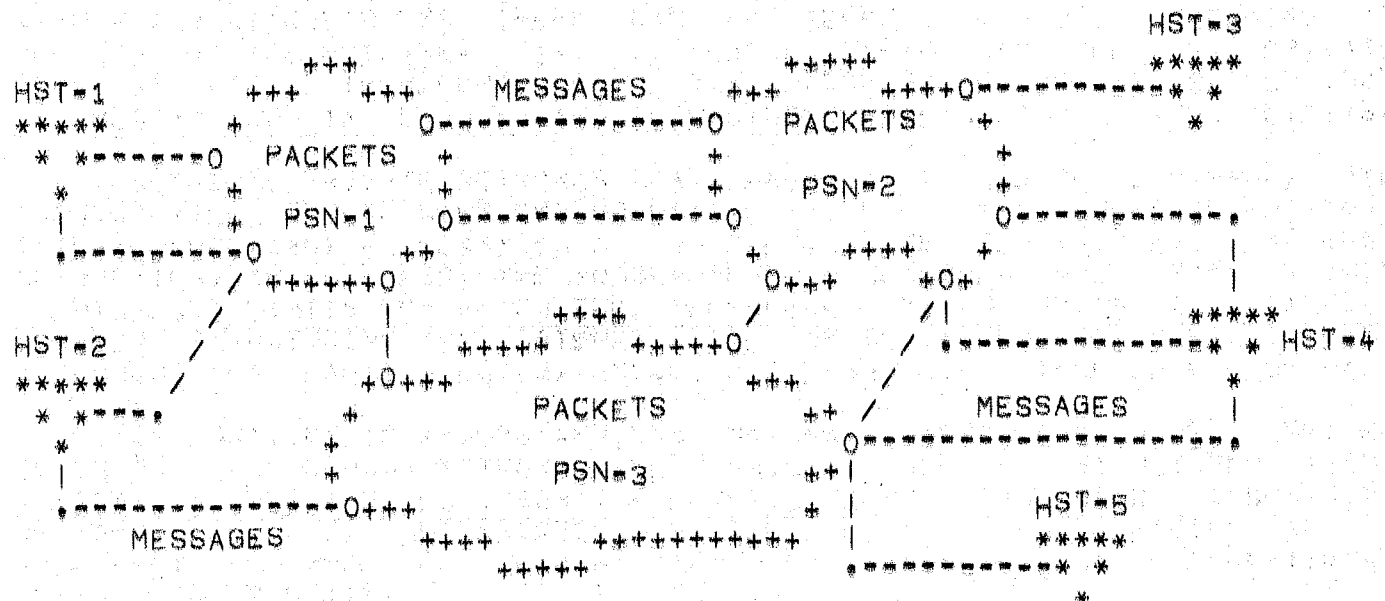(FIG. 2).

FIG. 2 - CATENET STRUCTURE

WHILE CATENET SHOULD BE IDEALLY A MERE PIECING TOGETHER OF
INDEPENDENT PSN'S, IT SHOULD NONETHELESS DISPLAY A CONSISTENT BEHAVIOR
EQUIVALENT TO A UNIQUE SIMPLE PSN. THIS CRITERION WILL BE EXERCISED
TO ASSESS THE VALIDITY OF ITS FUNCTIONAL STRUCTURE.

8 - NUMBERING PLAN

MESSAGE ADDRESSES MUST BE INTERPRETED BY EACH PSN IN ORDER TO ROUTE MESSAGES CLOSER TO THEIR FINAL DESTINATION. SINCE THE SENDER IS NOT NECESSARILY AWARE OF THE PSN'S BEING TRAVERSED, AND FOR BETTER CONVENIENCE, ADDRESSES IN CATENET TRAFFIC SHOULD CONFORM TO A UNIVERSAL PLAN PROMULGATED BY A STANDARDIZATION BODY, SUCH AS ISO. IN THE FOLLOWING, CONSTRAINTS AND PROPOSALS FOR A NUMBERING PLAN WILL BE STUDIED.

A - NAME SPACE

IT IS USELESS AND COSTLY THAT EACH PSN BE ABLE TO INTERPRET THE WHOLE ADDRESS FIELD OF MESSAGES WHOSE DESTINATION BELONGS TO A DIFFERENT PSN. ALL IT NEEDS TO KNOW IS A LIST OF POSSIBLE GATEWAYS THROUGH WHICH A PARTICULAR MESSAGE CAN BE FORWARDED TO A NEIGHBOR PSN.

GATEWAYS SHOULD NOT BE MENTIONNED DIRECTLY WITHIN AN ADDRESS, SINCE THE ROUTING CAN BE VARIABLE. THE ONLY INVARIANT IS THE DESTINATION ITSELF. THUS, GATEWAYS SHOULD BE DETERMINED FROM A PART OF THE TOTAL ADDRESS, WHICH SHOULD BE A CATENET GLOBAL NAME.

WHAT WE END UP WITH IS A HIERARCHICAL NAME SPACE, WITH A LOCAL COMPONENT AT THE PSN LEVEL, AND A GLOBAL ONE AT THE CATENET LEVEL. WITHIN A PARTICULAR PSN THERE CAN BE SEVERAL LEVELS, DEPENDING ON THE SIZE OF THE NETWORK. INDEED, LOCAL PSN'S MAY WELL BE PRIVATE ONES WORLDWIDE. THEREFORE, THE LOCAL ADDRESS COMPONENT SHOULD NOT BE RESTRICTED IN LENGTH AND STRUCTURE WITHIN TOO NARROW LIMITS.

ALTHOUGH PRIVATE NETWORKS MAY HAVE A WORLDWIDE COVERAGE, ONE SHOULD EXPECT COMMON CARRIERS OR PTT'S TO FORM THE BULK OF NETWORK INTER-CONNECTION, AT LEAST ON A LONG TERM. DUE TO NATIONAL BORDERS, MONOPOLIES, OR BUSINESS, THE NUMBER OF SUCH NETWORKS WILL STAY WITHIN PREDICTABLE LIMITS FOR WHICH THE TELEPHONE SYSTEM GIVES AN EXAMPLE. A WAY OF STRUCTURING THE CATENET NAME SPACE WOULD BE DERIVED FROM A GEOGRAPHICAL PARTITIONNING, MORE OR LESS LIKE TELEPHONE NUMBERS.

IN ADDITION TO A GEOGRAPHICAL NAMING, THERE SHOULD BE ANOTHER CLASS OF <WELL KNOWN> NETWORK NAMES, WHICH COULD BE STRUCTURED ALONG DOMINANT ACTIVITIES, E.G. SERVICE BUREAU, RESERVATION, BANK, INSURANCE, LIBRARY, MEDICINE, METEOROLOGY, POLICE, ETC. THE DECISION AS TO WHICH NETWORKS ARE WELL KNOWN MIGHT BE TAKEN BY AN INTERNATIONAL BODY, SUCH AS CCITT.

OTHER NETWORKS WOULD NOT BE IDENTIFIED AT THE CATENET LEVEL. THEY WOULD APPEAR JUST LIKE A REGULAR DESTINATION ADDRESS WITHIN A PARTICULAR PSN. THIS DOES NOT RESTRICT IN ANY WAY THEIR CAPABILITY TO EXCHANGE TRAFFIC WITH THE REST OF CATENET. IT ONLY MAKES THEIR ADDRESS LONGER.

INCLUSION OF A NEW OR EXISTING NETWORK IN CATENET WOULD ONLY REQUIRE ALLOCATING EITHER A WELL KNOWN NETWORK NAME, OR ONE OR SEVERAL

ADDRESSES WITHIN SOME LOCAL PSN'S NAME SPACE.   SINCE THE TOTAL NAME
SPACE IS HIERARCHICAL, CATENET NAMES MAY BE JUST A CONCATENATION OF
LOCAL NAMES WITH THE PSN NAME.

        EXAMPLES : (A, B, C, D, E, F, ARE USUAL HEXADECIMAL DIGITS)

  - 33...   FRENCH PTT PSN

  - 44...   BRITISH PTT PSN

  - 49...   HYPOTHETICAL GERMAN PTT PSN

  - CE...   SITA NETWORK

  - AA...   WORLD WEATHER WATCH

  - 33XXX...   COST-11 ADDRESS WITHIN FRENCH PSN

  - 41ZZ...   COST-11 ADDRESS WITHIN SWISS PSN

    A GENERAL STRUCTURE FOR A CATENET NAME IS :

            <NATIONAL | WELL KNOWN PSN> <LOCAL NAME WITHIN PSN>

        AS ONE CAN INFER, A SINGLE PSN MAY HAVE DIFFERENT NAMES, AND
MAY BE REACHED THROUGH DIFFERENT WAYS, PARTICULARLY IF IT EXTENDS
OVER NATIONAL BOUNDARIES. BUT THIS IS ALREADY QUITE CUSTOMARY WITHIN
THE TELEPHONE SYSTEM.

  B - ADDRESS STRUCTURE

        AS ADVOCATED IN THIS STUDY, THE GLOBAL COMPONENT OF A CATENET
ADDRESS SHOULD BE OF FIXED LENGTH. ALTHOUGH THIS IS NOT MANDATORY,
IT APPEARS AS A CONVENIENT SIMPLIFICATION, SINCE THE MAXIMUM SIZE
OF THE NAME SPACE IS FAIRLY PREDICTABLE. BUT THIS IS NOT THE CASE
IN A PARTICULAR PSN, WHOSE SIZE MAY VARY FROM A DEGENERATE 1-SUBSCRIBER
CASE UP TO THOUSANDS OF SUBSCRIBERS.

        THUS, A LOCAL ADDRESS SHOULD BE ALLOWED TO BE VARIABLE IN LENGTH
AND STRUCTURE TO FIT LOCAL REQUIREMENTS. SOME NETWORKS MAY WANT TO
ALLOW SHORT AND LONG ADDRESSES, OR USE A 2-LEVEL ADDRESS SPACE, ETC.
AT FIRST SIGHT, THIS SHOULD NOT CONCERN INTER-CONNECTION, SINCE LOCAL
NAMING IS REALLY LOCAL PSN BUSINESS.   BUT IT WOULD BE REASONABLE
TO USE ONLY LOCAL ADDRESSES, RATHER THAN CATENET, FOR LOCAL TRAFFIC
CONFINED WITHIN A SINGLE NETWORK. THIS IS ALL THE MORE TO BE EXPECTED
THAT NETWORKS TEND TO BE BUILT AS STAND ALONE OBJECTS. ONLY LATER ON
ONE DISCOVERS THAT THEY SHOULD COMMUNICATE WITH ANOTHER NETWORK.
AT THIS POINT IT IS TOO LATE TO REDESIGN ALL SUBSCRIBER SOFTWARE,
AND ONE HAS TO LIVE WITH TWO KINDS OF ADDRESSES.

        THEREFORE THE QUESTION ARISES, NOT HOW TO STRUCTURE A LOCAL
ADDRESS, BUT HOW TO TELL BETWEEN A LOCAL AND A CATENET ADDRESS.
AGAIN, THIS COULD BE THOUGHT OF AS A LOCAL PSN PROBLEM.   BUT IF IT
WERE SO, A CATENET ADDRESS WOULD REQUIRE REFORMATTING WHENEVER CROSSING

PSN BOUNDARIES. ALTHOUGH THIS CONVERSION PROCESS MAY BE ACCEPTABLE, IT IS CERTAINLY MOST DESIRABLE THAT PSN'S EXCHANGE ADDRESSES IN A GENERALLY UNDERSTOOD FORMAT, RATHER THAN ON A MUTUAL AGREEMENT BASIS.

CONSEQUENTLY, SOME STANDARD MARKER SHOULD INDICATE WHETHER OR NOT AN ADDRESS IS TO BE INTERPRETED AS CATENET, OR LOCAL. ACTUALLY, IT WOULD NOT BE SO SURPRISING THAT AN INTERNATIONAL STANDARD BE REVISED, OR THAT THE ASCII-EBCDIC SYNDROME LEAD TO BY-STANDARDS. THUS, ONE SHOULD BE PREPARED TO HANDLE A MIXTURE OF A SMALL NUMBER OF INTERNATIONAL OR DE FACTO ADDRESS STANDARDS.

THIS NEED CALLS FOR AN ADDRESS TYPE COMPONENT, OF FIXED LENGTH, WHICH WOULD DESIGNATE A PARTICULAR FORMAT STANDARD. THUS, A CATENET ADDRESS NOW LOOKS LIKE :

```
        <FORMAT>  <GLOBAL NAME>  <LOCAL NAME>
         FIXED       FIXED         VARIABLE
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AND WITHIN A PARTICULAR PSN, THE LOCAL COMPONENT MAY WELL BE STRUCTURED THE SAME WAY RECURSIVELY. THIS WOULD MAKE VERY STRAIGHTFORWARD ANOTHER TYPE OF NETWORK INTER-CONNECTION BY INCLUSION, I.E. A NETWORK WITHIN A NETWORK WITHIN A ... ----------
BUT THIS WILL BE ELABORATED ON IN THE FOLLOWING.

   C - AREA ADDRESSING

        A RECURSIVE STRUCTURE FOR THE ADDRESS FORMAT BRINGS SOME PRACTICAL ADVANTAGES. INDEED, A LOCAL NAME SPACE MAY BE PARTITIONNED INTO SEVERAL SUB-SETS, EACH OF WHICH CAN BE VIEWED AS A SUB-NET (AREA). WITHIN EACH AREA, LOCAL TRAFFIC ADDRESSES MAY BE SHORTENED TO THE ONLY SIGNIFICANT COMPONENT (LOCAL NAME WITHIN AN AREA). AND SO ON.

        IF IT HAPPENS THAT LOCAL TRAFFIC MAKES UP A SIGNIFICANT FRACTION OF THE TOTAL TRAFFIC, THEN SHORTER ADDRESSES MAY REDUCE MESSAGE OVERHEAD, AND SIMPLIFY THE DESIGN OF EQUIPMENT INTENDED ONLY FOR LOCAL TRAFFIC.

        FURTHERMORE, AREA BOUNDARIES NEED NOT COINCIDE WITH ANY PARTICULAR PHYSICAL PSN BOUNDARIES. ACTUALLY, THEY ARE TWO INDEPENDENT CONCEPTS. THUS, ONE MAY DEFINE AREAS SO THAT THEY COINCIDE WITH TRAFFIC CLUSTERS.

        TO THE EXTENT THAT ADJACENT OR OVERLAPPING PSN'S COMPLY WITH A HOMOGENEOUS FORMAT, AN AREA MAY WELL BELONG TO DIFFERENT PSN'S, OR STRADDLE OVER BOUNDARIES. THIS IS MOST CONVENIENT FOR SUBSCRIBERS WHICH CAN BE KNOWN BY THE SAME NAME WITHIN DIFFERENT PSN'S, OR CAN BE REACHED WITH SHORT ADDRESSES FROM AN ADJACENT PSN, AS IF THEY WERE IN THE SAME NET. BUT ALL THAT IS JUST BORROWING FROM THE TELEPHONE SYSTEM, WHICH IS AN INTERESTING AND SOPHISTICATED MODEL.
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## D - PRIVATE NETWORK
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AS HAS BEEN SAID PREVIOUSLY AN EXTERNAL DEVICE CAN BE A HOST, OR ANOTHER PSN. ACTUALLY, A DISTINCTION IS MADE HERE FOR THE SAKE OF BETTER UNDERSTANDING. BUT THE NATURE OT THE HOST/PSN IS IMMATERIAL. IT CAN BE ONE COMPUTER, A CLUSTER OF COMPUTERS, A BUNCH OF VIRTUAL MACHINES, A STAR NETWORK, ETC.

OF COURSE, IT SHOULD NOT BE EXPECTED THAT MESSAGES BE HANDLED IN ANY PREDEFINED MANNER, SINCE NO COMMON AGREEMENT IS REQUIRED AT THIS LEVEL. BUT THIS IS ALL RIGHT AS LONG AS NO TRANS-NETWORK TRAFFIC WOULD PASS THROUGH THIS KIND OF NETWORK. IT IS ONLY A SOURCE OR DESTINATION OF MESSAGES. IN SOME SENSE IT IS A TERMINAL, ALTHOUGH IT CAN BE A NETWORK TERMINAL.

ADDRESSING WITHIN A PRIVATE NETWORK HAS TO BE USER DEPENDENT, SINCE MOST OF THESE NETWORKS HAVE BEEN OR WILL BE BUILT FOR SPECIFIC APPLICATIONS, WITHOUT MUCH FREEDOM IN TERMS OF EQUIPMENT OR PROCEDURES. HOWEVER THEY MAY WANT TO EXCHANGE TRAFFIC WITH CATENET, AS IF THEIR SOURCES/DESTINATIONS OF MESSAGES WERE PSN SUBSCRIBERS.

SINCE THEIR ADDRESS FORMATS CAN BE QUITE EXOTIC, SOME CONVERSION WOULD HAVE TO BE EFFECTED AT GATEWAYS, PRESUMABLY ON THE HOST SIDE. THEN, THE ADDRESS INFORMATION MAY APPEAR IN CATENET FORMAT ON THE PSN SIDE. THIS IS NOT OF ANY USE FOR CATENET, AS IT ONLY LOOKS AT THE GLOBAL COMPONENTS OF AN ADDRESS. BUT IT MAY HELP END CORRESPONDENTS TO SEND/RECEIVE MESSAGES WITH A WELL DEFINED COMMON ADDRESS FORMAT, INSTEAD OF CATERING FOR AS MANY FORMATS AS POSSIBLE PRIVATE NETWORKS. FURTHERMORE, THIS ALLOWS PRIVATE NETWORKS TO CHANGE THEIR INTERNAL ADDRESSING SCHEME WITHOUT PUTTING A HARDSHIP ON THEIR CORRESPONDENTS.

BUT NOTHING PREVENTS PRIVATE NETWORKS TO USE PART OF THE MESSAGE TEXT TO IMPLEMENT ANY KIND OF WAY OUT ADDRESSING PLAN.


## E - ADDRESS FORMAT
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SOME SPECIFIC SIZES MUST BE PROPOSED FOR THE FIELDS OF AN ADDRESS, IN ORDER TO VISUALIZE WHAT THIS SCHEME MIGHT TURN OUT.

SINCE ADDRESSES MAY HAVE TO BE COMPOSED FROM KEYBOARDS OR PANELS, AND ARE LIKELY TO BE DISPLAYED ON DIAGNOSTIC EQUIPMENT, IT APPEARS CONVENIENT TO BE ABLE TO USE DIGITS, DECIMAL OR POSSIBLY HEXA. OF COURSE A CONVERSION LOGIC MIGHT WELL TRANSLATE INTERNAL FORMATS INTO HUMAN READABLE ONES, AND VICE VERSA, BUT IF IT HAPPENS NOT TO WASTE ANY SIGNIFICANT BANDWIDTH, IT IS PROBABLY SIMPLER TO KEEP INTERNAL FORMATS AS READABLE AS POSSIBLE.

FIELDS COULD BE AS FOLLOWING :

- FORMAT (1 DIGIT)
  ......
    = 0   LOCAL PSN ADDRESS
    = 1   1-DIGIT GLOBAL NAME
    = 2   2-DIGIT   ..    ..
    = 3   3-DIGIT   ..    ..
    = 4-F   RESERVED FOR FUTURE USE

- GLOBAL NAME (1-3 DIGITS)
  ..........
    = 1-9     VERY LARGE COMMON CARRIER OR PTT  NETWORK,  (CONTINENTAL)
    = A-F      ..    ..      WELL KNOWN NETWORK
    = 10-99  COMMON CARRIER OR PTT NATIONAL NETWORK
    = AO-FF   WELL KNOWN INTERNATIONAL NETWORK
    = 100-FFF   RESERVED FOR FUTURE USE

- LOCAL NAME (1-10 DIGITS)
  ..........
    NO PARTICULAR STANDARD IS IMPOSED, AS  IT  RELATES  TO  LOCAL  PSN
CHARACTERISTICS.  HOWEVER, IT WOULD PROBABLY BE CONVENIENT  TO  ALLOCATE
NAMES ALONG THE PRECEDING LINES.  SEE E.G. (1).

    TO SUM UP, THE ADDRESS SIZE WOULD BE 3  TO  14  DIGITS,  DEPENDING
MAINLY ON LOCAL NAME FORMAT.  EXCEPT  FOR  THE  DESTINATION  PSN,  OTHER
NETWORKS WOULD ONLY BE CONCERNED WITH FORMAT AND GLOBAL NAME,  I.E.  2-4
DIGITS.  THIS SHOULD BE QUITE ECONOMICAL.


    F - REMARKS
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    THIS QUESTION OF NUMBERING PLAN HAS BEEN ANALYZED IN  THE  CONTEXT
OF PACKET SWITCHING.  ACTUALLY  IT  APPLIES  VERBATIM  TO  ANY  TYPE  OF
DATA TRANSMISSION NETWORK.  IN THE  CASE  OF  A  (VIRTUAL  OR  PHYSICAL)
CIRCUIT-MINDED NETWORK, THE SETTING UP OF A  CALL  IMPLIES  THE  ROUTING
OF ONE OR SEVERAL INITIAL MESSAGES, BASED ON SOME  GENERALLY  UNDERSTOOD
ADDRESSING PLAN.  ONLY AFTER THIS  INITIAL  OPERATION  CAN  MESSAGES  BE
ROUTED IN REFERENCE TO  AN  ESTABLISHED  CIRCUIT,  INSTEAD  OF  A  FULL
DESTINATION  ADDRESS.    THEREFORE,  THE  ISSUE  OF  AN  INTERNATIONAL
ADDRESSING PLAN COULD BE STUDIED QUITE INDEPENDENTLY OF THE TRANSMISSION
TECHNIQUES, AND INTERFACE PROBLEMS.


9 - PACKET IDENTIFICATION
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    IN ORDER  TO  INSURE  MESSAGE  TRANSFER  RELIABILITY  SOME  NAMING
SCHEME  IS  REQUIRED  TO  IDENTIFY  INDIVIDUALLY  EACH  MESSAGE  BETWEEN
SOURCE AND DESTINATION.  THIS IS THE  ONLY  PRACTICAL  WAY  TO  PINPOINT
LOST OR DUPLICATE MESSAGES, (2).  NO MATTER HOW  RELIABLE  EACH  NETWORK
AUTHORITY WILL CLAIM TO BE,  IT  SHOULD  BE  EXPECTED  THAT  END  USERS
WILL RELY PRIMARILY ON THEIR OWN  ERROR  CONTROL  MACHINERY  WHEN  USING

CATENET SERVICES. CONSEQUENTLY THEY WILL HAVE TO RESERVE A NAME FIELD WITHIN EACH MESSAGE. THIS IS TYPICALLY WHAT IS CALLED A SEQUENCE NUMBER IN CONVENTIONAL TRANSMISSION PROCEDURES.

FURTHERMORE, OCCASIONALLY THERE WILL BE SOME ARGUMENTS BETWEEN NETWORKS AND USERS ABOUT WEIRD TRAFFIC BEHAVIOR. TROUBLE TRACING REQUIRES COMBING THROUGH HEAPS OF MESSAGE SNAPSHOTS WHICH ARE SUPPOSED TO MATCH. SOURCE AND DESTINATION ARE USUALLY INSUFFICIENT INFORMATION FOR THEY ARE ALL THE SAME. MESSAGE CONTENTS IS USEFUL FOR DETAILED ANALYSIS, AFTER DISCREPANCIES HAVE BEEN UNCOVERED, SO AS TO ZERO IN QUICKLY ON RELEVANT SAMPLINGS A MESSAGE IDENTIFIER IS NECESSARY. IT DOES NOT HAVE TO BE UNIQUE NETWORK-WIDE AS LONG AS THERE IS A SUFFICIENTLY LOW PROBABILITY TO FIND THE SAME IN A DIFFERENT MESSAGE. IF THEY OCCUR, AMBIGUITIES ARE RESOLVED BY LOOKING AT OTHER PARTS OF THE MESSAGES. IN AN OTHER DOMAIN THIS WOULD BE CALLED AN AUDIT TRAIL

SINCE AN IDENTIFIER IS NECESSARY TO RELATE USER AND NETWORK INVESTIGATIONS, IT MUST BE PLACED IN A DEFINITE POSITION WITHIN A MESSAGE. HENCE IT IS UNDESIRABLE TO CONSIDER IT AS PART OF THE TEXT, SINCE PSN'S SHOULD LOOK AT MESSAGE TEXT AS A SEALED ENVELOP, POSSIBLY ENCRYPTED.

IF THIS IDENTIFIER WERE TOO SHORT, FALSE MATCHES WOULD OCCUR QUITE OFTEN. EVERYONE'S REQUIREMENTS BEING ABOUT THE SAME, A VARIABLE LENGTH DOES NOT APPEAR JUSTIFIED.

A 12 TO 16-BIT FIELD SHOULD BE A REASONABLE FIGURE.


10 - CONTROL FUNCTIONS
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SO FAR IT LOOKS LIKE PSN'S TEND TO IMPLEMENT SOME SIMILAR FUNCTIONS SUCH AS: TRACE, ECHO. IT MAY BE SOMEWHAT EARLY TO DETERMINE COMMON FUNCTIONS EXTENDING ACROSS BORDERS, UNTIL MORE EXPERIENCE HAS BEEN GAINED IN INTERCONNECTION. BUT IT IS WITHOUT QUESTION THAT EVERY PSN WILL NEED SOME FIELD FOR PACKING A FEW CONTROL BITS. RATHER THAN HAVING TO REFORMAT AND STRIP OFF A MESSAGE WITHIN EACH GATEWAY, IT IS MORE EFFICIENT TO ASSIGN A SPECIFIC FIELD TO CONTROL BITS, EVEN THOUGH THEIR MEANING MAY VARY ACROSS PSN'S.

SUGGESTIONS FOR USING THESE BITS MIGHT BE AS FOLLOWS :

. 1 BIT. TRACE MESSAGES ARE SENT TO A PSN CONTROL CENTER, WHEN A TRACED MESSAGE PASSES THROUGH SOME NODES IN MONITORING STATE.

. 1 BIT. ECHO MESSAGES ARE SENT BACK TO THE SOURCE WHENEVER A MESSAGE CROSSES A PSN BOUNDARY, I.E. LEAVES OR ENTERS A GATEWAY.

. 3 BITS. MESSAGE CLASS, WHATEVER THAT MEANS.

. 3 BITS. RESERVED FOR INTERNAL PSN USE.

IT COMES TO A TOTAL OF 8 BITS.


## 11 - ACCOUNTING

CHARGING ITS OWN SUBSCRIBERS IS A MATTER THAT SHOULD BE LEFT
ENTIRELY IN THE HANDS OF EACH PSN. ON THE OTHER HAND, TRANS-NETWORK
TRAFFIC MUST BE CHARGED TO SOMEONE.

A SOLUTION WOULD BE TO RECORD IN EACH PSN EACH SOURCE-DESTINATION
PAIR TRAFFIC, AND PERIODICALLY SEND THE BILL TO A WORLD-WIDE CLEARING-
HOUSE. THE AMOUNT OF INFORMATION TO BE RECORDED WOULD BE MASSIVE,
AND HANDLING UNTRUSTWORTHY SUBSCRIBERS WOULD BE CUMBERSOME. AS A WHOLE
THIS APPROACH IS NOT TOO REALISTIC.

A MORE ATTRACTIVE METHOD, SIMILAR TO TELEPHONE PRACTICES, WOULD BE
AS FOLLOWS :

EACH PSN CHARGES ITS TRAFFIC COST TO THE NEIGHBOR PSN WHICH
PASSED A MESSAGE, REGARDLESS OF END ADDRESSES. SINCE A PSN IS NOT
TO HAVE MORE THAN A FEW DOZENS OF NEIGHBORS, THE NUMBER OF ACCOUNTS
STAYS WITHIN REASONABLE LIMITS. FURTHERMORE PSN'S ARE MORE LIKELY
TO BE TRUSTWORTHY CUSTOMERS THAN INDIVIDUAL SUBSCRIBERS.

ON THIS WAY COSTS WOULD ACCUMULATE BACK TO THE ORIGINAL PSN
SENDER. BUT HOW THEY ARE TO BE SHARED BETWEEN SOURCE AND DESTINATION
SUBSCRIBER IS UP TO THE ORIGINAL PSN.

IT WOULD BE UNREALISTIC TO RECORD ACCOUNTING INFORMATION SO
THAT EVERY MESSAGE COST BE SPLIT BETWEEN SOURCE AND DESTINATION.
THE ONLY PRACTICAL WAY SEEMS TO APPLY A FIXED COST PER MESSAGE.
IT CAN BE ADJUSTED DEPENDING ON DESTINATION PSN, MESSAGE CLASS, TIME,
REQUESTED SERVICES SUCH AS ECHO, ETC... AS LONG AS IT IS SIMPLE
ENOUGH TO BE EVALUATED BY GATEWAYS, WHENEVER A MESSAGE COMES IN.

TAKING INTO ACCOUNT EVERY TARIFF GIMMICK THAT A MESSAGE IS
TO ENCOUNTER ON ITS WAY WOULD BE VERY DIFFICULT TO IMPLEMENT IN THE
ORIGINAL PSN, SPECIALLY IF ROUTING IS ADAPTIVE. THEREFORE SOME
AVERAGING IS PRESUMABLY ACCEPTABLE, BASED ON PAST OR PROJECTED
TRAFFIC FIGURES.

HOWEVER THERE MAY BE SOME DISAGREEMENT ABOUT AVERAGING, AND
SOME SUBSCRIBERS MAY WANT TO RECORD EXACT FIGURES IN ORDER TO CREATE
THEIR OWN ACCOUNTING. IF THIS MUST BE IMPLEMENTED, A WAY IS TO
ACCUMULATE COST FORWARDS, AND STORE IT INTO A SPECIFIC FIELD OF THE
MESSAGE ITSELF. AT THE END OF THE TRIP, THIS FIELD CAN EITHER BE
DELIVERED TO THE DESTINATION SUBSCRIBER, OR SENT AS A SHORT MESSAGE
BACK TO THE SOURCE. A HIGHER TARIFF MIGHT BE APPLIED TO COMPENSATE
FOR THE EXTRA BURDEN PUT ON CATENET.

ANOTHER GIMMICK IS FIXED ROUTING.    THIS NEED MAY RESULT FROM SIGNIFICANT DIFFERENCES IN PSN TARIFF STRUCTURES, OR RELIABILITY. SOME TENSIONS MAY DEVELOP BETWEEN CERTAIN COUNTRIES, WITH THE RESULT THAT ONE OR BOTH PROHIBIT CARRYING MESSAGES TO THE OTHER.   THEREFORE EACH MESSAGE WOULD HAVE TO BE ROUTED IN ACCORDANCE WITH A PREDEFINED PATH.

BUT IT WOULD BE COSTLY AND SOMEWHAT UNMANAGEABLE TO MAINTAIN CUSTOM TAILORED ROUTING TABLES WITHIN EACH PSN, ALL THE MORE THAT THEY MAY BE SCARCELY USED. ANOTHER WAY IS TO PUT THE REQUESTED PATH WITHIN EACH MESSAGE. THE COST IS AS MANY BITS AS NEEDED TO LIST THE GLOBAL NAMES OF THE TRAVERSED PSN'S.    OF COURSE THIS REQUIRES THAT SUBSCRIBERS BE SOMEHOW AWARE OF NETWORK TOPOLOGIES.

IN ORDER TO DIFFERENTIATE BETWEEN POSSIBLE ACCOUNTING OPTIONS, SOME BITS ARE NECESSARY.   IN CASE THE MESSAGE CLASS FIELD IS TOO SMALL (SEE CHAPTER 10), ANOTHER 4-BIT FIELD MIGHT BE ADDED.

ON THE OTHER HAND, IF ROUTING OR ACCOUNTING REQUIRE ADDITIONAL SPACE FOR EXERCISING SOME OPTIONS, THIS SHOULD BE TAKEN OUT OF THE MAXIMUM TEXT SIZE. THE REASON FOR THAT IS TO AVOID INCREASING THE MAXIMUM MESSAGE SIZE JUST FOR THE SAKE OF A MINORITY GROUP.

## 12 - CHECKSUMS

MOST SYNCHRONOUS TRANSMISSION I-O ADAPTERS USE A CRC TO INSURE MESSAGE INTEGRITY OVER COMMUNICATION EQUIPMENT.   THIS RESULTS IN A BIT FIELD ADDED TO THE END OF A MESSAGE LEAVING A NODE, AND STRIPPED OFF ON RECEPTION BY THE NEXT NODE.

PRESUMABLY THIS SORT OF BIT ERROR CONTROL IS DESIRABLE BETWEEN OPPOSITE GATEWAYS. BUT THIS DOES NOT INTRODUCE FURTHER IMPLICATIONS AT CATENET LEVEL. IT IS ONE OF THE BOUNDARY PROBLEMS WHICH WILL BE EXAMINED LATER ON.

END-TO-END CHECKSUMMING APPEARS DESIRABLE TO PROTECT MESSAGES AGAINST ANY POTENTIAL TROUBLE MAKER, INCLUDING PSN MACHINERY.    SPECIAL HARDWARE WOULD HELP IN MAKING CRC GENERATION AND VERIFICATION MORE EFFICIENT THAN SOFTWARE SCHEMES. BUT IT MAY TAKE SOME TIME BEFORE THIS BECOMES CASUAL PRACTICE.    THEREFORE, END TO END CHECKSUMMING IS NOT PRECLUDED, BUT IT COULD BE CONSIDERED AS SUBSCRIBER CONVENTION USING PART OF THE MESSAGE TEXT.

IN VIEW OF A FUTURE STANDARDIZATION, IT COULD BE RECOMMENDED TO LOCATE END-TO-END CHECKSUMS AT THE END OF THE MESSAGE TEXT.    THE SUGGESTED POLYNOMIAL COULD BE THE PRESENT ISO STANDARD.

## 13 - MESSAGE LENGTH

THIS TOPIC HAS ALREADY BEEN DISCUSSED IN (3). THE CONCLUSION IS IN FAVOR OF A LENGTH INDICATOR FOR THE TEXT FIELD ONLY. IT CAN BE EXPRESSED AS AN 8-BIT FIELD GIVING A MAXIMUM TEXT LENGTH OF 255 OCTETS. THIS MESSAGE SIZE IS SLIGHTLY LONGER THAN EXISTING PACKET SIZES, SO THAT NO FURTHER FRAGMENTATION WOULD BE NECESSARY. ON THE OTHER HAND IT IS REASONABLY EFFICIENT IN TERMS OF BANDWITH AND TRANSIT TIME. ANYHOW, NOTHING PREVENTS SUBSCRIBERS TO DISPATCH SHORTER MESSAGES IF THEY REALLY WANT SHORTER TRANSIT DELAYS.

## 14 - HEADER FORMAT

HEADERS WILL HAVE VARIABLE LENGTH. ALTHOUGH IT WOULD BE POSSIBLE TO PARSE MESSAGES TO FIND WHERE TEXT STARTS, IT CERTAINLY WOULD SAVE A SUBSTANTIAL AMOUNT OF OVERHEAD IF HEADERS CAN BE READILY ISOLATED. TO THAT EFFECT, A HEADER LENGTH FIELD SHOULD BE PROVIDED, INDICATING THE TOTAL NUMBER OF OCTETS PRECEDING THE TEXT FIELD. THE MAXIMUM HEADER LENGTH EXCEEDS 16 OCTETS, AS WILL BE SEEN. BUT IT IS SUFFICIENT TO TAKE THE NUMBER OF OCTETS IN EXCESS OF THE MINIMUM HEADER LENGTH. THIS REDUCES THE FIELD TO 4 BITS.

FURTHERMORE, IT IS NOT UNUSUAL THAT NEW FORMATS BE INTRODUCED DUE TO UNANTICIPATED NEEDS. AS A RESULT, AT SOME FUTURE TIME, CATENET MAY HAVE TO DEAL WITH A FEW HEADER FORMATS. FOR THE SAME REASON AS BEFORE, A FORMAT FIELD WOULD SIMPLIFY FORMAT PARSING.

SUMMING UP ALL PREVIOUS REQUIREMENTS YIELDS THE FOLLOWING:

| | | | |
|---|---|---|---|
| . HEADER TYPE | 2 | | 2 BITS |
| . HEADER LENGTH (MINUS 8 OCTETS) | 4 | | 4 |
| . TEXT LENGTH | 8 | | 8 |
| . CONTROL | 8 | | 8 |
| . ACCOUNTING | 4 | | 4 |
| . PACKET IDENTIFICATION | 10 | TO | 16 |
| . DESTINATION FORMAT | 4 | | 4 |
| . DESTINATION GLOBAL NAME | 4 | TO | 12 |
| . SOURCE FORMAT | 4 | | 4 |
| . SOURCE GLOBAL NAME | 4 | TO | 12 |
| . DESTINATION LOCAL NAME | 4 | TO | 40 |
| . SOURCE LOCAL NAME | 4 | TO | 40 |
| | --- | | --- |
| TOTAL | 60 | TO | 154 BITS |
| I.E. | 8 | TO | 20 OCTETS |

SINCE HOSTS WILL HAVE DIFFERENT WORD LENGTH, IT IS NOT SUPERFLUOUS TO REDUCE FORMATTING OVERHEAD IN TRYING TO MATCH SOMEHOW HEADER AND WORD LENGTH. IN THAT RESPECT, SOME INTERESTING HEADER LENGTHS WOULD BE:

```
.  72 =  9 OCTETS, MULTIPLE OF 6 8 12     18 24    36
.  96 = 12    ..          ..     6 8 12 16    24 32
. 120 = 15    ..          ..     6 8 12       24        60
. 128 = 16    ..          ..       8    16       32
. 144 = 18    ..          ..     6 8 12 16 18 24    36
```

THEREFORE, RECOMMENDED SIZES COULD BE 9, 12, 15, 18 OCTETS. BUT THIS IS JUST FOR HOST CONVENIENCE, AND HAS NO EFFECT ON CATENET WORKINGS.

A SUGGESTED HEADER FORMAT IS ON FIG. 3. IT IS BASED ON THE FOLLOWING LINES :

. FIXED SIZE FIELDS ARE AT THE BEGINNING, TO REDUCE PARSING OVERHEAD.

. FIELDS FIT IN 8- OR 16-BIT WORD BOUNDARIES, SINCE SWITCHING NODES ARE LIKELY TO BE THAT KIND OF COMPUTERS.

. FORMAT INFORMATION IS LOCATED AT THE BEGINNING IN ORDER TO DIRECT PARSING MORE EASILY IN CASE OF MULTIPLE FORMATS.

. CONTROL INFORMATION IS GATHERED IN ONE FIELD, IN ORDER TO FACILITATE A REDEFINITION OF ITS COMPONENTS, IF AT ALL NECESSARY.

. GLOBAL ADDRESSES ARE PUT TOGETHER BEFORE LOCAL ADDRESSES, BECAUSE THE FORMER ARE CATENET STANDARDS, WHILE THE LATTER CONCERN ONLY END NETWORKS. ON THIS WAY GLOBAL ADDRESSES MAY BE IDENTIFIED EASILY WITHOUT KNOWING ABOUT LOCAL NAMING SCHEMES. FURTHERMORE, BY MUTUAL AGREEMENT BETWEEN CORRESPONDENTS, LOCAL ADDRESSES MAY EXTEND INTO THE TEXT FIELD WITHOUT REQUIRING ANY PRIOR CATENET ARRANGEMENT. THIS IS PARTICULARLY USEFUL FOR NETWORK HOSTS, OR SIMPLY MULTIPLE SUBSCRIBERS HOSTS, WHICH NEED TO APPEND SOME INTRINSIC ADDRESSES TO LOCATE THE FINAL RECIPIENT OF A MESSAGE.

. DESTINATION PRECEDES SOURCE, AS IT WILL LIKELY BE PROCESSED MORE OFTEN IN THE SWITCHING MACHINERY.

```
RESERVED FOR LOCAL PSN        2 BITS           XX
HEADER TYPE                   2                 **
HEADER LENGTH (=8 OCTETS)     4                 ****
TEXT LENGTH (OCTETS)          8                 ********

LOCAL PSN CONTROL             3                 XXX
ECHO                          1                 *
TRACE                         1                 *
MESSAGE CLASS                 3                 ***
RESERVED FOR FUTURE USE       4                     0000
ACCOUNTING                    4                        ****
MESSAGE IDENTIFICATION        16                ****************

GLOBAL DESTIN FORMAT          4                 ****
   ..          ADDRESS        4-12              ************
   ..     SOURCE FORMAT       4                 ****
   ..        ..   ADDRESS     4-12              ************

LOCAL DESTIN ADDRESS          4-40
   ..    SOURCE   ..          4-40
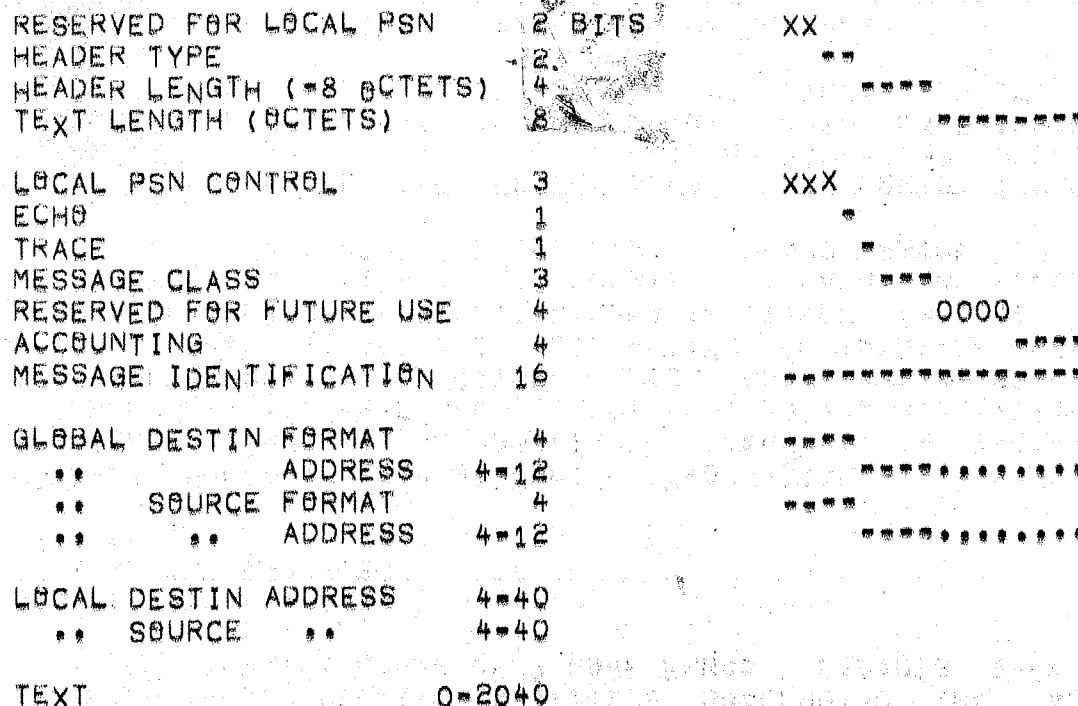
TEXT                          0-2040
```

FIG. 3 - MESSAGE FORMAT

THE HEADER FORMAT PROPOSED HERE MIGHT SEEM BULKY. BUT IT IS NOT SO MUCH AFTER ALL. WITH TYPICAL 12-BIT PSN NAMES (2 DIGITS + FORMAT) THE FIRST 9 OCTETS ARE ALL THAT IS NECESSARY TO ROUTE A MESSAGE ACROSS CATENET. THIS ALSO HAPPENS TO BE A RECOMMENDED SIZE. THE REST OF THE HEADER IS ACTUALLY DEVOTED TO THE USER (HOST, SUBSCRIBER). IT CAN CONTAIN PORT OR PROCESS NAMES WHICH MUST BE TRANSMITTED ANYWAY. WITH THE PRESENT SCHEME USERS CAN TAKE ADVANTAGE OF THE HEADER FORMAT FLEXIBILITY TO MAKE TEXT LENGTH ALMOST FIXED, RATHER THAN CHOP IT DOWN FOR INTERNAL ADDRESSING NEEDS. THIS WOULD HELP COMPATIBILITY BETWEEN NETWORK APPLICATIONS AND SERVICES.

15 - SIGNALING

SO FAR SIGNALING HAS NOT BEEN ADDRESSED EXPLICITLY EXCEPT PERHAPS BY MEANS OF THE CONTROL FIELD. BUT THIS IS QUITE RESTRICTIVE, SINCE IT DOES NOT CARRY MUCH INFORMATION. ON THE OTHER HAND THE INTER-CONNECTION APPROACH ADVOCATED HERE LEAVES COMPLETE AUTONOMY IN IMPLEMENTING EACH PSN, SO THAT NO PARTICULAR SIGNALING APPEARS NECESSARY ANYWAY. BUT THIS MAY BE A PREMATURE CONCLUSION DUE TO THE LACK OF EXPERIENCE.

IT MAY HAPPEN THAT SOME SPECIFIC INFORMATION WILL HAVE TO BE EXCHANGED BETWEEN PSN'S, RELATED OR NOT TO A PARTICULAR SUBSCRIBER MESSAGE. SOME OF IT MAY REQUIRE CATENET STANDARDS, OR JUST MUTUAL AGREEMENT BETWEEN DIRECTLY CONNECTED PSN'S. NOT ENOUGH EXPERIENCE

IS AVAILABLE TO BRING UP ANY MEANINGFUL PROPOSAL.

NEVERTHELESS, STEPS SHOULD BE TAKEN SO THAT SIGNALING BE INTRODUCED GRADUALLY, IF NECESSARY, WITH EXPERIENCE BEING GAINED. A WAY TO DO JUST THAT IS TO CONSIDER SIGNALING MESSAGES AS REGULAR TRAFFIC SENT TO SPECIAL DESTINATIONS WITHIN PSN'S, INSTEAD OF OUTSIDE.

IN OTHER WORDS, PART OF THE ADDRESS SPACE IN EACH PSN WOULD BE RESERVED FOR INTERNAL COMPONENTS INVOLVED IN SINALING PROCESSING. THIS TECHNIQUE SYSTEMATICALLY USED IN CIGALE (4) IS HIGHLY FLEXIBLE, SINCE IT DOES NOT REQUIRE ANTICIPATING ALL POSSIBLE NEEDS. FURTHERMORE, THE ADDRESS SPACE IS LARGE ENOUGH SO THAT A SUFFICIENT CHUNK BE RESERVED FOR INTERNAL USE WITHOUT PUTTING ANY RESTRICTION ON SUBSCRIBER SERVICES. FINALLY, NO ADDITIONAL OVERHEAD IS INCURRRED IN MESSAGE SIZE OR PROCESSING FOR SIGNALING INFORMATION.

16 - ERROR MESSAGES
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CUSTOMARILY PSN'S SEND SOME ERROR MESSAGES BACK TO THE SOURCE WHENEVER THEY RECOGNIZE CONDITIONS PRECLUDING THE CORRECT FORWARDING OF A REGULAR MESSAGE.

EVEN IN THE CASE OF A SINGLE PSN, IT IS NOT CLEAR WHETHER THIS PRACTICE IS ACTUALLY USEFUL. THIS IS EVEN MORE DEBATABLE IN CATENET, AS IT COULD RAISE A TARIFF QUESTION ABOUT WHOM SHOULD BE CHARGED FOR DIAGNOSTICS TRAFFIC. FURTHERMORE, SOME PRECAUTIONS ARE NECESSARY SO THAT SUCCESSIVE FAILURES DO NOT WIND UP IN PRIMING A MESSAGE EXPLOSION. FINALLY, SOME STANDARDIZATION WOULD BE MANDATORY IF THEY ARE TO BE ANY USEFUL FOR END RECIPIENTS.

CONSEQUENTLY, IT IS SUGGESTED THAT DIAGNOSTICS MESSAGES BE CONFINED WITHIN EACH PSN. THEIR PROPAGATION THROUGH CATENET SHOULD NOT BE ALLOWED UNTIL RECOGNIZED NECESSARY BY EXPERIENCE.

17 - PSN INTERFACE
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COMMUNICATIONS BETWEEN CATENET PSN'S REQUIRE SOME COMMON AGREEMENT. AS LONG AS THE TECHNIQUE USED IS TRANSPARENT TO MESSAGE CONTENTS, NO CATENET STANDARD IS REQUIRED. ONLY MUTUAL AGREEMENT BETWEEN NEIGHBOR PSN'S IS NECESSARY. THEY CAN USE ANY TRANSMISSION PROCEDURE SUITABLE FOR THE DATA LINKS AT HAND. ACTUALLY EACH DATA LINK MAY BE CONTROLLED BY A SEPARATE PROCEDURE, DEPENDING ON LOCAL AGREEMENT AND LINK NATURE (HALF-, FULL-DUPLEX, SATELLITE, OPTICAL, ETC...)

SO AS TO SAVE ON DISCUSSIONS AND INVESTMENT, IT WILL PROBABLY BE ADVISABLE TO STANDARDIZE A FEW GOOD PROCEDURES. BUT THIS IS NOT A PREREQUISITE IN CATENET CONSTRUCTION.

18 - CONCLUSIONS

        THIS STUDY ATTEMPTS TO PUT FORWARD A REALISTIC SCHEME ALLOWING POINT TO POINT MESSAGE TRANSFER ACROSS SEVERAL INDEPENDENT PACKET SWITCHING NETWORKS.   AS CAN BE EXPECTED, THIS REQUIRES A COMMON AGREEMENT IN FORMATTING MESSAGES, BUT CONSTRAINTS ARE MINIMIZED WHILE PRESERVING IMPLEMENTATION FREEDOM AND EFFICIENCY.

        THE PROPOSED MESSAGE FORMAT SHOULD MAKE UNNECESSARY AN INTERNAL REFORMATTING OR WRAPPING AROUND, WITHOUT RESORTING TO EXOTIC FEATURES, SO THAT INTERNAL AND TRANS-NETWORK TRAFFIC COULD BE HANDLED BY THE SAME SIMPLE SWITCHING MACHINERY.

19 - REFERENCES

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4 - GRANGE J L, POUZIN L - CIGALE, LA MACHINE DE COMMUTATION DE PAQUETS
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