RC NET

general information

RCNET
General Information

A/S Regnecentralen
Marketing Department

Second Edition
September 1977
RCSL 43 - Ri 0635

Author: Erik Lilholt
Text Editor: Mare Sergo

KEY WORDS: RC 8000, RC 3600, RC 3500, Computer Network, Communication

ABSTRACT: This manual describes in an introductory manner the concepts and facilities of the computer network RCNET.

Printed by A/S Regnecentralen, Copenhagen

Table of Contents

INTRODUCTION page 7

1 RCNET OVERVIEW 9
1.1 Main Structure 9
1.2 The Packet Switch 10
1.2.1 Nodes 10
1.2.2 Communication Lines 10
1.2.3 Regions 11
1.2.4 Connection of Networks 12
1.3 Hosts 12
1.3.1 RCNET Packet Transporter 14
1.3.2 RCNET Message Transporter 15
1.3.3 Network Interface Implementation 15
1.3.3.1 RC 8000 Network Interface 15
1.3.3.2 Foreign Computer Network Interface 16
1.3.4 External and Internal Hosts 16
1.3.4.1 External Host 16
1.3.4.2 Internal Host 16
1.4 Summary 16

2 RCNET COMPONENTS 18
2.1 Hardware Components 18
2.1.1 RC 8000 18
2.1.2 RC 3600 18
2.1.3 RC 3500 19
2.1.4 Datapoint 19
2.2 Software Components 19
2.2.1 RC 8000 Software Components 19
2.2.1.1 Link Driver 19
2.2.1.2 Front End Driver 19
2.2.2 RC 3600 Software Components 20
2.2.2.1 The Network Control Program 20
2.2.2.2 The Router Module 20
2.2.2.3 The HDLC Module 20

2.3 Functional Components page 20

2.3.1 Device Controller 20

2.3.2 Node 22

3 RCNET PACKET SWITCH 23

3.1 Network Topology 23

3.1.1 Nodes and Communication Lines 23

3.1.2 Alternate Paths 24

3.1.3 Regions 25

3.1.4 Region Identification 26

3.1.5 Node Identification 26

3.2 Hosts 26

3.2.1 Host Identification 27

3.2.2 Host Attributes 27

3.2.2.1 HOME-REGION 28

3.2.2.2 CURRENT-REGION 28

3.2.2.3 CURRENT-NODE 28

3.3 Packet Format 29

3.3.1 Format of the Packet Header 29

3.3.2 Content of the Packet Header 30

3.3.2.1 FORMAT 30

3.3.2.2 PACKET TEXT LENGTH 30

3.3.2.3 PACKET HEADER LENGTH 30

3.3.2.4 USER HEADER LENGTH 30

3.3.2.5 STATE 30

3.3.2.6 PRIORITY 30

3.3.2.7 RECEIVER CURRENT-REGION 30

3.3.2.8 RECEIVER CURRENT-NODE 30

3.3.2.9 SENDER CURRENT-REGION 30

3.3.2.10 SENDER CURRENT-NODE 30

3.3.2.11 RECEIVER NET-ID 30

3.3.2.12 SENDER NET-ID 31

3.3.2.13 RECEIVER HOME-REGION 31

3.3.2.14 SENDER HOME-REGION 31

3.3.2.15 RECEIVER HOST-ID 31

3.3.2.16 SENDER HOST-ID 31

3.3.2.17 FACILITY MASK 31

3.3.2.18 IDENTIFICATION 31

3.3.3 The Packet Text 31

4 RCNET PACKET TRANSPORTER page 33
4.1 Position in the Network Protocols 33
4.2 Method of Control 33
4.3 Pipelines 34

5 RCNET MESSAGE TRANSPORTER 37
5.1 Position in the Network Protocols 37
5.2 Method of Control 38
5.3 Relations to Pipelines 39

6 RCNET DEVICE CONTROL PROTOCOL 40
6.1 Links 40
6.2 Device Specification 40
6.3 Master - Slave Relation 41

7 RCNET EXAMPLES 42
7.1 RC 8000 Access to Devices 42
7.2 Foreign Computer Access to RCNET 42
7.3 Back-up Facilities 43

8 RCNET VOCABULARY 45

References

1 Data Communications
High Level Data Link Control Procedures
Elements of Procedures
ISO/TC 97/SC 6. 1005 with amendments.

2 RCSL 43 - Ri 0174
Erik Lilholt:
RCNET - Device Control Protocol (Reference Manual)

3 RCSL 43 - Ri 0610
Herbert L. Jessen:
RCNET - Introduction to Networks

Introduction

RCNET is a computer network developed and marketed by Regnecentralen.

RCNET offers a general transportation service based on packet switching technology.

RCNET offers standard modules for interfacing the network to user programs executed on RC computers and for interfacing to RC marketed peripheral equipment. The modules allow standard access methods to be utilized by user programs when communicating through RCNET.

RCNET offers standard methods for adding user-defined interfaces to other computers.

The information in this manual is intended to give a reader, familiar with general network principles, a knowledge of the structure of RCNET, the concepts laid down in the design and the terminology used.

The manual does not contain sufficient detail to allow it to be used as a reference manual. For an introduction to general network principles and for an explanation of terms often met in the literature (and therefore assumed well-known in this manual), refer to [3].

Finally note that with the publication of this manual the earlier published "RCNET - General Description", by Ole Krag Hansen, RCSL 31-D372, is no longer valid.

1 RCNET Overview

This section gives a summary description of RCNET.

At this stage it may provide the reader with enough information to allow him to omit the rest of the manual, yet having given him an impression of RCNET capabilities.

Later chapters contain more detailed explanations of the concepts presented.

1.1 Main Structure

Basically RCNET is divided into a Packet Switch and attached hosts.

The Packet Transporter and the Message Transporter are two protocols offered by RCNET for the exchange of information between hosts.

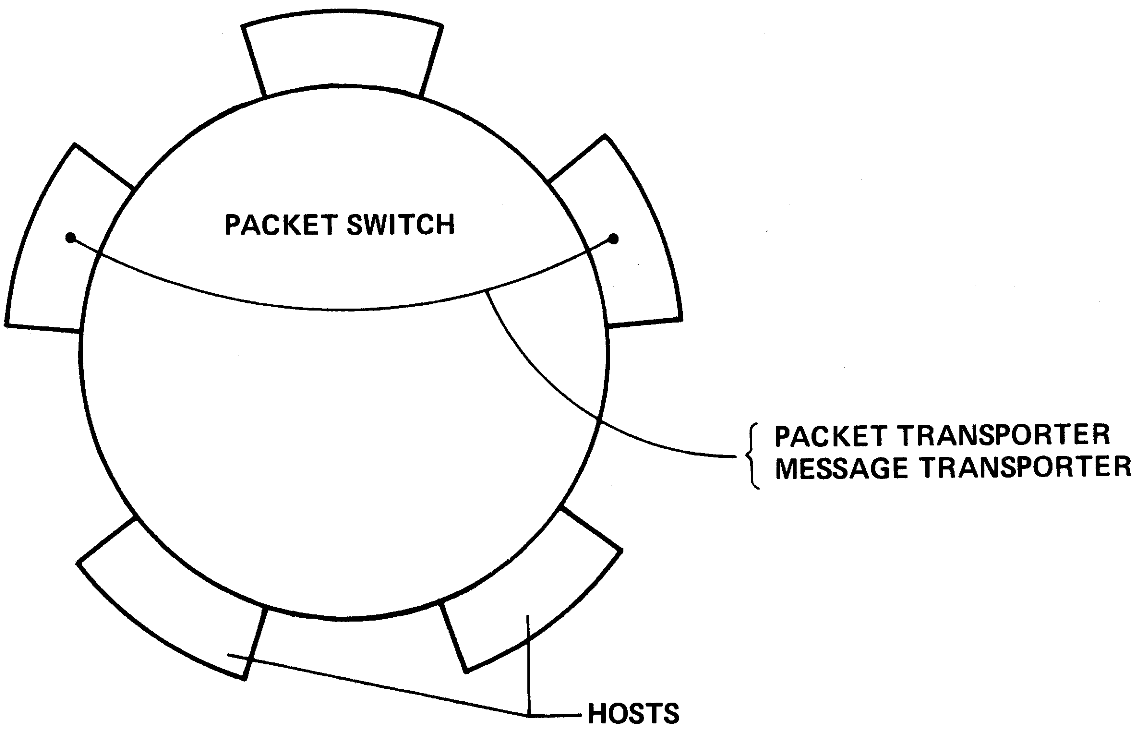


Figure 1.1. RCNET structure.

1.2 The Packet Switch

The RCNET Packet Switch functions as a self-contained packet switching network offering the basic transportation service needed in a computer network.

The Packet Switch is made up of nodes, in the form of RC 3600 or RC 3500 minicomputers.

The addressable unit of the Packet Switch is a host. Each host is assigned a unique identification, the HOST-ID.

1.2.1 Nodes

The main function of the Packet Switch nodes is to keep track of the hosts currently connected and their locations in the network.

The Packet Switch accepts packets from the connected hosts. Part of the packet contains the HOST-ID of the host to which the packet is sent.

Based on the routing algorithm implemented in the Packet Switch, the packet is forwarded from node to node until it reaches a node to which the receiving host is connected.

The routing algorithm is based on routing tables maintained in the nodes and a strategy for updating these tables. This strategy may range from no changes of the routing tables (fixed routing) through changes due to network reconfigurations (node or line failure) to dynamic changes taking into account line load and queuing estimates.

1.2.2 Communication Lines

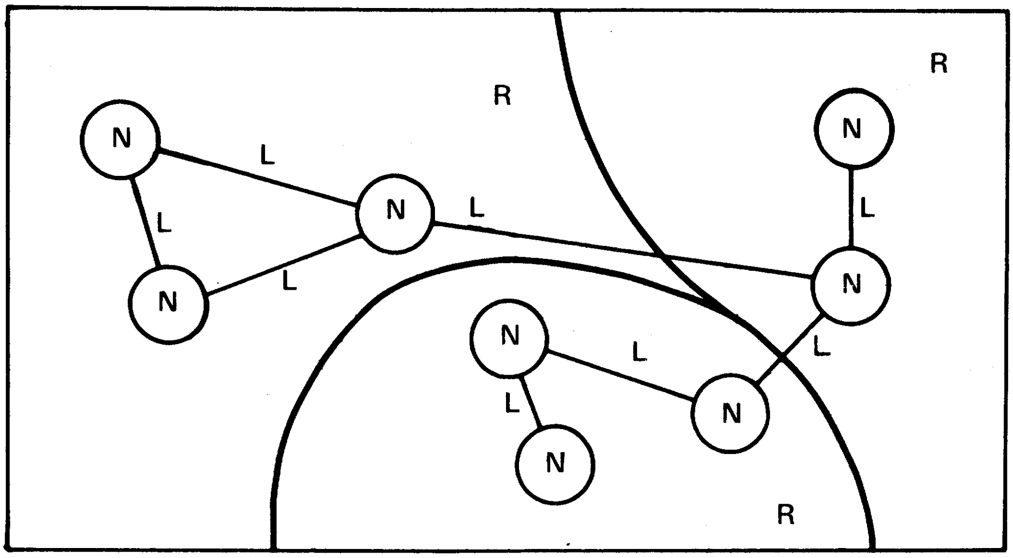
The nodes are connected by means of communication lines. The protocol adopted by RCNET for synchronous lines is the HDLC-protocol.

For use on existing BSC controllers, RCNET will offer a slightly modified HDLC-protocol, where the frame-format is changed, but the contents of the address, control and information fields remain unchanged. Lines handled by HDLC-controllers conform to the standard defined in [1].

1.2.3 Regions

The nodes of RCNET are collected into logical entities denoted regions.

For a specific network the region structure is intended to be defined in such a way, that there is a much larger exchange of information within a region than between regions.



N: Nodes
L: Communication lines
R: Regions

Figure 1.2. The Region concept.

The routing tables of a node will in detail describe the structure of the region to which the node belongs. Other regions will, however, be regarded as "black boxes" whose internal structure is not known.

Note that the region concept does not prohibit communication between hosts in different regions.

1.2.4 Connection of Networks

RCNET is prepared for network interconnection.

Each network is assigned an identification, NET-ID, so that each host has a NET-ID in addition to its HOST-ID.

The HOST-ID must be unique within a network. In case of connected networks, NET-ID together with HOST-ID forms a unique identification. NET-ID is included in the packet-format together with HOST-ID.

A format field in the packet allows the packet-structure of foreign networks to be utilized within RCNET.

1.3 Hosts

As stated, a host is the unit which may be addressed by the Packet Switch.

A more user-oriented viewpoint is to regard a host as a collection of processes which, within a network, is seen as a separate entity and should be addressed as such.

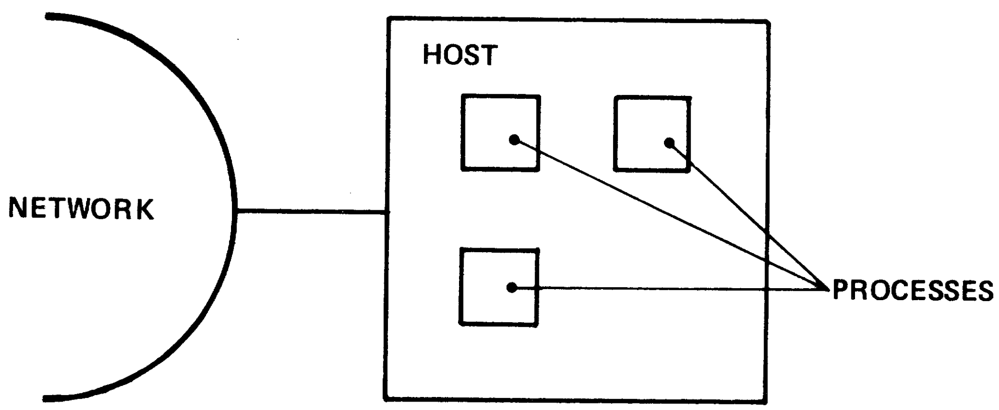


Figure 1.3. The host as a collection of processes.

The service a user expects from a transportation network is based on its capability to receive and transmit information of any content and (nearly) any length via the network (with the identification of the receiving host). In RCNET such information is called a message.

As the Packet Switch only performs the routing and switching functions, it is the responsibility of the hosts to implement an end-to-end check on the information exchanged. End-to-end checking means that the transmitting host expects an acknowledgement signal to be returned from the receiving host when some information has passed through the network. If this signal is not received within a specified time, an error recovery procedure is activated which may cause retransmission of the information.

This means that a host can be regarded as being divided into a Network Interface Part and an Application Part.

The Network Interface performs a conversion of formats known in the Application Part to the formats required by the Packet Switch. Part of this is the conversion between messages and packets.

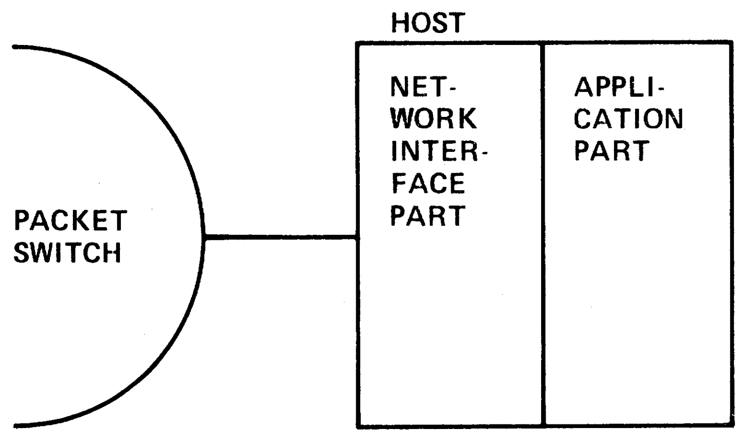


Figure 1.4. HOST structure.

RCNET will offer standard protocols for communication between Network Interfaces in different hosts. The protocols implement layers of responsibility.

The RCNET Packet Transporter is based directly on the services offered by the Packet Switch. The RCNET Message Transporter again utilizes the functions of the Packet Transporter.

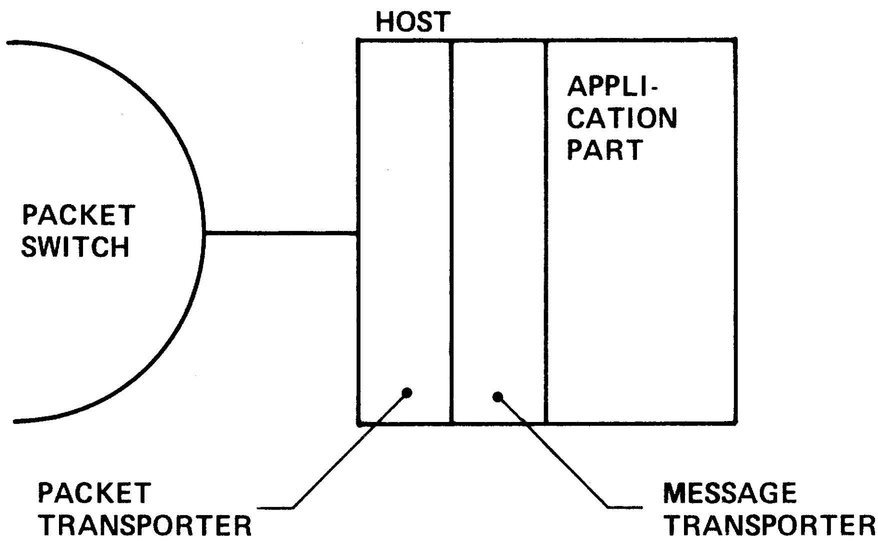


Figure 1.5. Network Interface structure.

1.3.1 RCNET Packet Transporter

This protocol implements the end-to-end functions needed to ensure that packets entered into the Packet Switch actually reach the specified receiving host, provided it is currently connected to the network.

The method of control is very much similar to the one adopted in the HDLC-protocol. Packets are sequentially numbered and the number is included in the packet. They also carry the number of the last packet that (along with earlier packets) has been correctly received.

Though this makes the Packet Switch look very much like a communication line, some differences exist.

For instance, packets are not necessarily delivered from the network in the sequence in which they are received. This is especially the case when packets with different priorities are entered into the network.

For this reason, the Packet Transporter implements a number of logical channels, called pipelines. On each pipeline the packets are independently numbered and acknowledged. The pipelines may be utilized in such a way that a specific pipeline is used for packets having a certain priority.

1.3.2. RCNET Message Transporter

This protocol implements the functions needed to control the disassembling of messages into packets at the transmitting host and the reassembling of the message at the receiving host.

The packets are individually transmitted through the Packet Switch utilizing the end-to-end check of the Packet Transporter.

The Message Transporter adds the message's sequential number, the packet's sequential number within the message and the number of packets in the message to each packet of the message.

1.3.3 Network Interface Implementation

An important feature of RCNET is that the abovementioned protocols are not restricted to use on a specific computer. They should simply be considered as logical levels in the network which may be implemented in different ways.

This idea is illustrated by two examples.

1.3.3.1 RC 8000 Network Interface. When an RC 8000 is connected to RCNET, the Network Interface Part resides partly in the RC 8000, partly in the Device Controller connected to the RC 8000. The actual separation of functions is done so as to ensure the most efficient use of the hardware and to reduce the buffer requirements as much as possible.

1.3.3.2 Foreign Computer Network Interface. When a foreign computer is connected to RCNET, all Network Interface functions will typically reside in an RC 3600 computer. This is in turn connected to the foreign computer by a standard interface, normally some sort of communication line.

This approach eliminates the need for modifications of the foreign computer.

1.3.4 External and Internal Hosts

RCNET distinguishes between two kinds of hosts.

1.3.4.1 External Host is used to designate a user of the network transportation service. The host is assigned a HOST-ID, which bears no relation to the physical connection between the network and the host.

1.3.4.2 Internal Host is used to designate certain modules executing network-related functions. The internal hosts are associated with the nodes, which means that it is possible to address a certain function at a certain node.

The HOST-ID of an internal host is made up of the NODE-ID of the corresponding node and the function which the internal host performs.

The HOST-ID of an internal host may, however, be used to address the host through the network in exactly the same way, and utilizing the same mechanisms, as when communicating with an external host.

1.4 Summary

By means of the layers of protocols defined, RCNET offers the transportation service level needed by the application system in question.

Protocols are defined in terms of their functions rather than in terms of the hardware on which they are executed. This allows the functions to be implemented at the network location and on the hardware best suited.

At the lowest levels RCNET takes advantage of packet switching technology.

On communication lines RCNET utilizes the HDLC-protocol.

For an application, utilizing the high-level protocols, RCNET provides a safe transportation service which accepts any information together with an identification of the receiver. RCNET ensures that either the information reaches its destination or that the sender will be informed if the receiver is no longer connected to the network.

Figure 1.6 summarizes the levels of protocols, that may be recognized in RCNET.

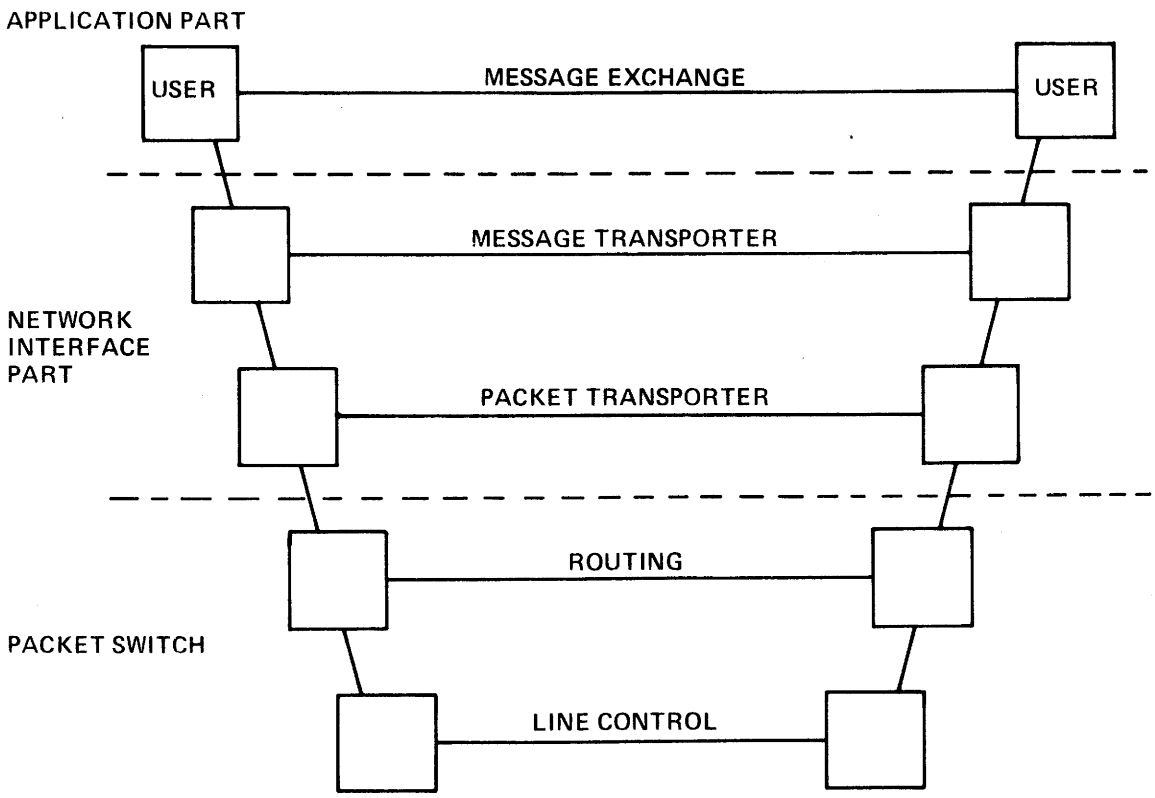


Figure 1.6. RCNET Protocol Levels.

2 RCNET Components

This chapter defines a number of components that may be tied together in various ways to make up an instance of RCNET.

It will be seen, that there is no fixed relationship between a function to be performed and the hardware and/or software actually doing the work.

We wish to point out, that new components may be added as the need arises.

Three major groups of components can be distinguished:

- Hardware components
- Software components
- Functional components.

2.1 Hardware Components

RCNET encompasses a wide range of hardware. This section, however, describes only the computers involved.

2.1.1 RC 8000

A medium-scale computer suitable for general purpose data processing.

It has software for administrative purposes such as payroll, production and stock control. These systems utilize a general data base management system.

It has compilers for the high level languages ALGOL and FORTRAN. User jobs are executed under the time-sharing operating system BOSS 2.

2.1.2 RC 3600

A minicomputer, which includes a multiprogramming system. A large range of peripheral equipment is available as well as communication equipment. Software is available for emulating most existing RJE terminals.

In RCNET, RC 3600 is used as a node and as a controller for devices accessed through the network.

2.1.3 RC 3500

A minicomputer including software for multiprogramming. It is particularly suited to handling a large number of fast communication lines. In RCNET it is used as a node, especially when an RC 8000 is connected to a network with a high demand on throughput capacity.

2.1.4 Datapoint

The Datapoint is a minicomputer used to control a number of terminals and to concentrate their traffic on a single communication line. Equipment like printers and cassette tapes may also be added.

2.2 Software Components

A number of individual software components are described in the following.

2.2.1 RC 8000 Software Components

An RC 8000 may connect to the network as a single host. The Network Interface part residing in RC 8000 consists of the following modules.

2.2.1.1 Link Driver. A device may be accessed through RCNET using standard RC 8000 access methods. A Link Driver transforms the RC 8000 conventions into network conventions. One Link Driver exists for each device currently accessed. The Link concept is related to the Device Control Protocol as described in Chapter 6.

2.2.1.2 Front End Driver. A module which controls a high-speed connection between RC 8000 and its RC 3500/RC 3600 Front End Processor.

2.2.2 RC 3600 Software Components

2.2.2.1 The Network Control Program, often abbreviated NCP, implements functions needed to interface user programs to the network. It may also control peripheral devices connected to the RC 3600 and by means of the Link Drivers in RC 8000 make them accessible to RC 8000 programs.

An RC 8000 is connected to the network through an RC 3600, in which part of the Network Interface resides.

2.2.2.2 The Router Module implements the routing and switching functions needed in RCNET.

2.2.2.3 The HDLC Module implements the HDLC-protocol on a number of synchronous communication lines.

2.3 Functional Components

The following describes a number of functional components of RCNET.

The description is followed by examples of the hardware and software components implementing the functions.

2.3.1 Device Controller

A Device Controller handles a number of peripheral devices according to the Device Control Protocol.

Figures 2.1 and 2.2 illustrate different hardware and software components which implement the functions of a Device Controller.

In Figure 2.1 all functions are located in one hardware unit, RC 3600.

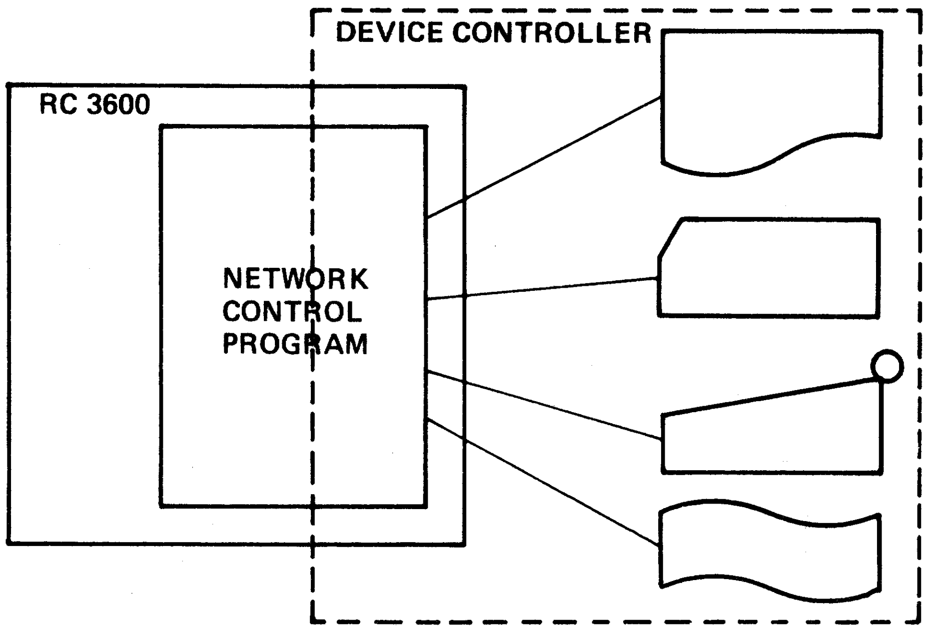


Figure 2.1. Device Controller in a single computer.

In Figure 2.2 the functions reside partly in an RC 3600, (A), partly in another RC 3600 or a Datapoint, (B). The computers are connected by means of a synchronous communication line, utilizing the HDLC-protocol.

The implementation allows the RC 3600 (A) to communicate with more than one RC 3600/Datapoint (B).

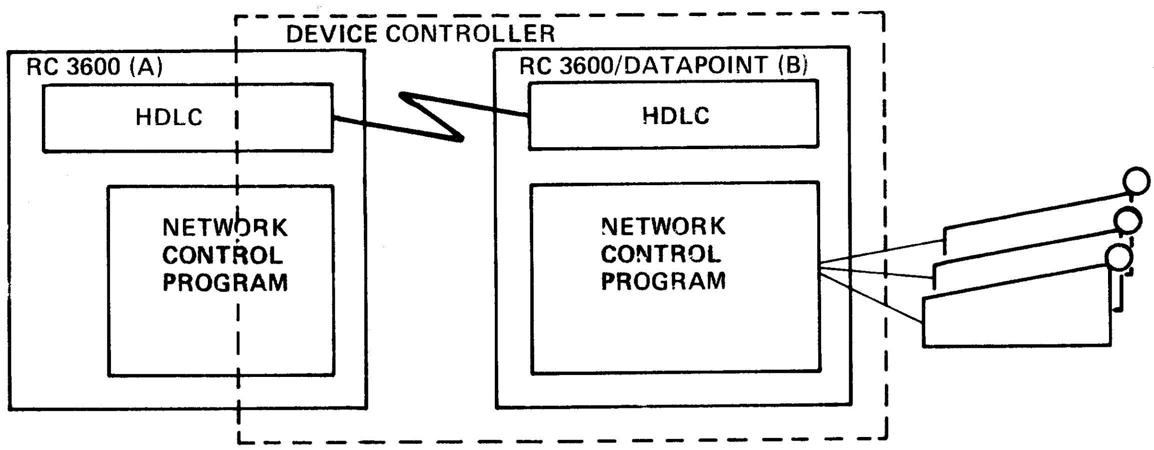


Figure 2.2. Device Controller in multiple computers.

2.3.2 Node

A node is the functional component that accepts packets from other nodes or from hosts. The destination stated in the packets direct them towards the receiver. If the receiver is in direct connection with the node, the packet is delivered. Otherwise, a routing algorithm is used to determine the next node to receive the packet.

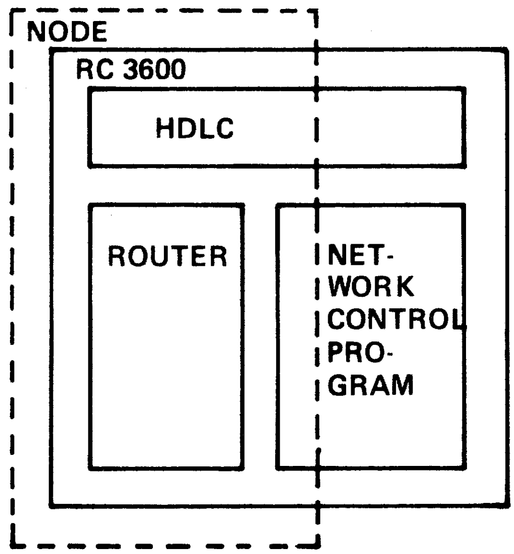


Figure 2.3. A Node.

It should be noted, that the HDLC-module may be replaced by another communication module depending on the type of communication line between the nodes.

3 RCNET Packet Switch

The Packet Switch provides the switching and routing functions of RCNET.

Information is accepted in the form of packets consisting of a packet header and an optional packet text.

The identification of the receiving host of the packet is, in addition to other information, stated in the packet header.

From the sending to the receiving host, the packet may pass through a number of intermediate nodes. Each node uses the identification of the receiver to determine the next node to receive the packet. The algorithm which selects the next node is normally called the routing algorithm.

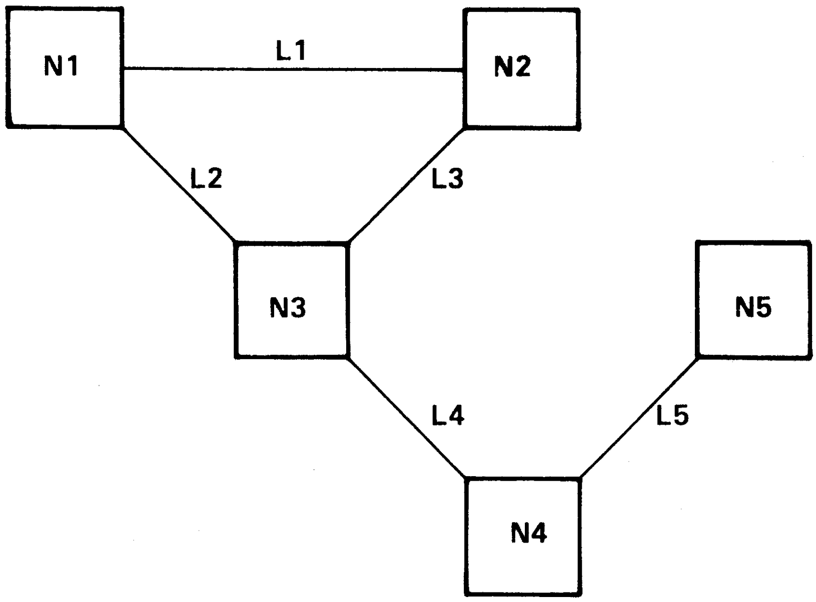
3.1 Network Topology

The following describes the topology of the network as determined by the Packet Switch.

3.1.1 Nodes and Communication Lines

A number of nodes are connected by a number of communication lines. There is no requirement that nodes should be connected directly. A path from one node to another may very well pass through a number of other nodes.

Figure 3.1 overleaf illustrates that the nodes N1, N2 and N3 may all communicate directly. Traffic from N1 or N2 to N4 must, however, pass N3, and traffic from N1 or N2 to N5 must pass both N3 and N4.

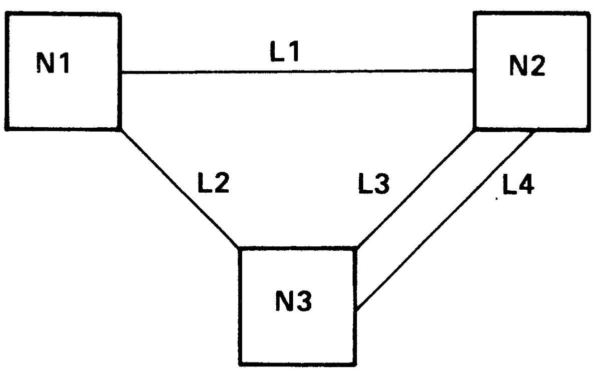


N1, ..., N5: Network nodes
L1, ..., L5: Communication lines

Figure 3.1. Example of a network structure.

3.1.2 Alternate Paths

Depending on the communication lines, nodes may be connected by more than one path. This may be accomplished either by the presence of more than one communication line between two nodes or by paths going through different intermediate nodes.



N1, N2, N3: Network nodes
L1, ..., L4: Communication lines

Figure 3.2. Network with alternate paths.

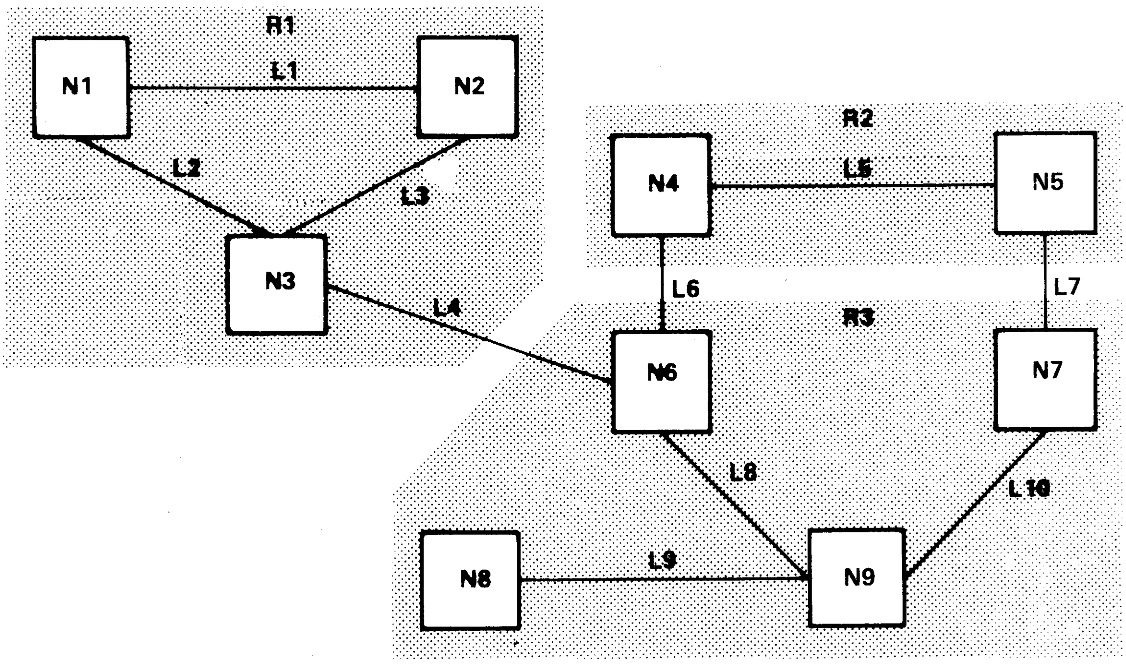
Figure 3.2 illustrates, that traffic from node N2 to N3 may use either the direct communication lines L3 or L4 or the path through node N1 using the communication lines L1 and L2.

When more than one path exists between nodes, these paths are designated alternate paths.

3.1.3 Regions

Nodes are grouped into regions. The region structure is defined individually for each network.

The purpose of the regions is to divide the network logically into a number of clusters in such a way that, within each region, there is a frequent exchange of information, but between regions only a limited exchange of information takes place.



R1, R2, R3: Regions
N1, ..., N9: Network nodes
L1, ..., L10: Communication lines

Figure 3.3. Example of region structure.

Figure 3.3 illustrates that nodes N1, N2 and N3 constitute region R1, nodes N4 and N5 constitute region R2 and nodes N6, N7, N8 and N9 constitute region R3. It also illustrates that regions may be connected by zero, one, or more communication lines. Traffic between regions R1 and R2 has to pass one or more nodes in region R3.

The region concept reduces the amount of information needed in each node to describe the current topology of the network. Nodes will maintain detailed information on how to reach other nodes within the same region. They will, however, only maintain information on how to reach another region, but not on how to reach a specific node within that region.

The (logical) region topology can not be arbitrarily imposed on the (physical) node topology. From one node it should, in fact, be possible to reach all other nodes in the same region without having to pass nodes in another region.

3.1.4 Region Identification

Each region is assigned an identification, REGION-ID, which can take a value from 1 to 255.

3.1.5 Node Identification

Each node within a region is assigned an identification, NODE-ID, which can take a value from 1 to 255. The complete identification of a node within the network consists of its REGION-ID followed by its NODE-ID within that region.

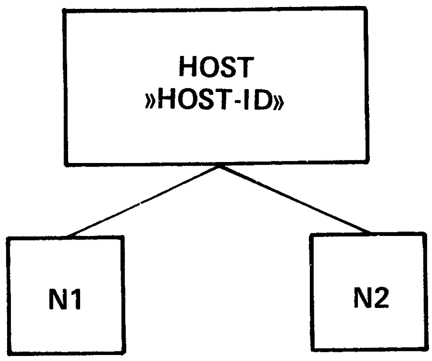
3.2 Hosts

The addressable unit of the Packet Switch is called a host. A host may deliver packets destined for other hosts to the Packet Switch and it may receive packets from other hosts.

3.2.1 Host Identification

Each host is assigned its own unique identification, HOST-ID, within the network. When a host connects to the Packet Switch it states its own HOST-ID.

It should be noted that HOST-ID does not in any way relate a host to a certain node in the network. In fact, a host may connect to any node in the network and even to more than one node at a time, and still use the same HOST-ID on all connections.



N1, N2: Network nodes

Figure 3.4. Host with double connection to the network.

Figure 3.4 illustrates a host, which is connected to the network through nodes N1 and N2. The same HOST-ID is used towards both nodes.

In order to be prepared for connection of networks, possibly of different types, the HOST-ID is extended with an identification of the network to which the host belongs. This identification is denoted NET-ID.

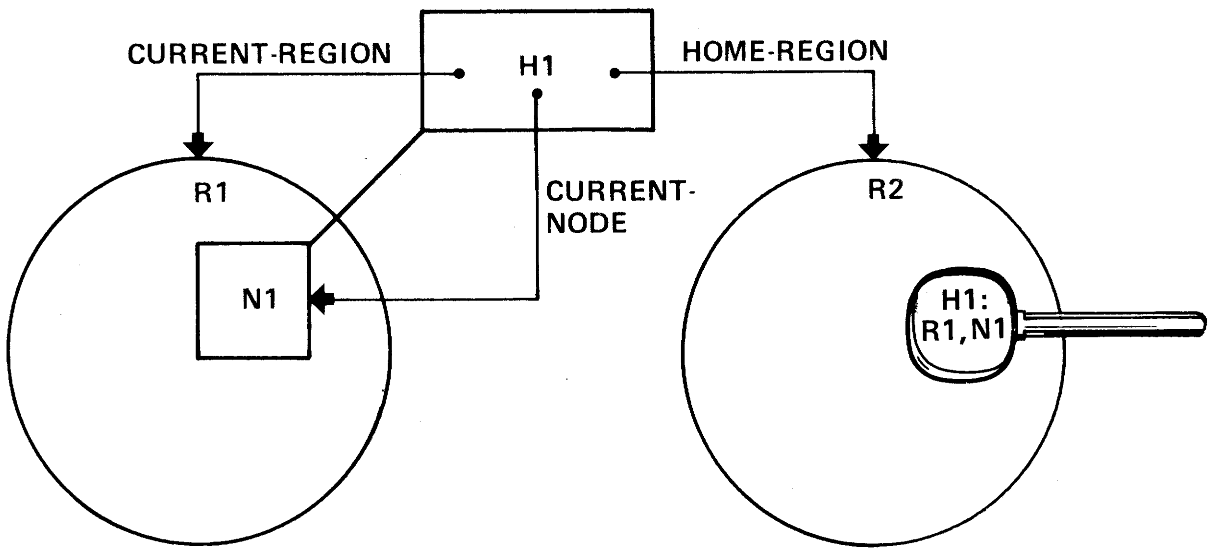
3.2.2 Host Attributes

The identification of a host may be extended with some attributes. They do not influence the uniqueness of a HOST-ID as the identification of a host within the network, but merely serve to locate the host in the network.

3.2.2.1 HOME-REGION of a host is the identification of a region, which will know the current location of the host if it is connected to the network, even when connected to a different region.

3.2.2.2 CURRENT-REGION of a host is defined only when the host is connected to the network. It then holds the REGION-ID of one of the regions to which it is connected.

3.2.2.3 CURRENT-NODE of a host, like CURRENT-REGION, is defined only when the host is connected to the network. It then holds the NODE-ID of one of the nodes (within CURRENT-REGION) to which it is connected.



H1: Host
R1, R2: Regions
N1: Network node

Figure 3.5. The concepts HOME-REGION, CURRENT-REGION and CURRENT-NODE.

Figure 3.5 illustrates a host, H1, which has region R2 as HOME-REGION, but which is currently connected to region R1, node N1. Thus in region R2, information will be maintained, stating that CURRENT-REGION and CURRENT-NODE for H1 is R1 and N1.

3.3 Packet Format

The following describes in short the format of a packet.

A packet consists of two parts: a packet header and a packet text.

3.3.1 Format of the Packet Header

Figure 3.6 shows the format of the packet header as it will appear in a computer with 16 bits per word.

WORD \ BIT 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15				
0	FORMAT	PACKET TEXT LENGTH		
1	PACKET HEADER LENGTH	USER HEADER LENGTH	STATE	PRIORITY
2	RECEIVER CURRENT-REGION	RECEIVER CURRENT-NODE		
3	SENDER CURRENT-REGION	SENDER CURRENT-NODE		
4	RECEIVER NET-ID	SENDER NET-ID		
5	RECEIVER HOME-REGION	SENDER HOME-REGION		
6	RECEIVER HOST-ID			
7	SENDER HOST-ID			
8	FACILITY MASK			
9	IDENTIFICATION			

Figure 3.6. Format of packet header.

3.3.2 Content of the Packet Header

The following is a short description of the fields in the packet header.

3.3.2.1 FORMAT. May be used to distinguish between packets of different formats if, for example, other networks' packet formats are to be allowed within RCNET.

3.3.2.2 PACKET TEXT LENGTH. The length of the packet text part, counted in characters of 8 bits each. Though the size of this field allows a packet text size of up to 4095 characters, a smaller maximum size may be imposed on the network.

3.3.2.3 PACKET HEADER LENGTH. The length of the packet header in characters of 8 bits each.

3.3.2.4 USER HEADER LENGTH. The number of 8-bit characters from the beginning of the packet text that should be retained if the packet is returned to the sending host.

3.3.2.5 STATE. Determines whether the packet is on its way towards the receiving host, or whether the Packet Switch is returning it to the sender.

3.3.2.6 PRIORITY. Packets may be transmitted through the network with 4 different priorities. Each node will transmit packets to the next node in order of priority.

3.3.2.7 RECEIVER CURRENT-REGION. The CURRENT-REGION of the receiving host.

3.3.2.8 RECEIVER CURRENT-NODE. The CURRENT-NODE of the receiving host.

3.3.2.9 SENDER CURRENT-REGION. The CURRENT-REGION of the sending host, e.g. the region in which the packet entered the network.

3.3.2.10 SENDER CURRENT-NODE. The CURRENT-NODE of the sending host, e.g. the node in which the packet entered the network.

3.3.2.11 RECEIVER NET-ID. The NET-ID of the receiving host.

3.3.2.12 SENDER NET-ID. The NET-ID of the sending host, e.g. the network, where the packet was entered.

3.3.2.13 RECEIVER HOME-REGION. The HOME-REGION of the receiving host.

3.3.2.14 SENDER HOME-REGION. The HOME-REGION of the sending host.

3.3.2.15 RECEIVER HOST-ID. The HOST-ID of the receiving host.

3.3.2.16 SENDER HOST-ID. The HOST-ID of the sending host.

3.3.2.17 FACILITY MASK. A mask which is used to signal that certain test and tracing procedures should be applied to the packet in the nodes passed.

3.3.2.18 IDENTIFICATION. A field that is unchanged by the Packet Switch and used exclusively by the host.

3.3.3 The Packet Text

The optional packet text occupies as many 8-bit characters as stated in the field PACKET TEXT LENGTH. It is left completely unchanged by the Packet Switch except for certain test and tracing packets.

However, if a packet can not reach the host stated as its receiver, the Packet Switch will attempt to return it to the transmitting host. In this case the field USER HEADER LENGTH is inspected to determine how many 8-bit characters, from the beginning of the packet text, that should be retained. The rest of the packet text is discarded.

Figure 3.7 illustrates the concept of the user header.

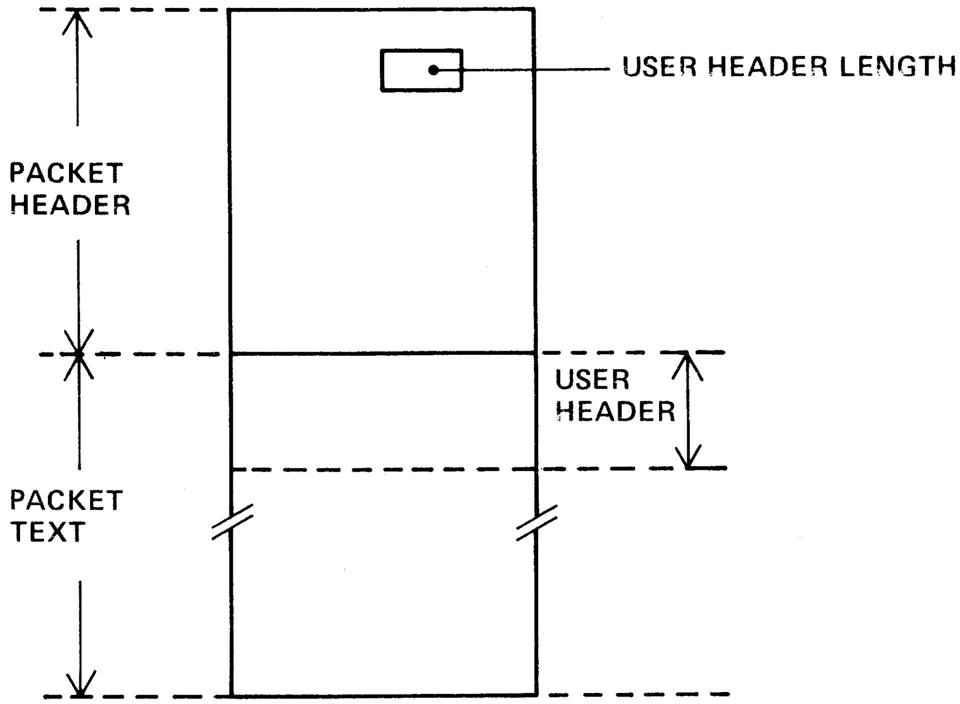


Figure 3.7. The user header in a packet.

4 RCNET Packet Transporter

The purpose of the Packet Transporter protocol is to control that packets entered into the Packet Switch actually reach their destination. A time-out situation will be detected, if the receiver has not acknowledged the packet within a certain time.

4.1 Position in the Network Protocols

The Packet Transporter protocol is a host protocol, meaning that it is not part of the Packet Switch. RCNET offers standard software for implementing this protocol. It is executed in an RC 3500 or an RC 3600 also when these act as front-end computers for RC 8000.

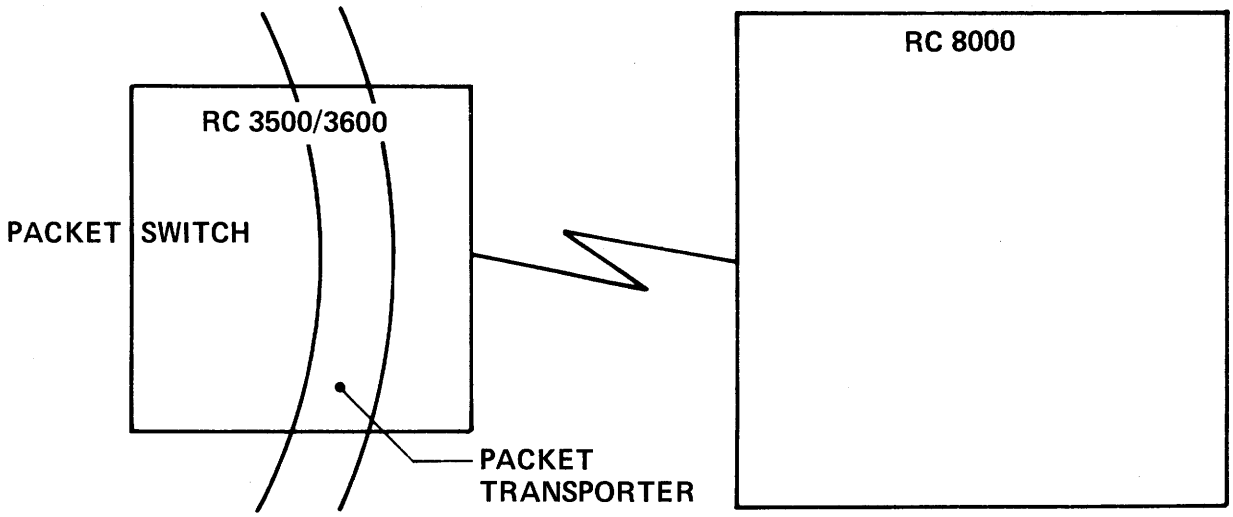


Figure 4.1. Position of the Packet Transporter in the network.

4.2 Method of Control

The end-to-end check is implemented by a double, independent, numbering scheme, similar to the one defined in HDLC (the protocol used for synchronous communication lines within RCNET).

The packets are independently numbered in each direction. Each packet normally includes two counters, TRANSMIT SEQUENCE COUNT and RECEIVE SEQUENCE COUNT.

TRANSMIT SEQUENCE COUNT is the number of this packet in the direction from sender to receiver.

RECEIVE SEQUENCE COUNT signals from sender to receiver that all packets up to, but not including, this number have been received and are thus acknowledged.

As in the HDLC-protocol, both counters are included in normal data packets.

This means that only if the traffic is currently unidirectional must the receiving host generate dummy packets, containing the RECEIVE SEQUENCE COUNT. As these packets do not otherwise carry any information they are not themselves numbered (no TRANSMIT SEQUENCE COUNT).

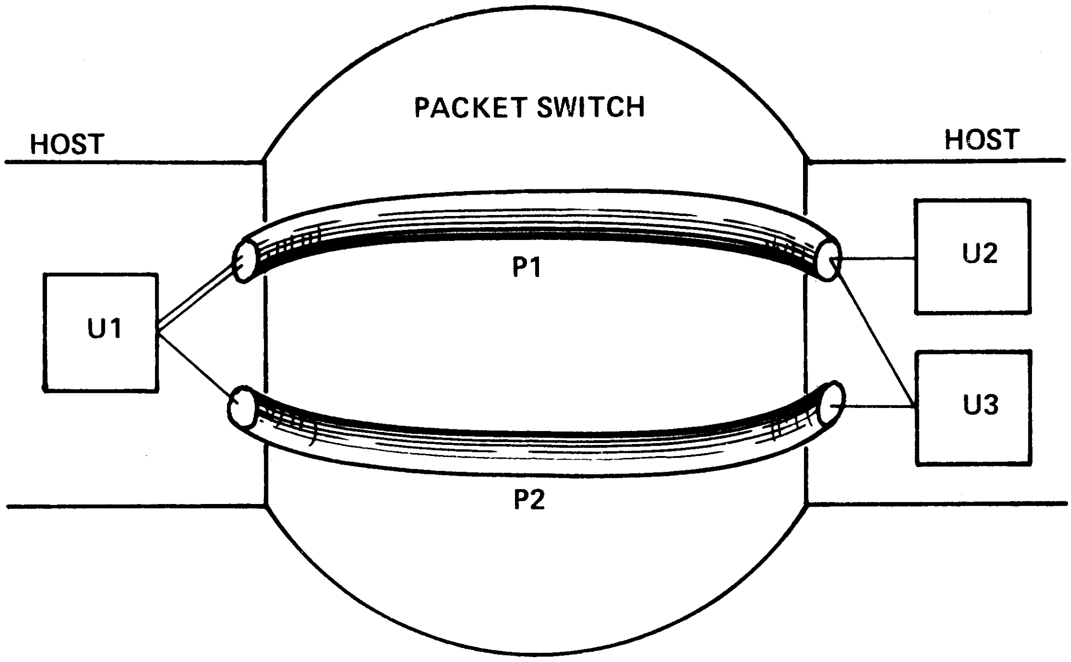
The counters take the values 0,1,...,255,0,1,.... This interval, which is significantly greater than the one used in HDLC (0,1,...,7,0,1,...), has been chosen because of the greater delay that may be expected to occur between transmission of a packet and acknowledgement. The interval determines the number of outstanding packets (here 255).

4.3 Pipelines

The sequence-count method described above is best suited for traffic, where the items arrive at the receiver in the same order as they were transmitted.

This can not normally be expected in a network where priority mechanisms and dynamic routing algorithms may change the order of the packets. The very idea of assigning priority is to be able to change the order of the packets even after they have been delivered to the Packet Switch.

In RCNET this has led to the concept of pipelines. A pipeline is a logical pipe from one host to another through the Packet Switch. A number of pipelines may be established between two hosts.



U1, U2, U3: User processes
P1, P2: Pipelines

Figure 4.2. The pipeline concept.

Pipelines are dynamically created and removed as the need arises.

On each pipeline an independent set of TRANSMIT SEQUENCE COUNT and RECEIVE SEQUENCE COUNT is maintained and added to the packets. This means that the traffic on each pipeline may flow with its own speed, independent of the other pipelines, without introducing the sequencing problem described above.

One way of allocating the pipelines will be to use one pipeline for each priority level, as packets with the same priority level are handled in the nodes in order of arrival.

Once again it should be noted that the Packet Transporter is a host protocol. This means that the pipeline concept only exists within hosts, not within the Packet Switch. The pipelines have no relation to the physical network topology or to the routing methods applied to the packets. Packets transmitted on the same pipeline may very well find different ways through the network, and may even be entered into the destination host from different nodes.

5 RCNET Message Transporter

The Message Transporter protocol controls the division of messages into packets. These packets are then handed over to the Packet Transporter for transmission through the network. The Message Transporter does not have to control the transmission of the individual packets as this is done by the Packet Transporter. If, for some reason, the packets can not reach their destination - due to line failure, for example - the Packet Transporter notifies the Message Transporter.

At the receiver, the Message Transporter will receive the individual packets and assemble them to form the original message.

5.1 Position in the Network Protocols

The Message Transporter is a host protocol. As with the Packet Transporter, RCNET offers standard software for the implementation of this protocol on RC 3500/RC 3600, also when these act as front-end computers for RC 8000.

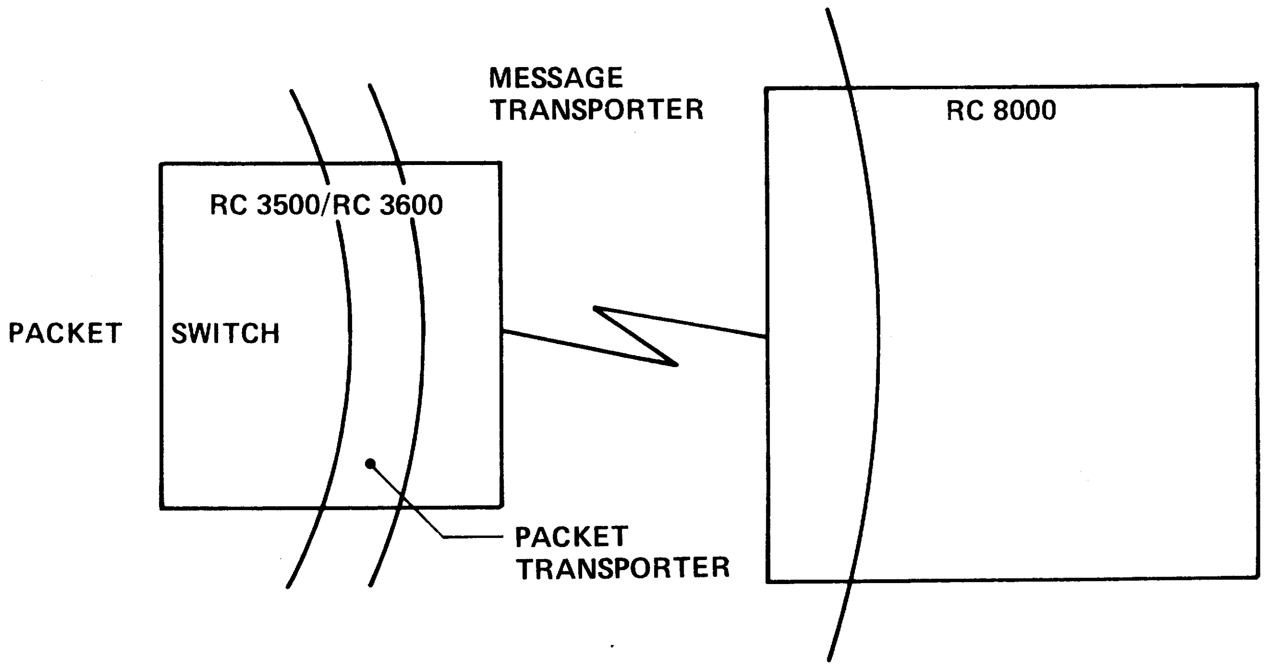


Figure 5.1. Position of the Message Transporter in the network.

As can be seen from Figure 5.1, the work of the Message Transporter is actually shared between RC 3500/RC 3600 and the RC 8000. This is for reasons of efficiency and reduced buffer requirements. This implementation is one of the outcomes of the separation between logical protocol levels and the physical implementations.

The Message Transporter forms the outermost level of the transportation network. Utilizing this protocol, messages of nearly infinite length may be transmitted through the network to a specified host. The sender will be assured that the message reaches the receiver, or else he will be notified that the receiver is not accessible.

Thus it forms the basis for implementation of Message Protocols.

5.2 Method of Control

Messages are sequentially numbered. Each packet includes three fields, MESSAGE NUMBER, PACKETS IN MESSAGE, PACKET NUMBER IN MESSAGE.

MESSAGE NUMBER is the sequential number assigned to the message from which this packet derives.

PACKETS IN MESSAGE is the number of packets into which this message has been divided. Each packet except the last has a fixed length.

PACKET NUMBER IN MESSAGE is the number of this packet within the message.

The field PACKETS IN MESSAGE is included instead of a LAST PACKET flag, because it allows the receiver to determine the buffer space needed for this message as soon as at least one packet has been received.

5.3 Relations to Pipelines

All packets of a message are transmitted on the same pipeline. This is because the MESSAGE NUMBER is not intended to ensure correct sequencing of messages, but only to identify the message to which a packet belongs.

Thus a MESSAGE NUMBER is maintained for each pipeline active, and no confusion can arise if packets having equal values of MESSAGE NUMBER are received on different pipelines.

6 RCNET Device Control Protocol

The RCNET Device Control Protocol is used when a number of devices residing at one host are accessed and controlled by other hosts in the network. The reference manual for the protocol is listed as [2].

The protocol is a "user protocol" in the sense that it is intended to function parallel with other - maybe user defined - Message Protocols utilizing the transportation service of the Message Transporter.

6.1 Links

A fundamental concept in this protocol is the link. It is a logical path through RCNET, tieing together a device at one host and a process at another host.

Links are created and removed upon request.

Links are, among other things, used to ensure indivisible access to a device for a certain period. Requests for link creation, arriving at a device which is already occupied by another link, may be queued for a time specified in the request.

Note: Links have no relation to pipelines. Packets from different links (or from other protocols) may share the same pipeline.

6.2 Device Specification

The device to which a link is created, is specified in terms of some characteristics which should be satisfied. These specifications are interpreted by the host on which the devices reside.

The characteristics are:

- Device type (e.g. printer, card reader, etc.)
- Device name
- Buffer resources needed (among which is the maximum acceptable buffer size).

6.3 Master–Slave Relation

The Device Control Protocol is a strict master - slave protocol in the sense that initiative for input or output operations originates in the program.

The device itself will not take any action apart from reporting that some specific events have occured.

7 RCNET Examples

This chapter contains a few examples of RCNET configurations. Further examples are given in [3].

7.1 RC 8000 Access to Devices

In this example, a number of remotely located devices are accessed from RC 8000 programs.

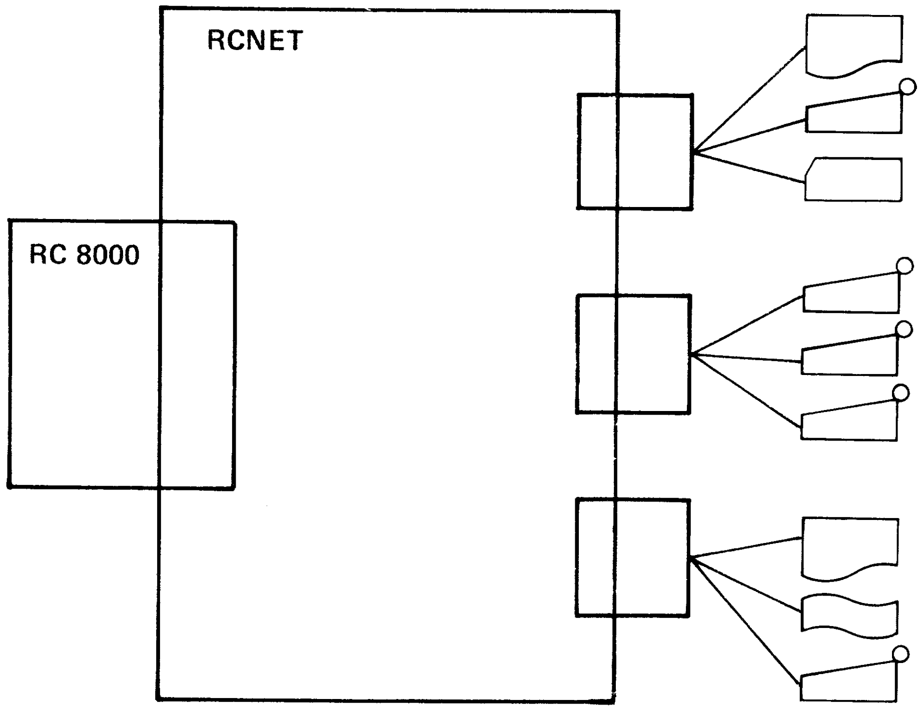


Figure 7.1. RC 8000 accesses devices through RCNET.

7.2 Foreign Computer Access to RCNET

The example below illustrates how a computer from another manufacturer, in this case an IBM, may be interfaced to RCNET.

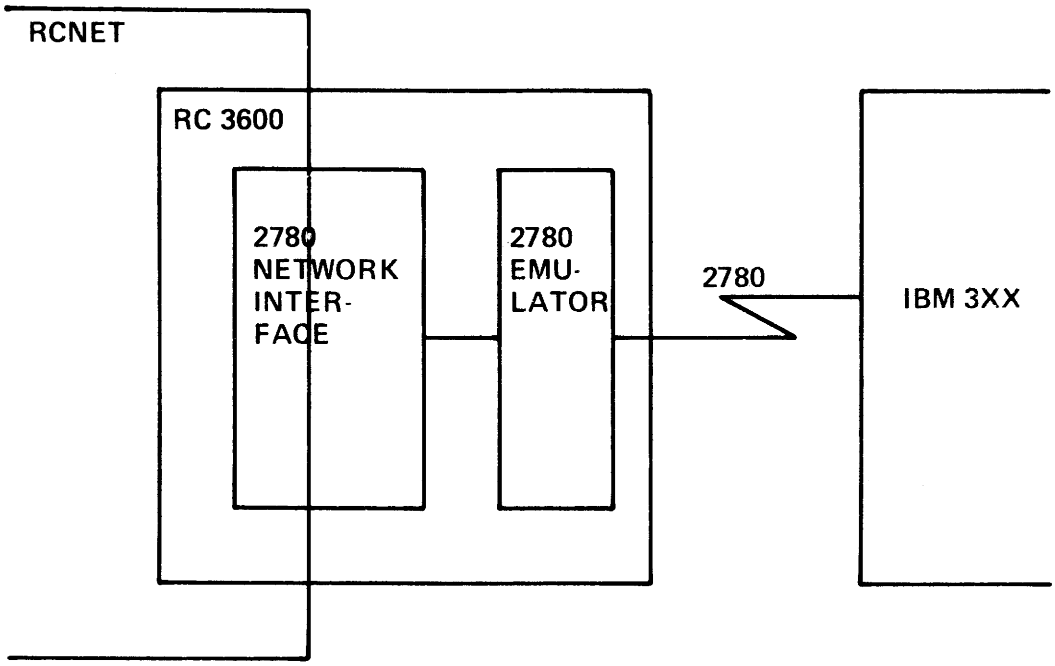


Figure 7.2. Interface between RCNET and an IBM computer.

In this example, an IBM 2780 type of connection has been chosen to connect to the IBM computer. Any other standard IBM type of terminal could, of course, have been used instead. The choice depends on the type of traffic.

The figure illustrates that the 2780 NETWORK INTERFACE may take advantage of standard RCNET protocols.

7.3 Back-up Facilities

This example illustrates how a computer may be connected to RCNET through two nodes. By using the same identification on both connections, one of the nodes may cease to function. This does not change the identification used to access the host.

One of the lines may actually be a dial-up line.

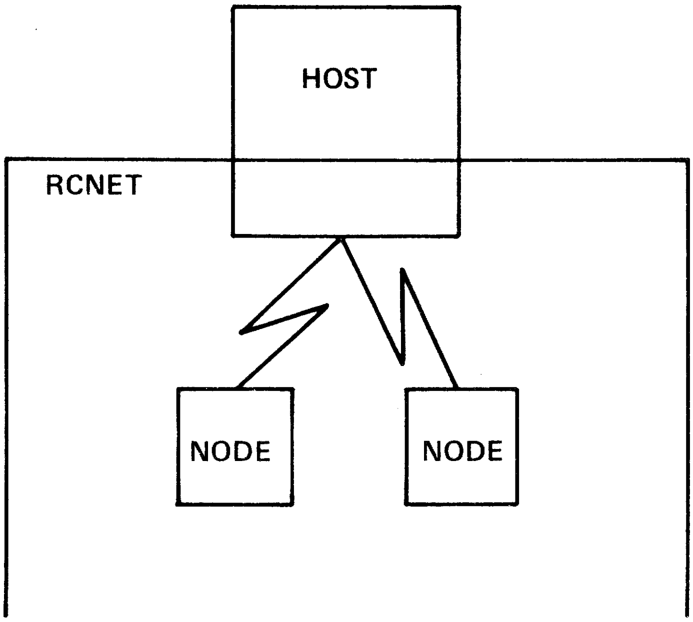


Figure 7.3. Network connection with back-up.

8 RCNET Vocabulary

This is an alphabetic list of definitions of terms assigned a specific meaning within RCNET.

Within each definition, the first occurrence of a term defined elsewhere in the vocabulary is underlined.

COMMUNICATION LINE
A physical connection between computers on which information may be exchanged.

CURRENT-NODE
An attribute associated with each host while connected to the network. It is the NODE-ID of a node to which the host is connected.

CURRENT-REGION
An attribute associated with each host while connected to the network. It is the REGION-ID of a node to which the host is connected.

DEVICE CONTROL PROTOCOL
A Message Protocol within RCNET. It is used, when one host controls devices at another host.

DEVICE HOST
A concept within the Device Control Protocol. It is a designation for the host at which the devices reside. Cf. Jobhost.

EXTERNAL HOST
A host, whose HOST-ID is not related to a specific node.

HOME-REGION
An attribute associated with each host. It is the REGION-ID of a region in which information about the current location of the host in the network is maintained.

HOST

The addressable unit of the Packet Switch. Each host is identified by NET-ID and HOST-ID.

HOST-ID

Within a network a unique identification of a certain host.

INTERNAL HOST

A host that is related to a specific node. The corresponding NODE-ID may be derived from the host's HOST-ID.

JOBHOST

A concept within the Device Control Protocol. It is a designation for the host at which programs are executed, accessing devices at the Device host.

LINK

A concept within the Device Control Protocol. It is a logical connection between a process executed at a Jobhost and a device at a Device host. The links serve reservation, sequencing and resource control purposes.

MESSAGE

The name for the information accepted by the Message Transporter.

MESSAGE CONTROL INFORMATION

The information added by protocols to the original message supplied by the user.

MESSAGE PROTOCOL

A protocol utilizing the service offered by the Message Transporter. The Device Control Protocol is a Message Protocol.

MESSAGE TRANSPORTER

A protocol level within RCNET. It forms the basis for implementation of Message Protocols. It accepts information of (nearly) any length and of any content, and controls its transmission through the network to the specified host.

NET-ID

An identification associated with a network. NET-ID together with HOST-ID forms the unique identification of a host when networks are tied together.

NODE

A functional unit within the Packet Switch, taking part in the routing of packets.

NODE-ID

The identification of a node within a region. The total identification of a node within the network consists of REGION-ID together with NODE-ID.

PACKET

The basic unit of information exchanged with and within the Packet Switch.

PACKET SWITCH

A protocol within RCNET. It accepts packets from hosts and routes them towards the host specified as receiver.

PACKET TRANSPORTER

A protocol within RCNET. The protocol is implemented in hosts. It controls the transmission of packets through the Packet Switch and includes mechanisms to detect the loss of a packet.

PIPELINE

A concept within the Packet Transporter. A pipeline is a logical pipe from one host to another through the Packet Switch. The pipelines are part of the end-to-end check implemented by the Packet Transporter.

PROTOCOL

A set of rules, formats and procedures agreed upon by the participants in an exchange of information.

REGION

The nodes within a network may be grouped into a number of regions. Each region is assigned a REGION-ID.

REGION-ID

The identification of a region within a network.

ROUTING

The procedure applied to packets when passing a node. The procedure determines the next node to receive the packet.