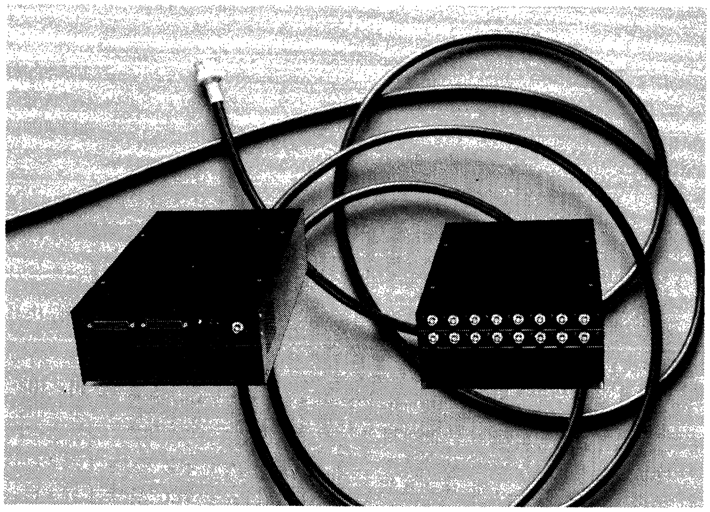
DATAPOINT



ARCNET Local Area Network Protocols

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1.0 GENERAL DESCRIPTION

ARCNET™ is Datapoint's local networking architecture that forms the interconnection among "nodes" (suitably configured processors and processor-based peripherals). The physical components of ARCNET are the Resource Interface Modules (RIMs), coaxial junction boxes (Hubs), and the coaxial cable itself.

Each node is connected to the ARCNET through an attached RIM, which can be integral to the node's circuitry or in a separate unit. ARCNET operates at 2.5 megabaud using a serial asynchronous transmission protocol of 11 elements per byte. Up to 255 nodes can take part in an ARCNET.

Nodes can be added to the system, removed or powered-down without affecting the operation of any of the other nodes in the network.

2.0 HARDWARE DESCRIPTION

Each node connects via a RIM and a length of RG62 coaxial cable to a port on a "Hub." The RIM functions as both the physical and logical interface between the node and the network. The coax is properly terminated at each end and no taps of any kind are used. A standard ARCNET system uses baseband transmission methods. The hubs see that the transmissions of any one RIM are heard by every other RIM, and function as signal amplifiers and network taps, providing total reflection suppression without signal loss, even with unterminated or shorted lines.

Each of the ports of a hub may be connected to an ARCNET RIM, to another hub, to an unterminated length of coax, or to nothing at all. Extra cables may be put in for future expansion or for mobility of equipment. Cables may be routed through the same raceways and conduits used for the telephone system, which uses a similar wiring scheme.

The RIM forms the interface between a node (processor or processor-based peripheral) and the rest of the network.

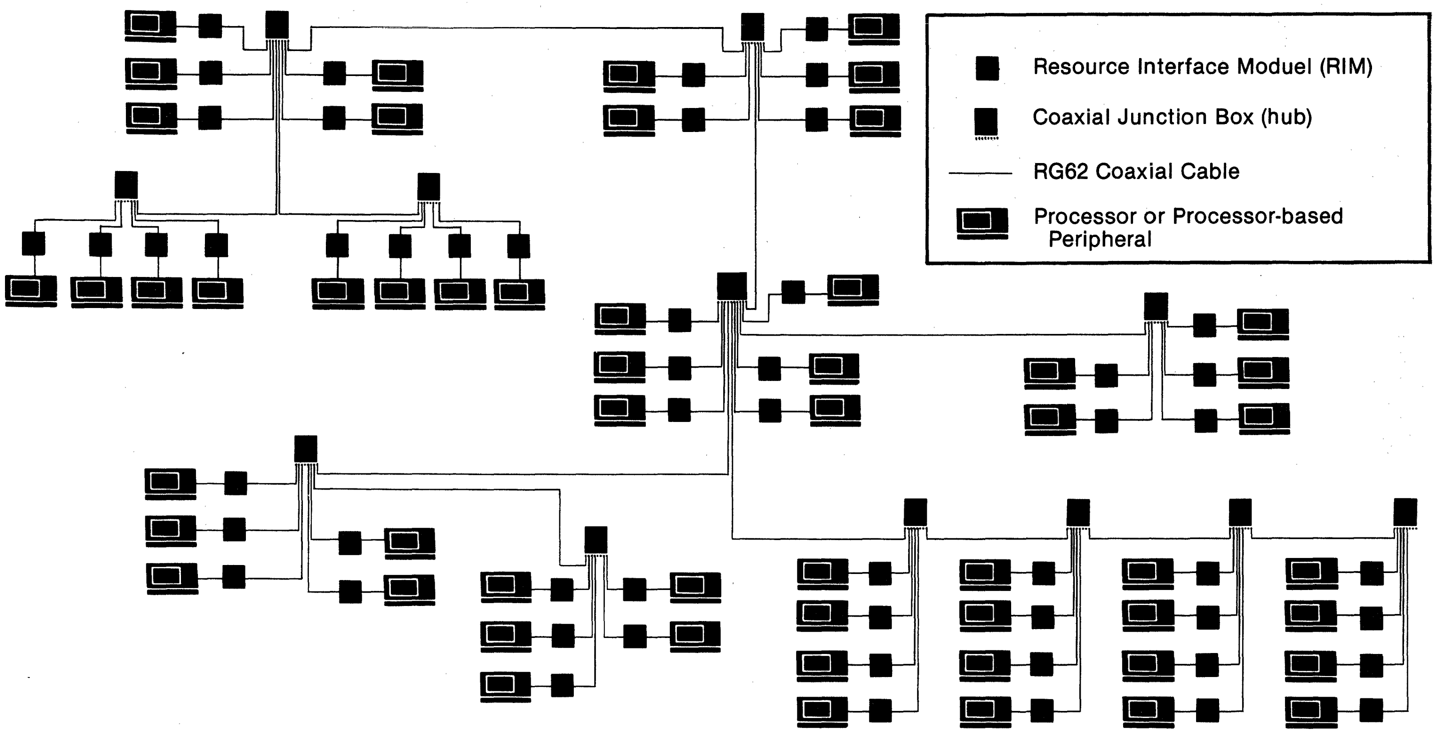

Figure 1-1: ARCNET's unconstrained topology.

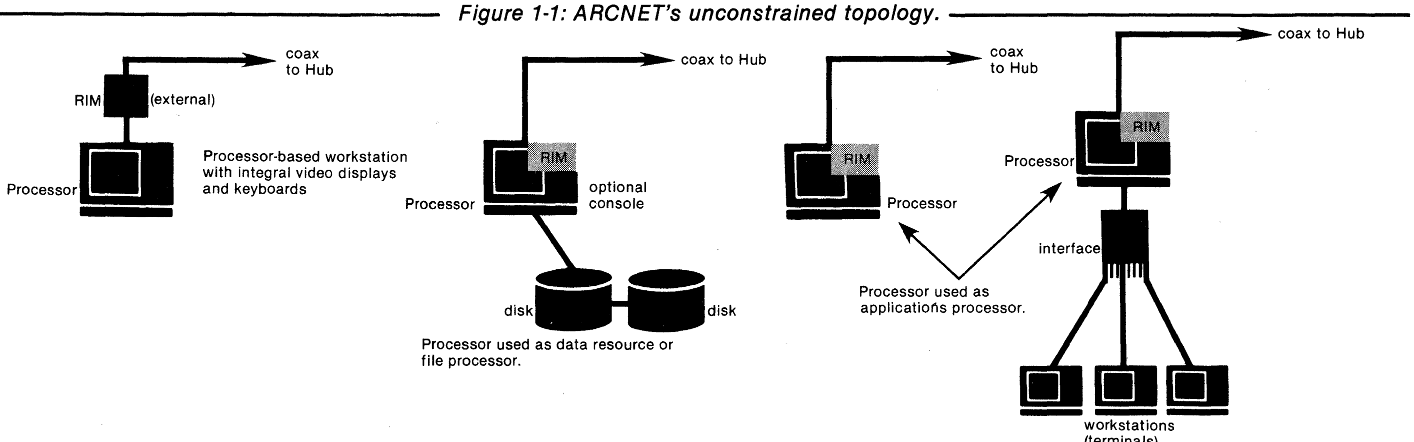

Figure 1-2: Hardware Configuration Diagrams.

Interaction between the processor and the RIM is on a message by message, as opposed to a byte by byte, basis. The RIM contains four 256 byte message buffers and the arbitration logic required to share them among the processor, the RIM transmitter, and the RIM receiver. To send a message, the processor writes the message into a RIM buffer and issues a transmit command. To receive a message, the processor assigns a buffer to the RIM receiver.

The coding scheme uses a 200 ns. wide dipulse (a 100 ns. wide positive pulse immediately followed by an identically shaped negative pulse) transmission for a mark. No energy at all is transmitted for a space, resulting in a system with virtually no intersymbol interference. The use of transformer coupling and matched filters ensures the reliability of the architecture.

An NMOS LSI integrated circuit is used to implement a major part of the RIM circuitry.

ARCNET protocol requires that each node must be able to hear any other node, and there be only a single path between any two nodes. Signals must be able to pass between any two nodes in no more than 31 microseconds, which translates to a physical distance limitation of about four miles. Hubs may be no more than 2,000 feet apart, although as many as 10 hubs may be "cascaded."

3.0 ARCNET Protocol

3.1 General Description

ARCNET is a contention-free network architecture in which control of the network is passed by means of a "token" from RIM to RIM. Each RIM has a unique address. An attempt to pass control involves the RIM with the token sending the token to the RIM with the next sequential address. If the RIM passing control detects any activity on the network (the start of a data packet, the continuation of polling, or an attempt by a new RIM to enter the network), the RIM considers the attempt successful and relinquishes control. If no activity is detected for the maximum amount of time it should take to receive an acknowledgement from the farthest possible RIM, the RIM again attempts to pass control, using the next higher sequential address.

Each RIM stores the address of the RIM to which it last passed control, so a dispersed list of all the active RIMs in the network is maintained, with one address stored at each RIM. The list of active RIMs speeds network operations, since no time is spent waiting for responses from nonexistent RIMs.

3.2

Transmission Characteristics

The line idles in a spacing (no signal) condition. Each transmission starts with an alert burst consisting of six unit intervals of mark (signal). Eight-bit characters are then sent with each character preceded by two unit intervals of mark and one unit interval of space.

There are five different types of transmission:

INVITATIONS TO TRANSMIT-An ALERT BURST followed by three characters: an ASCII EOT (End Of Transmission) character and two (repeated) DID (Destination IDentification) characters. Used to pass control of the line (the "token,") from one RIM to another.

| EOT | DID | DID |

FREE BUFFER ENQUIRIES-An ALERT BURST followed by three characters: an ASCII ENQ (ENQuiry) character and two (repeated) DID (Destination IDentification) characters. Used to ask a RIM if it is able to accept a packet.

| ENQ | DID | DID |

PACKETS-An ALERT BURST followed by from 8 to 260 characters: An ASCII SOH (Start Of Header) character, an SID (Source IDentification), two (repeated) DIDs (Destination IDentification), a COUNT, from 1 to 253 data characters, and two CRC (Cyclic Redundancy Check) characters. Used to move data between RIMs.

| SOH | SID | DID | DID | COUNT | data | CRC | CRC |

ACKNOWLEDGEMENTS-An ALERT BURST followed by an ASCII ACK (ACKnowledgement). Used to acknowledge PACKETS and as an affirmative response to FREE BUFFER ENQUIRIES.

| ACK |

NEGATIVE ACKNOWLEDGEMENTS-An ALERT BURST followed by an ASCII NAK (Negative AcKnowledgement). Used as a negative response to FREE BUFFER ENQUIRIES.

| NAK |

The receiver validates all incoming transmissions by checking for:

- At least one mark and exactly one space preceding each character;
- An EOT, ENQ, SOH, ACK, or NAK following the ALERT BURST;
- Proper CRC (packets only);
- Proper number of characters (3, 8 to 260, or 1);
- At least nine spaces following the last character.

3.3

Token Passing

Each RIM in a network has a unique ID (IDentification) from 1 to 0377 (octal) selected by jumpers. (ID 0 may not be assigned to any RIM since destination 0 is used to indicate a BROADCAST to all RIMs.) System operation is based on an INVITATION TO TRANSMIT being passed around the system with each RIM passing it to NID (Next ID), the RIM with the next higher ID in the system. When a RIM receives an INVITATION TO TRANSMIT containing its ID, it assumes control of the line. The identification of each RIM's NID is determined during SYSTEM RECONFIGURATION, or redetermined if the current NID fails to respond.

3.4

System Reconfiguration

When a RIM is first powered on, or has not received an INVITATION TO TRANSMIT for approximately 840 ms., it sends a RECONFIGURE BURST consisting of eight marks and one space repeated 765 times. The purpose of this burst is to terminate all activity on the line. It is longer than any other type of transmission and will therefore interfere with the next INVITATION TO TRANSMIT and keep any RIM from seeing it and assuming control of the line. It also provides line activity so that the RIM sending the INVITATION TO TRANSMIT releases control of the line. Thus the RIM that had control releases it and no other RIM picks it up.

When any RIM sees that the line has been idle for 78μs. it knows the system is being reconfigured and it initializes its NID to its own ID. It then starts a time-out equal to 146μs. times the quantity 255 minus its own ID. If this time-out expires with no line activity the RIM starts sending INVITATIONs TO TRANSMIT. (Note that this time-out will expire only in the RIM with the highest ID in the system.)

After sending an INVITATION TO TRANSMIT the RIM waits for activity on the line (the RIM receiving the invitation sending a FREE BUFFER ENQUIRY, PACKET, or INVITATION TO TRANSMIT or any RIM sending a RECONFIGURATION BURST). If there is no activity for 74 μs. the RIM increments NID and tries again. If it detects any activity before the time-out expires, it releases control of the line. During SYSTEM RECONFIGURATION, INVITATIONs TO TRANSMIT will be sent to all 256 possible IDs (ID 0 is also polled). Each RIM, however, will have saved NID, the ID of the RIM that assumed control from it. From then until the next SYSTEM RECONFIGURATION (which will occur only when a new RIM is powered up or when a RIM gets dropped from the system due to line errors causing it to miss an INVITATION TO TRANSMIT), control is passed directly from RIM to RIM with no wasted INVITATIONs TO TRANSMIT sent to IDs not in the system.

The time required to do a SYSTEM RECONFIGURATION depends on the number of RIMs in the system and the propagation delays between them, but will be in the range of 24 to 61 ms.

A SYSTEM RECONFIGURATION is not required when a node is turned off or disconnected from the system. When the node that tried to pass the token to an absent node hears no response to its INVITATION TO TRANSMIT, it increments NID and sends another INVITATION TO TRANSMIT. This sequence continues until a node acknowledges the token.

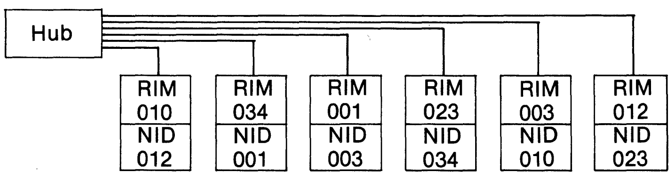

Figure 3-1: RIM ID and NID Example. Both ID and NID are independent of physical location.

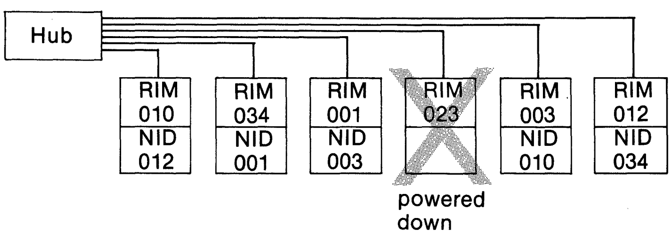

Figure 3-2: Network after RECONFIGURATION.

3.5

Data Exchange

When a RIM receives an INVITATION TO TRANSMIT it checks to see if it has a packet to send. If not, it sends an INVITATION TO TRANSMIT to NID (passes the token). If there is a packet to be sent, it tests the DID (Destination IDentification) byte of the packet. If this byte is 000 the packet is a BROADCAST and the RIM sends the packet. Otherwise it sends a FREE BUFFER ENQUIRY to the DID RIM and waits up to 74µs. for a response. If the response to the FREE BUFFER INQUIRY is an ACK, it sends the packet. If the response is a NAK it passes the token and will send another FREE BUFFER ENQUIRY the next time it receives an INVITATION TO TRANSMIT. If the RIM times-out waiting for a response to the FREE BUFFER ENQUIRY it sends an INVITATION TO TRANSMIT to NID.

After sending a packet the RIM waits up to 74µs. for a response. If it receives an ACK it passes the token. If it times-out waiting for an ACK (packets are never NAK'ed), it passes the token and will attempt to transmit the packet again the next time it gets the token.

When a RIM receives a FREE BUFFER ENQUIRY it tests to see if its receiver inhibited flag is set. If it is, it sends a NAK. Otherwise, it sends an ACK.

When a RIM receives an SOH (indicating the start of a packet), it writes the SID into the receive buffer and then checks the first DID. If this byte is 000 (indicating a BROADCAST) the RIM tests to see if reception of BROADCASTs is enabled. If reception of BROADCASTs is enabled, or if the first DID is the RIM's own ID, the RIM writes the second DID and the rest of the packet into the receive buffer. Otherwise it ignores the rest of the packet. If after being written into the receive buffer the packet fails either the CRC or length validation phases, the RIM ignores it. Otherwise it tests byte 001 in the receive buffer, the DID. If this byte is 000 the packet is a BROADCAST and the RIM simply sets the receiver inhibited flag. If this byte is the RIM's own ID the RIM sends an ACK before setting the receiver inhibited flag. If the DID is neither 000 nor the RIM's own ID, the RIM ignores the packet.

4.0

PERFORMANCE FACTORS

Generally, the most important aspect of local network performance is the amount of time a RIM may have to wait before being able to send a message. In a token passing scheme this waiting time is bounded by the time it takes the token to make the rounds of each and every RIM.

There are several possible sequences of events that can occur when a RIM receives the token. Two of these make up the vast majority of cases, while the others deal with error conditions, messages sent to non-existent RIMs, etc. The two cases of interest are a simple token pass and a message followed by a token pass.

A simple token pass takes about 28µs. (ignoring propagation delay). A message followed by a token pass takes about 141µs. plus 4.4µs. per byte of data (again ignoring propagation delays). Thus the time required for the token to make a complete trip around the network is approximately 28µs. per RIM plus 113 µs. per message plus 4.4 µs. per byte.

For example, in a system consisting of 10 RIMs and sending messages no longer than 100 bytes, a complete token trip will be at least 280 µs. (when no messages are sent) and no longer than 5810 µs. (when all 10 RIMs send a 100 byte message). If only a single RIM is sending messages, it can send one every 833 µs. a rate of 1200 messages, or 123,000 bytes, per second. If all 10 RIMs are sending messages, each one can send one every 5810 µs. a rate of 172 messages per second per RIM.