ArcoNet: A Proposal for a Standard Inter-network for Communication and Control in Real-Time Performance

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ABSTRACT

This paper proposes a standard local area network (LAN) be developed for equipment control and communication among performance systems, such as music synthesisers, tape players, lighting equipment, and slides, laser, and video projectors. The existing IEEE 802 standard, although useful, is too limited for such applications, and most commercial LANs are not designed for the requirements of real-time control. Hence a new network standard is proposed, provisionally called ArcoNet.

After introducing the proposed network and discussing its applications in the audio field in live performance, this paper examines the technical requirements for the network. A brief treatment of issues in local area network design is given, including discussion of the ISO reference model for Open Systems Interconnection and the CCITT X.25 recommendations for Message Handling Systems. A critical survey of existing LAN technology is presented, followed by a set of suggestions for the ArcoNet design. Finally, an overview of how to establish and propose the ArcoNet standard is discussed.

following the paper is an appendix which contains a set of specific suggestions for the ArcoNet standard. Though tentative and incomplete, it provides a basis for discussion of an ArcoNet proposal in concrete terms.

1. INTRODUCTION

Until recently, the concept of using computer networks in the studio as an in-studio performance was only an engineer's dream. That reality changed when the Musical Instrument Digital Interface (MIDI) was developed in the 1980s. Since then, the demand for such integrated systems has increased, and the potential of such integrated systems continues to grow. However, the full potential cannot be realized with MIDI alone. Hence we propose that a new network standard be developed for this purpose.

Connecting all devices involved in a live performance to a common network would give the same precise control with no need to worry about separate mixing of cues. In the recording or film/video production studio, having several devices on a network would save time by allowing complex sequences of events to be programmed in advance, without the need to change physical device connections.

Such networks could include not only musical instruments and signal processors, but lighting and projection controllers, cue transports, general and other input devices. Potentially, for devices which generate or are controlled by digital data streams could be connected. Thus in this paper we will speak of 'integrated multi-media networks'.

The MIDI standard, while it represents a major advance, is not a suitable foundation on which to build even modestly complex integrated systems. Its basic 48-kb/s format lacks any provisions for synchronous transmission or connection, and its bandwidth is too low to permit useful multiplexing of connections.

To realize the concept of an integrated multi-media network, some kind of local-area network (LAN) standard will be needed. We claim that although existing LAN designs may be useful, they cannot in general meet the demands of real-time performance applications. We further claim that because it is market driven, equipment manufacturers cannot be expected to design a suitable communication standard which will be backwards-compatible. Therefore it is up to the community of professional users to develop and promote a suitable network standard.

2. WHAT IS BEING PROPOSED

We propose that part of a standard digital network for real-time, data communication between devices used in performance and recording and then refined to an "dialect" of equipment to eliminate any indication of attachment, the name ArcoNet (Arts/Net's Computer Network) to refer to the proposed system.

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The four fundamental purposes of Archeid are as follows:

1. to permit the interconnection of different types of multi-media equipment to be standardized, if possible, to some degree.

2. there are many devices on the market which produce, or can be controlled by, digital data sources. These are also a physical interface to different pieces of equipment, such as SMPTPE and S/PDIF codes, digital direct digital ‘white’ connectors, and so forth. The first aim of Archeid is to provide a standard network on which these devices may be connected, so that they may exchange digital data and event signals.

3. a standard network will not be limited to any two pieces of equipment to be used separately. This will usually require the use of a network to connect each device to the network. Software to control the network, such as code, etc., and a defined approach to handling the instructions. A standard network will provide a foundation for new services on the technical level, and also make them more manageable on the practical level. Efforts to interface digital equipment can be viewed as developing a system of general use, rather than an expensive equipment which shall not be built within a single organization.

2. to allow multi-network components to be standardized for network control, data generation, processing, storage and distribution

An Archeid system would include at least one computer, which might serve as part of a master protection control console, where an operator could monitor and modify the progress of pre-programmed sequences.

The term sequence, as used in this paper, implies any programmed sequence of events. Examples would be musical time sequences, lighting control objects, and sequences of operations performed by slides, lasers, or video projections.

Software for developing and controlling such sequences would be the key to Archeid's effectiveness. As possible, the network should use available digital sequencers, such as the Archeid system. In other cases, the existence of a standard network with publicly-available specifications will foster the development of new software.

3. to provide for synchronization of multiple devices, by means of a system-wide master timing reference and asynchronous time encoding among any of devices.

Some consideration must be given to providing a master timing output (or “system clock”) to synchronize devices across the network. This facility should be independent of any digital reference (such as a master time clock and 100 base). The system should be designed to ensure that the master timing is accurate across all devices in the network.

In this paper, the term event means any single event within a performance, such as the sounding of a musical note, the projection of an image, a change in lighting, a passion movement of a human performer, and so on. Archeid's capabilities derive from the fact that it allows events to be programmed within the network to trigger at two, or other, events. In this way, a performance may be key to the actions of human performers for non-deterministic devices such as kinetic sculptures simulating an environment (system context).

It should be possible to calibrate a general model of event, signaling as part of the Archeid specification. This would foster the development of successful software such that sequences written for one device could include instructions to play data from another devices, or receive instruction from other devices.

4. to define a standard set of methods, protocols and programs (subject to minimal revision) for controlling existing and future multi-media equipment, which shall be built in the public domain.

For the Archeid idea to succeed, it is vital that it be accepted as the standard for multi-media equipment and development. Any proprietary systems can be used, but from the point of view of the standard, it will in general only apply to the establishment of a de facto standard. With a truly useful standard, many of the existing vendors will have access to the information they need to produce compatible products.

3. CONCEPTION OF THE ARCHEID SYSTEM

An Archeid network would be the form shown schematically in Figure 1. At least one general-purpose computer would be included for controlling the network, and at least one hardware core processor would be used in interface other devices to the network.

Figure 1: schematic diagram of an Archeid network

Archeid will be useful both in live performances and in motioning or pre-programmed production modes. In performance, which now consists music, one-person, and theatrical performance, all digital-connected devices used in a performance will be linked by Archeid, and we are or may encounter one content. It is also possible that specialized hardware devices, which are means to direct the motion of a dancer or dancer. To control the movement of this, could be included in the system and interfaced to the Archeid.

As a standard network, an which existing equipment could be interfaced, Archeid would provide a basis for simplicity and more.
4. REQUIREMENTS FOR ARCNET

The design of Arcnet should reflect the following three fundamental issues:

1. The importance of having the network design as sound engineering principles. It is vital that we study the general principles of network design, and specific networks before attempting to develop a new system. Careful consideration should be given to rigorous examination before adopting as part of the design.

2. The need to anticipate technological change. The present operating communication medium is coaxial cable, but an engineering breakthrough might tip the scales in favor of optical fibers in a few years. The design of Arcnet must be structured so that new technology can be "merged" with minimal redesign.

3. The need to accommodate as many existing technologies and standards as possible. For Arcnet to succeed it must become a de facto standard. This cannot happen if an important technology (such as IMMPTE synchronous or MII) cannot be used with it.

It is also important to keep the cost of Arcnet within reasonable bounds. An extensively expensive system will never become a de facto standard. But so long as mentioned, the final design must cost compete with existing engineering for the cheapest. It should be possible to market standard Arcnet node processors for under $1,000. Each arcnet controller (plug-compatible with all-sea series computers such as IBM PC) for under $100. Even these prices are conservative—it should be possible to bring them down lower.

The design of Arcnet should follow logically from experimenting with other LANs. Therefore it should have a logical architecture, permitting some measure of hardware independence. This time is elaborated in the next section.

Experience has shown that it is often desirable to connect several LANs to form a supernetwork. This requires hardware bridging devices called "routers," which act as nodes on two or more networks simultaneously and allow information to pass from one to another, and inter-networking protocols, which regulate this information exchange. Inter-networking protocols should be designed as an Arcnet from the start.

Standard protocols for Arcnet's basic functional interface, operating, and inter-node communication must be defined and published. Protocols for other types of messages, such as path message communication and DUTI, must be also be developed. These standards can form the basis of a third-party software program written by others that can be marketed and sold.

Having all these in a performance setup linked by high-bandwidth cable suggests other possible uses for the cable. It should not be difficult to include digital voice signaling in the "interleaved" communication over the network. Digital voice can be used to playback pre-recorded cans for human performers or technicians.

Initial, only a few classes of Arcnet node processors should be
needed, it allows connecting various classes of equipment to the network. As Amantel/MEDU has built-in redundancy between one and eight MEDUs (in our case, seven). Connections. An Amantel/MEDU box, with two or eight RS232 serial connections, could be used with devices controlled through this interface as well as ordinary data terminals. Plug-in boards for connecting terminals would be defined for various buses, such as Apple II, IBM PC, and Multisens or VisiData (e.g., Visi-bus workstations), so that less than a dozen basic designs should be enough to build every complex network.

These protocol nodes will allow Amantel to embrace many existing interface standards, at least at the hardware level. We can go further and imagine that Amantel supports the standard scheme for transportation-level protocols, as most systems do well. For example, since the 56200 protocol-level protocol defines several types for remote computers, we do not need to change our protocol. Communication protocols can be built with integrated Amantel interfaces, allowing each user control over operation of devices currently available under MEDU.

5. DESIGNS IN LAN DESIGN

This section briefly introduces the most important aspects of LAN design—in this case, the most important, the Amantel scheme gives an excellent treatment of networks in general, while Vidal (1983) covers local networks in particular.

5.1 Packet Switching

Most network designs are built on the concept of packet switching. Long communications between pairs of nodes are divided into small blocks of data called packets. Each packet includes some information specifying the intended recipient. This technique, combined with effective data rate, is seen in a slow-speed low-speed network. Through packet switching, several devices which need to communicate can share the network transmission facilities, and result in a simple-channel system.

5.2 The ISO Reference Model for Open Systems

Interconnection

The complexity of computer network design suggests that they be broken up into layers. The usual approach is to consider a network as a hierarchy of layers, each of which is independent of the lower ones. Recently, the International Organization for Standardization (ISO) has published a standard reference model for networks (Carayannis 1983), which has been widely accepted. This model, which is shown schematically in Figure 2, identifies seven distinct layers which may exist in a network design. Each layer provides a set of services to the layer above, by building upon the services provided to it by the layer below. Each layer is implemented in hardware/software, or of a combination.

![Figure 2: OSI model showing 7 connected stations](image)

These seven layers are not cost in stone. Some network designs may omit one or more lower layers or implement the functions of two or more adjacent layers in a single system.

Most network consist of a set of computers called hosts connected by means of a communications device. In larger networks, the system consists not only of communication links but also of computers which serve to move data around the network. Figure 2 shows two hosts, where communication is handled by an intermediate computer. The latter need only implement lower-layer protocols of the ISO model (those connected with actual data transmission). Most local-area networks are relatively simple; that is, there are no subnetworks or subnetworks in a single system.

The subnet is usually considered to be formed by the physical, data link, and network layers of the OSI model. The physical layer consists of the transmission medium and the mechanical and electrical standards for accessing that medium. It provides the service of physically linking all parts of the network. The data link layer consists of a network interface circuit, and provides the service of sending data between stations and in a direct transmission. The network layer supports the operation of the subnet and ensures that transmission errors are corrected, usually by retransmission of bad data blocks.

Higher layers in the OSI model are concerned with how the basic communication facilities provided by the subnet is used. The transport layer provides a straightforward way for programs to communicate over the network, which is unknowable of the results of the subnet's operation. The session layer provides services to the application level. The presentation layer provides services to the application level.
With a hierarchically layered design, each layer can be implemented without regard for the details of how other layers operate. For example, a subnet based on optical fibers could be substituted for one based on coaxial cable, without having to change the transport, network, host, or application layers or protocols.

Another consequence of hierarchical design is that protocols—sets of rules governing communication—can be designed separately for separate layers. When layer 4 communicates with layer 3, one may consider that layer 3 has a stream of data coming directly with layer 4 on layer 3 and vice versa. The fact that the communication must pass through layers 1 through 31 on both machines is of no consequence. The two primitives in layer 4 are called peer protocols, since communication is governed by the layer-3 protocol.

5.3 The CCITT X.400 Series Recommendations

Another international standard which may have a bearing on A-I's work is the X.400 series recommendations from the Consultative Committee on International Telegraphy and Telephony (CCITT) (1983). These define how networks based on the ISDN model can be used for the exchange of messages between users, as in electronic mail. Accurately, the primary purpose is to carry messages such as event signals between devices, whereas the X.400 recommendations may provide a useful framework in which to express its design.

Recommendation X.400 will be particularly important. It gives a standard method for defining how data are to be encoded at the presentation level, including a standard syntax for expressing some definitions in print. This will be useful in defining new presentation-level protocols.

5.4 Subnet Design Issues

Wood (1985) identifies seven major design parameters for a LAN. These are topology, transmission medium, signalling mode, access method, data rate, cabling device, and type of interfaces.

A network's topology is the pattern formed by its communication links. Typical topologies are the star, bus, and ring, shown schematically in figure 2. Note that the topology may not be apparent from the physical layout of a network. Figure 3 shows how a ring network might be laid out in the form of a star. The most popular transmission media are twisted-pair cable and coaxial cable. The former offers better noise resistance, while the latter offers higher bandwidth. Optical fibres, which carry an optical medium in virtually all respects, will require expensive expensive optical hardware.

Networks may operate either half-duplex or half-duplex. Signalling, in broadcast, two voltage signal levels, representing binary 1 and 0, are impressed directly onto the transmission medium. With broadcast signalling, no binary signal is used to modulate a higher-frequency carrier signal.

The access method determines which station may transmit on the subnet at any particular instant, and is in part of the ISO network layer. Time-division multiplex allows each station a certain amount of

time on the network. Polling methods use a central controller to tell other myriad of its own turns to transmit. In a reservation method, each station can request to be given a right to transmit a message before putting it on. In connection-based methods, stations will transmit whenever they can transmit medium is free, with special access being taken when two stations communicate "outside".

A network's data rate Gauge on the network. A network's data rate is based on the total number of bits which may be exchanged between nodes in a given time. Most LANs today operate at rates between 1 and 10 million bits per second (Mbps). Medium connections require 30,000 bits per second (0.0125 Mbps), so a 1 Mbps network could potentially support over 30 simultaneous MDE connections without introducing significant delay.

To be cost-effective, network interfaces must be based on conventional large-scale integrated circuits (LSI) chips. Such chips, which implement most of the data link layer of the ISO model, are now available for the bus and ring topology networks. Some form of microprocessor will also be needed, with LMA (linear memory)

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section) capability to move information to and from the network at high rates. The IEEE has proposed a set of draft standards for LANs (Ethernet (1983), which include standards for both thin and broad-band CSMA/CD - style basic systems and backhaul token rings. These standards will likely be implemented in new IBM ships. The coexisting design may be useful for Anecho, since token-passing and other predictable message delays.

As mentioned earlier, only a few types of interface boxes will be needed, including Anecho/MH, Anecho/eth, and plug-in cards for pepcon computers.

5.5 Low-level protocols
Three issues are important in designing data link, network, and transport protocols for Anecho. The first is error detection and recovery. It may be possible to detect and correct errors due to noisy transceiver media, and Anecho's real-time nature further demands that this be done quickly.

The second issue is that different levels of transport service will be required. A big message from a computer to a computer cannot be delayed to clear up the network and delay event-urgent messages.

Finally, the protocols must avoid deadlocks and starvation. Deadlock occurs when two stations are stuck, each waiting for a message from the other before proceeding. Starvation occurs when some station is never allowed to transmit, so it is never allowed to do so sufficiently often. These two possibilities must also be avoided at the session and application levels.

5.6 Presentation Level Protocols
Anecho will need a common protocol for signaling events across the network. Each event will typically be represented by a short message from one station to one or more others, including only a single number representing the type of event. Although this is a presentation-level concept, it must be supported by lower-level protocols to ensure that event signals can be sent and received with very short and deterministic delays.

A variety of useful presentation-level protocols, or data-encoding schemes, have been defined. These include ASCII for text, RHAPS (ANSI (1982), Lay and Olsson (1983)) for volume, and the MHDE messages for particular events. It is important to note that Anecho can and should support these existing protocols, as well as new ones which may be desired later.

6. SURVEY OF EXISTING DATA COMMUNICATION TECHNOLOGIES
This section discusses some of the leading LAN and data-interfaced technologies in current use, and assesses their applicability to Anecho.

5.1実は: A Discussion and Critique
The Musical Instruments Digital Interface (MIDI (1983), Lay (1985)) is an interface standard primarily designed for point-to-point connections between instruments, composers, and digital processors. In terms of the ISO reference model, MIDI defines a physical layer (MIDI cables and connectors), a data link layer (the 3125 Kbps serial transmission mechanism), and a presentation layer (the message and their meanings).

It is a tragedy to the success of this standard that most new synthesizers and signal processing processors since about 1982 have been equipped with MIDI interfaces. This success has led some manufacturers to see MIDI as the basis for integrating all equipment in a studio or multi-track setup in a kind of LAN. However MIDI is not suitable as the basis for a useful LAN for several reasons.

First, MIDI is a simple protocol. Each MIDI connection carries data in one direction only, hence a sender as a receiver, without permitting the receiver to respond in any way. Such an acknowledgement capability is vital for error-avoiding protocols. (While error-correcting codes exist for use with simple channels, they are quite inefficient.)

Second, MIDI's data rate of 31250 bits per second is just too slow for use in a multi-access network. When driving several synthesizers on different MIDI channels from a single MIDI port, the narrow bandwidth limits this port speed.

Third, MIDI provides only 16 logical channels, or 256 addresses. To be useful, a LAN should provide at least 256 addresses. A related problem is that it is totally necessary to manually preset MIDI-based devices onto the desired channel after each power-up (and manually reset them, if something goes wrong). Without a 256-channels system, it is impossible to mix several devices to a single MIDI line, but with only one transmitter. Although various "multi" extenders have been developed in an attempt to overcome this, the MIDI standard itself imposes absolutely no provision for multiple transmitters during the same line.

It is possible to design a star-network based on dedicated MIDI connections (both host and machine) between a central computer and each device. This approach circumvents all the above problems, and will undoubtedly be tried commercially. However it is still has all the problems inherent in star networks, presently the fact that each new node added to the network will require new MIDI interface support on the control computer.

Finally, although a revised "MIDI 2.0" standard is expected soon, which potentially will clear up some of MIDI's present defects, it is unlikely to be sufficiently improved to form the basis for a useful LAN. This is because MIDI is essentially an interface-standard which can only be partially connected to others--rather than a multi-access network standard.

6.2 Commercial LAN Products
Various all commercial LANs are designed to allow computer resources (i.e. processors, printers, disks) to be shared within an
other environments. Hence they would be designed for large data transfers rather than short messages, and for efficient use of costly cable rather than real-time performance over inexpensive cable. These differences make it unlikely that commercial LAN products would be usable, unchanged, for Arecibo.

Probably the best-known LAN design is Ethernet (DEC 1980). This is a connection-oriented, two-topology network using broadcast signalling (usually at 10 Mbit/sec) over special coaxial cable. Ethernet pioneered the CSMA/CD access method (Carrier Sense Multiple Access with Collision Detection), which uses the cable bandwidth well but places an upper limit on the time taken by a message to reach its destination. The later makes Ethernet unsuitable for demanding real-time applications.

Haugland (1984) has surveyed the LAN product offerings for IBM PC and compatible machines, and reports that in 1984 a number of totally incompatible systems were available. None of these products are likely to be usable unchanged for Arecibo, but in some cases they embody excellent design ideas which should be examined carefully.

Mirent (Wood 1983) is a broadband bus network which uses standard community antenna television (CATV) cable. It carries one or more digital data channels using CSMA/CD, and permits several video, FM radio and voice channels to share the same cable. Elements of this product's subnet design might be adopted for Arecibo.

IBM Corporation has recently announced its token-ring network (IBM 1985), Simics (1986), which is a switched coaxial cable ring network using token passing for access control. The fact that this network conforms to the IEEE 802.6 standard for token ring systems adds extra weight to the IBM standards. The cost of IBM's network components is very high, however, so they would probably not be usable for Arecibo.

6.5 Computer buses and the GPIB Bus

Many experimental systems have been built (including some for computer music) in which special-purpose devices are plugged directly into the computer, store and data buses of a general purpose computer. This approach has some distinct advantages, but could not be used in the Arecibo subnet because of the high cost of two interfaces and cables, and the fact that two cables cannot be run over distances greater than a few feet.

Another bus technology is the General Purpose Interface Bus (GPIB), also called the IEEE 488 bus developed by Hewlett-Packard corporation (Hewlett 1982). This is a parallel bus (where several bits can be sent at once) designated for controlling electronic test equipment in a computer. The GPIB's guidance requirements are not so strict as those of a general-purpose computer bus. Once again, though, the cost of multiple-cable buses makes this technology unsuitable for Arecibo.

6.6 Other High-speed Interconnects

Some manufacturers and microprocessor manufacturers have looked to high-speed parallel interfaces, available on some microprocessors, as alternatives to Arecibo. An example is the Kernwell Instruments' use of the RS-422 port on the Apple Macintosh computer, described by Byrd and Yewell (1985).

These interfaces, although much faster than 1 Mbit/sec, are still designed for point-to-point communication rather than networking. In contrast to a true LAN, however, with connections would be useful for moving data between specific devices in a network with very low bandwidth, which makes them useful for applications requiring real-time synchronization.

7. DESIGN SPECIFICATIONS FOR Arecibo

The Arecibo specification must express a consensus of opinion of all interested parties, if this stage it is too early to prescribe the network design in detail. However, given the discussion of LAN design and technology in the previous sections, we can identify at least some desirable aspects of the proposed network.

The ISO reference model for Open Systems Interconnection has been accepted as an international standard, and its terms of reference are rapidly being assimilated into the "ecology of design engineers. Hence the Arecibo architecture should be specified in terms of this model.

The following paragraphs roughly follow the ISO model with attention to the requirements of Arecibo's design.

The ISO 802 draft standards for Local Area Network subnets are also being accepted by engineers, and it is likely that these standards will be implemented in commercial LSI chips. Arecibo will benefit by following these standards, by being able to use the chips.

Existing LAN subnet designs should be examined closely to see if they can be used for Arecibo, because using existing components is nearly always cheaper than designing new ones.

The subnet will likely have a star or ring topology, using coaxial or twisted-pair cables. The cables should be inexpensive but also durable and reliable, since Arecibo networks will need to be set up and taken down many times in five performance applications. CATV cable will be a good choice, because it is inexpensive and very easy to terminate (connections are cheap and can be assembled without soldering).

Existing physical and data-link standards, such as IEEE 802.3 and RS-422, should be considered for connecting equipment to Arecibo nodes processors. As already mentioned, only a few input/output types, each having a different kind of external device interface, should be considered for most application.

Each node processor should contain a microprocessor, memory, and a network interface based on a standard LSI chip. This chip will implement a standard data link protocol, and forward the microprocessor will implement a network level protocol which provides for delivery of messages from any station to any other station or group of stations, with automatic error detection and acknowledgement of receipt. The reliable multi-drop operation, a deterministic-delay access method such as token passing should be chosen.

At the transport level, at least three classes of service should be available. A new service, providing for transmission of messages

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from one station to one or more others, with acknowledgment but no error correction, could be used for digitized voice transmission. A design-time version would provide error transmission with error correction, and would be used for error-sensing signals. A protocol specification, using message buffering to allow stations in the communication to determine correct use of the system, will be useful for MIDI applications.

At the station level, delivery and acknowledgment would message classes should be defined, together with a way of sending programs to the microsystems in each station. At the presentation level, a class of error-corrected messages would also be defined, each event being represented by a number in the message, with network control software on the application layer defining the communication of events at even stations.

System ways of using existing presentation-level protocols within Anarchist should be adopted. For example, MIDI messages would usually be sent over virtual-circuit connection, with packet buffering software knowing about MIDI to operate efficiently without delaying messages.

The Anarchist specification will have to include some protocol development level network management software which will react to the application level, such as software that will monitor MIDI traffic and aid computer configuration, sound, and control of stationethernet, assignment of event numbers to potential events, and synchronization of real-time clock signals across the network.

After configuration, software distributed within the network would be concerned with the playback of events as (see sec. 2). Since sequences would be used by particular events, it would be feasible to specify alternative assignments, to be evaluated conditionally depending on which of several cases was involved in a given time. This would help ensure integrity against the "tyranny of tape", which implies that once a sequence playback is started it generally cannot be stopped or saved to match live music.

Application-level software for Anarchist will operate primarily through the transport of local messages between stations. In keeping with earlier suggestions about correspondence to integrated standards, such software should conform to the C2465 X.400 conventions for Message Sequencing System similar as possible.

Further ideas for Anarchist, solely of which are theoretical, are given in some papers.

8. GETTING THERE FROM HERE

Accepting that a standard LAM, designed specifically for the needs of digital music with integral access, is desirable, we need what steps are necessary and possible.

We now already understand the importance of establishing Anarchist as a self-contained, universal sound and music system. This can only be accomplished by testing out a complete, and fully enclosed, description of the system we want, before development has proceeded sufficiently to a different design. As potential users we can probably define what we would like to have, but as your standards are controlled by the proliferation and use of real, working products.

It is vital that the Anarchist architecture and protocols be fully public, both to avoid any anti-competitive tactics and to ensure that individual users can develop their own software. Thus, the initial process of defining the specifications for the most protocol Anarchist is intended to evolve existing technologies rather than replace them.

The Anarchist specifications will have to be workable not to support anything all interested parties. Some version of a group of people will be the basis of cooperation and development of ideas. The help of existing groups such as the Computer Music Association and the International MIDI Association should be solicited. Supporting funds should be secured without compromising the public nature of Anarchist in any way.

When the Anarchist specifications are complete as the point of being viable, they may be published in some form distributed. This would be handled either by the groundwork group mentioned above or by a commercial distributor. Considerate efforts will be required to define and promote the Anarchist standard. The responsive, however, is unique in which select few 1% are optimal receivers.

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APPENDIX: TOWARDS A FIRST-LEVEL SPECIFICATION FOR ANARCHIST

The preceding paper was intended to propose that there be an Anarchist standard, not to define the details of that standard, and hence no detailed technical recommendations were given in that paper. This appendix gives a set of specific suggestions for Anarchist which, while somewhat near complete, should provide a starting point for further discussion.

Submit topology: A ring should be used, which in turn is embedded in a binary tree. The root is point-to-point connected a ring without having "pair-wise" addresses to each. However, each node must include pointers to bypass it if the power fails.

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### Section 3: Automatic configuration

#### Automatic configuration page

- **Objective**: Determine the initial configuration parameters for a network.
- **Procedure**: Use automated algorithms to analyze network traffic and adapt settings dynamically.
- **Benefits**: Improved performance, reduced maintenance overhead.

#### Automatic configuration step

- **Step 1**: Identify network segments.
- **Step 2**: Assign appropriate configuration settings.
- **Outcome**: Optimized network performance for each segment.

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### References