Proceedings of the Institute of Acoustics

DIGITAL AUDIO NETWORKS, PRACTICAL ISSUES IN MAKING THE SYSTEM WORK

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1. INTRODUCTION

The objective of this paper is to highlight the hidden problems facing the un-initiated in the implementation of distributed digital audio systems. Manufacturers of the relevant equipment are keen to point out the merits of their particular products and the advantages over `BRAND X' but are not generally as forthcoming about potential problems in use.

It is true to say that most manufacturers of these systems do have good product support often supported by web sites. These do not however generally advise on implementation and expect the user to have the appropriate knowledge to achieve this themselves.

2. BEWARE! HIDDEN PITFALLS

So what problems can we expect? You just take two units, plug in a bit of interconnecting cable and away you go. Unfortunately life is never that easy and a number of potential problems await the unwary. The first obstacle to be overcome is the design & implementation of the network and this is very dependant upon the product chosen and it's suitability for the design goal.

3. THE RIGHT PRODUCT FOR THE JOB

We are dealing with distributed systems so this effectively eliminates stand-alone units with no network capabilities. Suitable products are manufactured by a number of companies a few are: -

BSS - Soundweb
Peak Audio - CobraNet with units from Peavey,
QSC
Bi-Amp
Etc.,
Klotz Digital - Vadis

Each of these has it's own method of interfacing into a network, for example the Klotz Vadis uses a on board fibre optic link whilst the BSS Soundweb uses a simple Cat5 connection between units and a network hub. The Peavey implementation of CobraNet uses external third party hubs or switchers connected by Cat5+ or fibre.

The most suitable product for a particular system will depend largely on a number of system design requirements: -

- Is a star or ring topography required,
- What, if any, level of redundancy is required,
- How much DSP processing,
- How many simultaneous audio channels,
- Is it a life safety critical system?

In looking at practical implementations, for the purposes of this paper we will consider three basic systems types: -

BSS - Soundweb,
Peak Audio - CobraNet (Peavey implementation),
Klotz Digital - VADIS.

This is not to say there are no alternatives only that experience with these different systems serves to highlight both the similarities and differences in use and the implications of creating a successful networked system.

4. SYSTEM TOPOGRAPHY

The topography chosen immediately brings into consideration the number of channels required for each of the examples.

4.1 Star / Radial Systems

When creating a Radial network, each of the examples has it's own limitations. For example, with the Soundweb each network link carries 8 Tx channels and 8 Rx channels and without additional hardware the maximum number of devices that can be directly interconnected is limited to three giving a maximum system capacity of 24 inputs and 24 outputs. (Diagram 4.1).

With a Peavey CobraNet system each network spur is capable of handling 64 channels equally split between inputs and outputs. Without additional third party hardware only one unit can be connected to a network giving a maximum of 16 inputs, 16 outputs or 8 of each. As shown on diagram 4.2 the use of a hub or switcher allows the full channel complement of 32 inputs and 32 outputs to be used.

The Vadis is a modular system and inherently more flexible in creating networks with each network module capable of handling 64 channels and carrying all these to a remote frame. The channels are effectively an extension of the 256 channel backplane and can carry any combination of inputs and outputs. A total of 4 network modules can be supported. The limitation is however the available space for signal processing & I/O cards. (Diagram 4.3).

4.2 Ring Systems

The major problem when creating a true ring topology is ensuring a continuous, closed loop, data path is not created whilst ensuring all required audio signals are carried where required.

Consider the system in diagram 4.4. A source presented to input A can appear at outputs only if the intermediate nodes are configured to receive and either retransmit or loop the data.

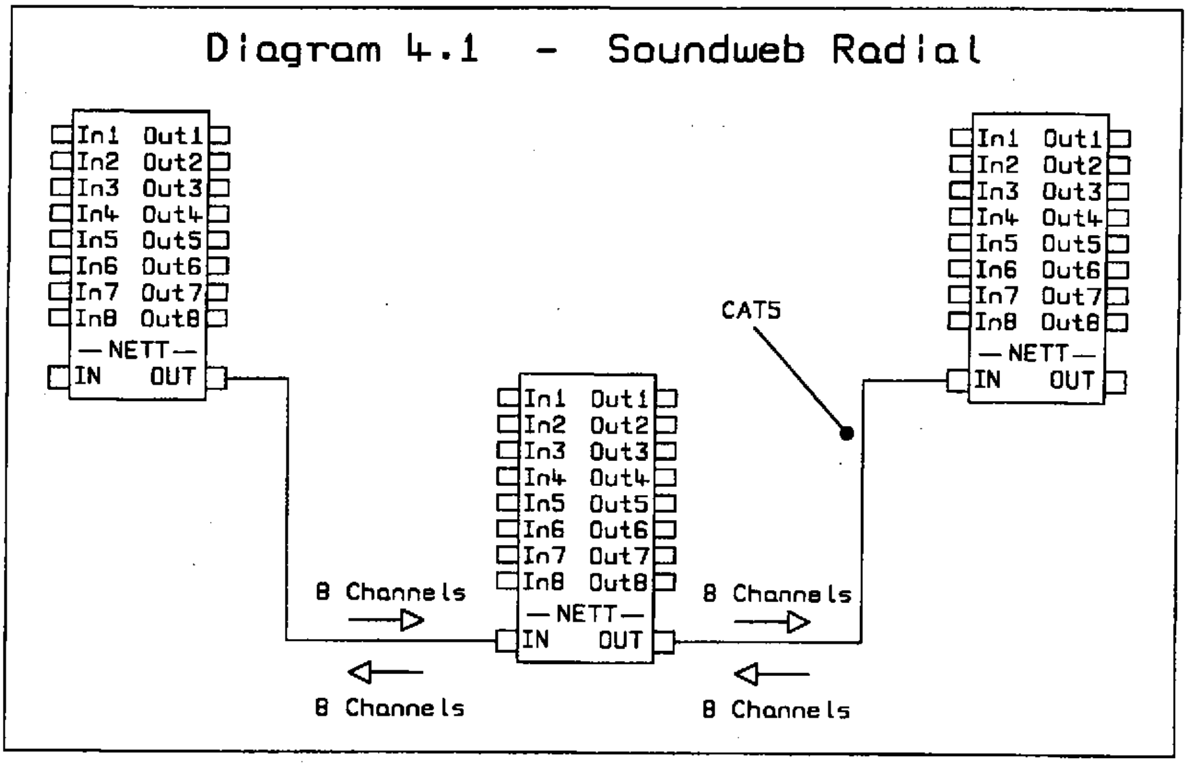


Diagram 4.1 - Soundweb Radial
In1 Out1
In2 Out2
In3 Out3
In4 Out4
In5 Out5
In6 Out6
In7 Out7
In8 Out8
— NETT —
IN OUT
CAT5
8 Channels
8 Channels
8 Channels
8 Channels

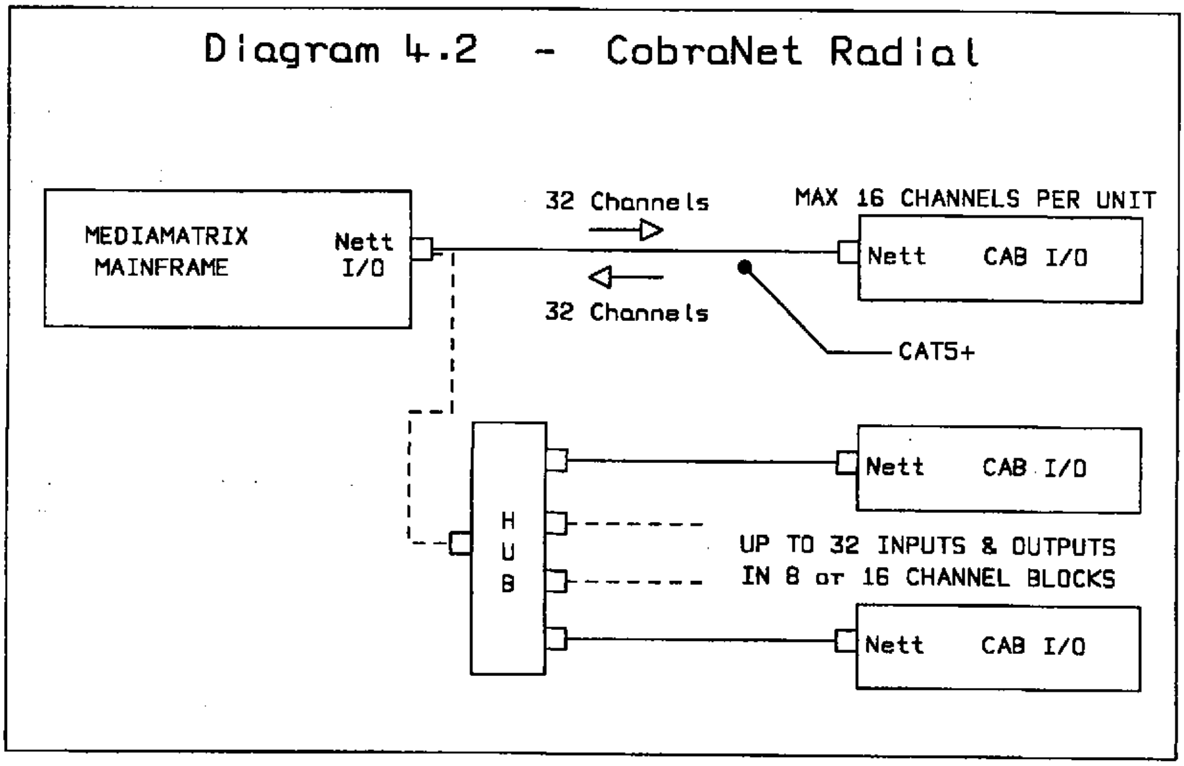


Diagram 4.2 - CobraNet Radial
MEDIAMATRIX MAINFRAME
Nett I/O
32 Channels
32 Channels
MAX 16 CHANNELS PER UNIT
Nett CAB I/O
CAT5+
HUB
Nett CAB I/O
UP TO 32 INPUTS & OUTPUTS IN 8 or 16 CHANNEL BLOCKS
Nett CAB I/O

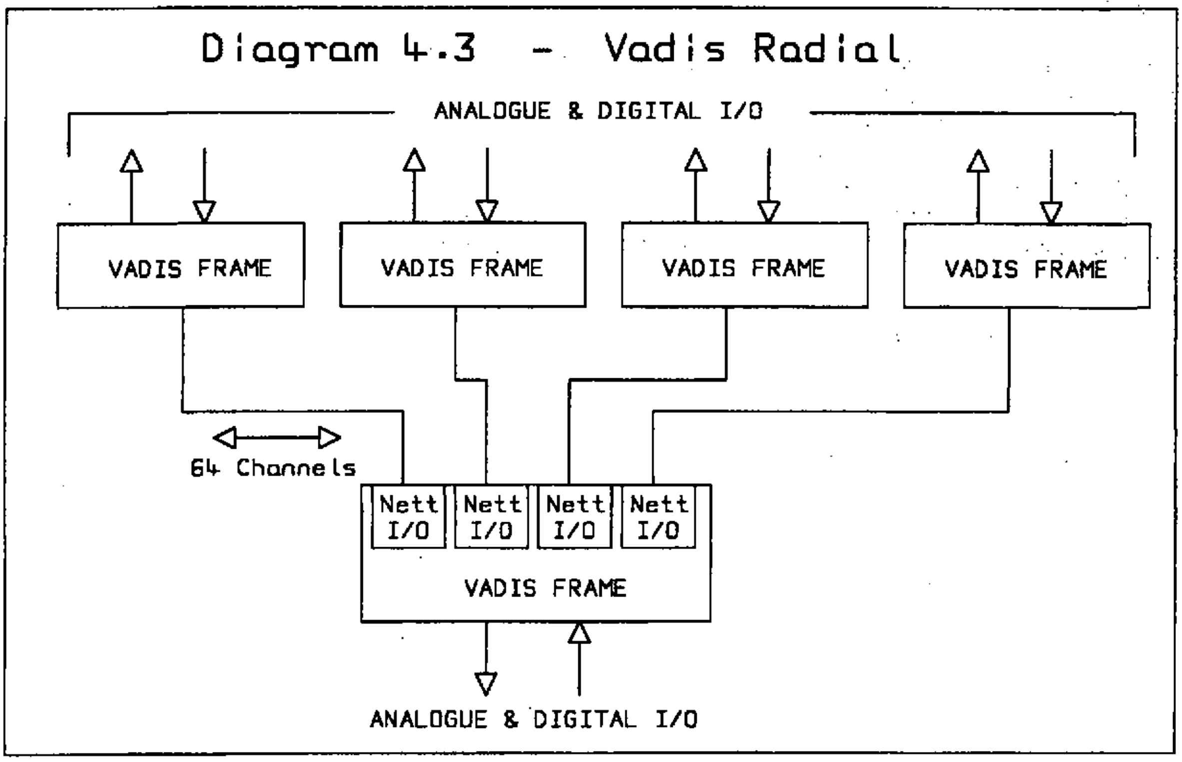


Diagram 4.3 - Vadis Radial
ANALOGUE & DIGITAL I/O
VADIS FRAME
VADIS FRAME
VADIS FRAME
VADIS FRAME
64 Channels
Nett I/O
Nett I/O
Nett I/O
Nett I/O
VADIS FRAME
ANALOGUE & DIGITAL I/O

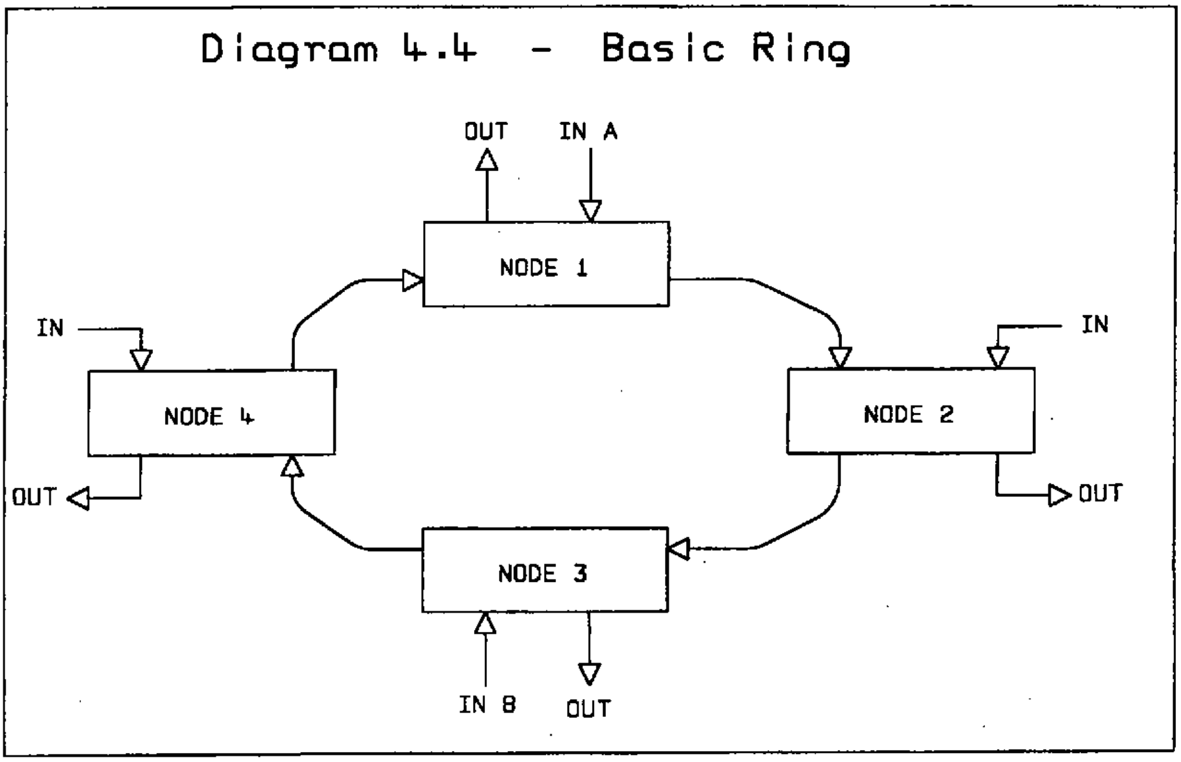


Diagram 4.4 - Basic Ring
OUT
IN A
NODE 1
IN
IN
NODE 4
NODE 2
OUT
OUT
NODE 3
IN B
OUT

This also applies to the originating node if this is to receive inputs from another nodes input i.e. input B.

With a pure master slave system, for other than a life safety critical system, this last link of the ring is not required so no problem exists. For multi-master systems, as per the three examples, they have the ability to introduce inputs at any node so this is not an option.

Our three examples all have alternative methods of eliminating this problem that whilst similar in concept are very different in implementation. Perhaps the simplest is the Vadis method (diagram 4.5) that uses no additional hardware to create a true ring and uses software configuration to assign channels to be carried over each section of the network. This will allow any signals generated within a node to be omitted from the data stream reaching the originating node from the previous node on the network. The Vadis system only supports network interconnection via fibre-optics.

The system is slightly more complicated with the CobraNet as additional third party hardware is required to create a ring (diagram 4.6). It is important to note that whereas network hubs were used in the radial system, it is essential to use network switchers with spanning tree capability for a ring system. It is not within the scope of this paper to discuss the difference between hubs and switchers but further information can be obtained from the web site in appendix 1.

In this implementation the same potential problem exists but with a twofold solution. First the sources all have a software defined channel address to identify their allocation as groups of 8 channels within the 64 channel availability. The second requirement is to configure the switchers using their own software to enable what is known as a spanning tree to stop the data from being passed from node to node ad infinitum. Simplistically the spanning tree identifies channels originating within a network node and blocks the retransmission of these channels if they are received from another node. Unfortunately this does require two sets of different software to be configured.

Interconnection between switchers can be by either Cat5+ cables or fibre optics as preferred.

Without additional hardware the Soundweb can create a virtual ring (diagram 4.7). In this case the eight return channels create the ring with software manipulation required within each Soundweb to ensure that no closed loops are created. With additional proprietary hardware a true ring network can be created (diagram 4.8). Software configuration will be required in both the hubs and Soundweb but the manufacturers have created a simple 'device' to make this easy to achieve.

Network interconnections can be by Cat5 cables or fibre optics.

In all the above examples we have seen that a true ring system is possible with software and / or hardware manipulation. The Star / Radial system is easy to implement for smaller systems whilst the ring topography is more suited to larger distributed systems and essential for fault critical and life safety systems. Whilst irrelevant for radial systems, of significance with larger ring systems is the effects of any propagation delay within hubs, switchers, fibre converters etc.. Unlike pure data networks, audio distribution must be contiguous and real time with network latency a major issue particularly on larger systems.

4.3 Redundancy

The requirement for redundancy in equipment and distribution for critical and life safety systems is well documented. All three of the sample systems have a facility to incorporate this as a feature of the network but the actual method of achieving this is different.

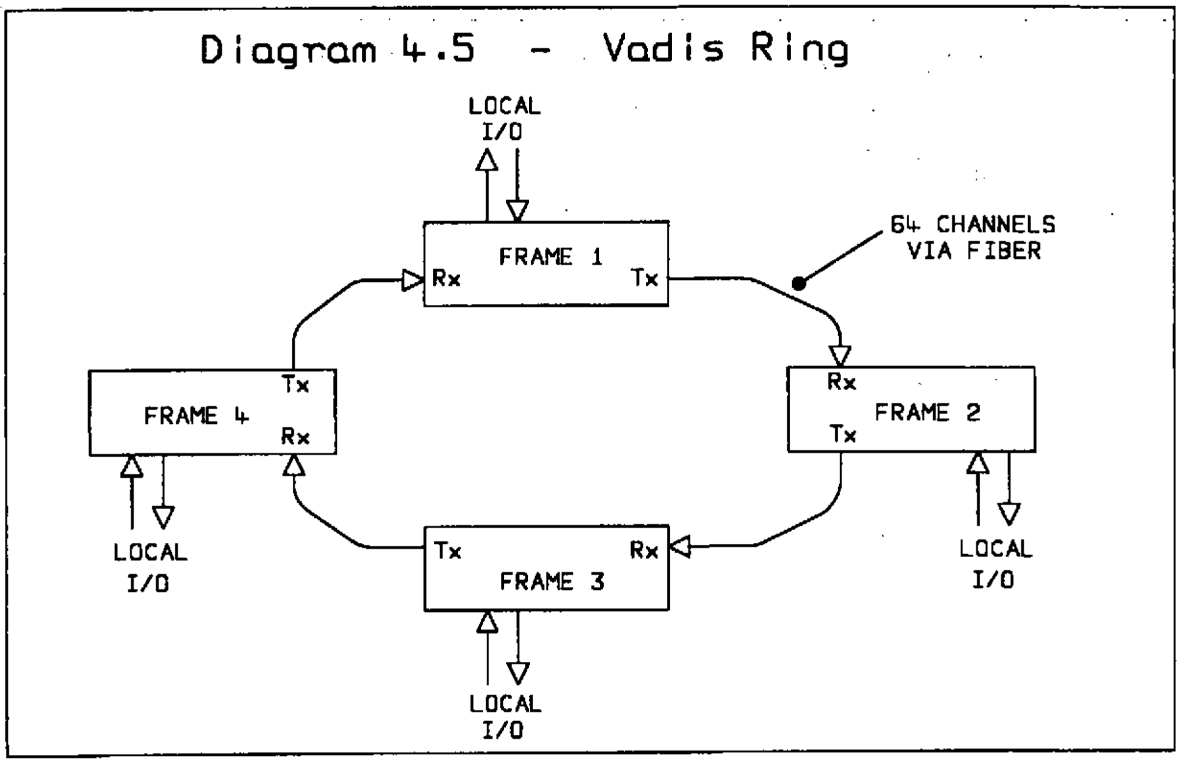


Diagram 4.5 - Vadis Ring
LOCAL I/O
FRAME 1
Rx
Tx
64 CHANNELS VIA FIBER
FRAME 2
Rx
Tx
LOCAL I/O
FRAME 3
Tx
Rx
LOCAL I/O
FRAME 4
Tx
Rx
LOCAL I/O

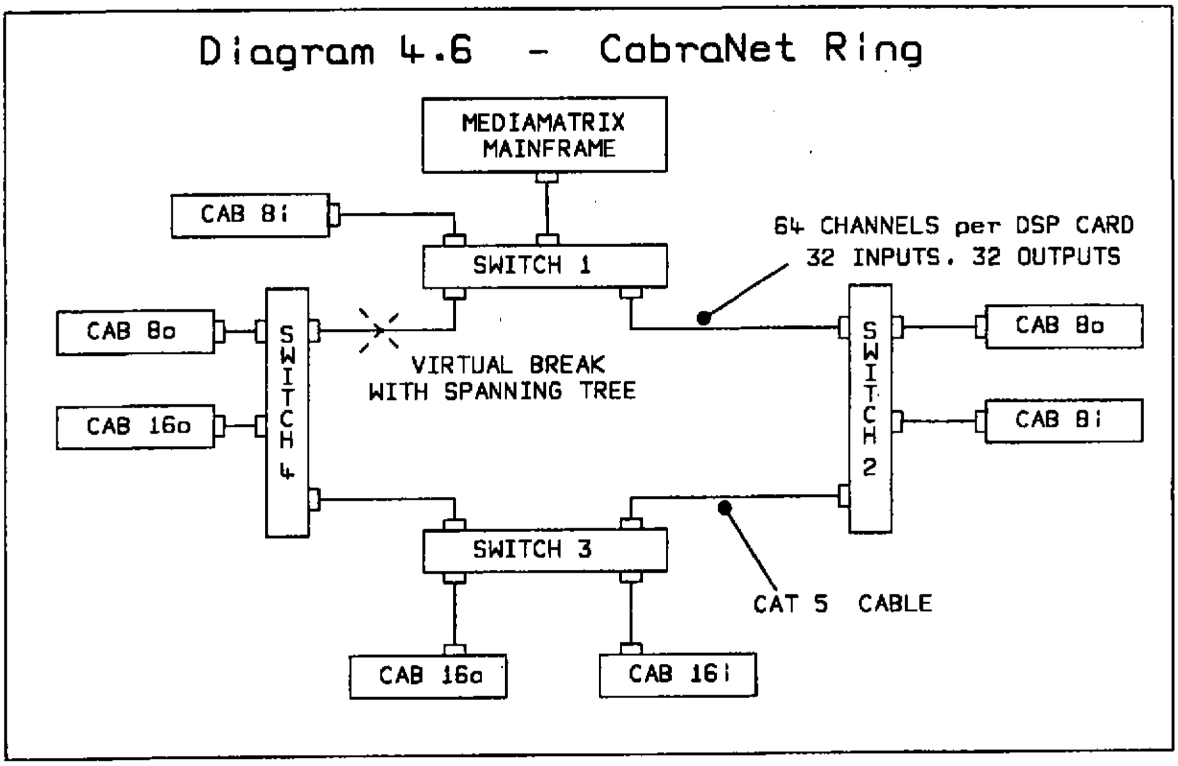


Diagram 4.6 - CobraNet Ring
MEDIAMATRIX MAINFRAME
CAB 8i
SWITCH 1
64 CHANNELS per DSP CARD
32 INPUTS, 32 OUTPUTS
CAB 8o
SWITCH 4
VIRTUAL BREAK WITH SPANNING TREE
CAB 16o
SWITCH 2
CAB 8o
CAB 8i
SWITCH 3
CAT 5 CABLE
CAB 16o
CAB 16i

Diagram 4.7 - Soundweb Virtual Ring

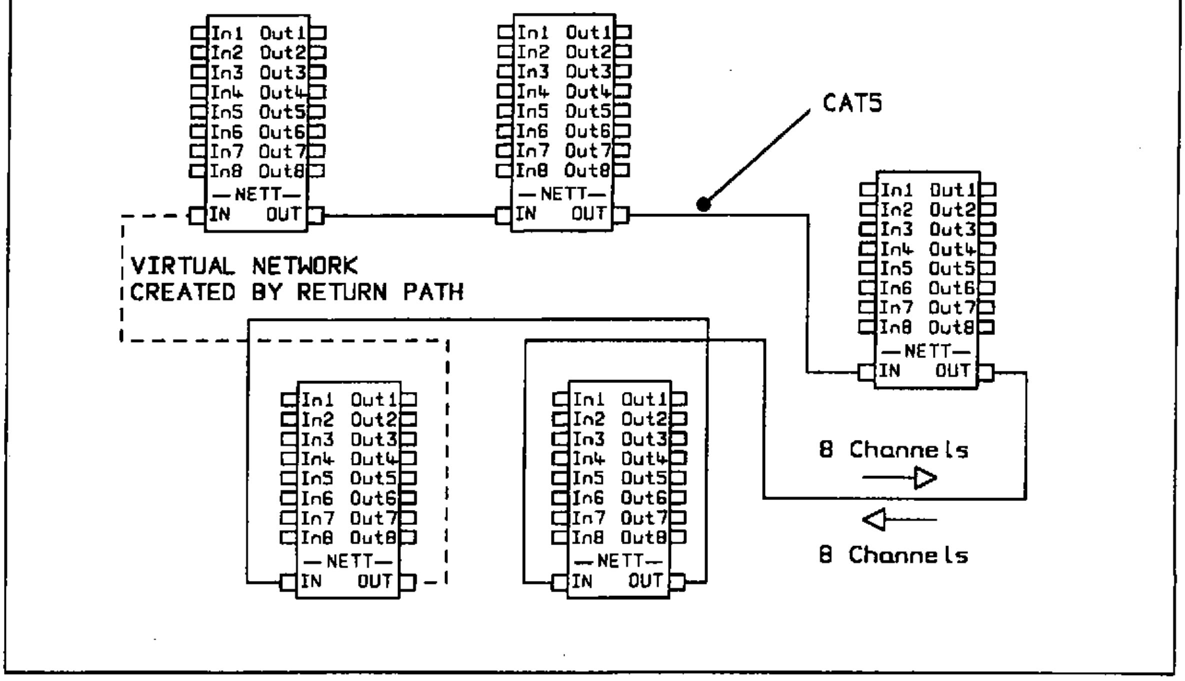


Diagram 4.8 - Soundweb True Ring

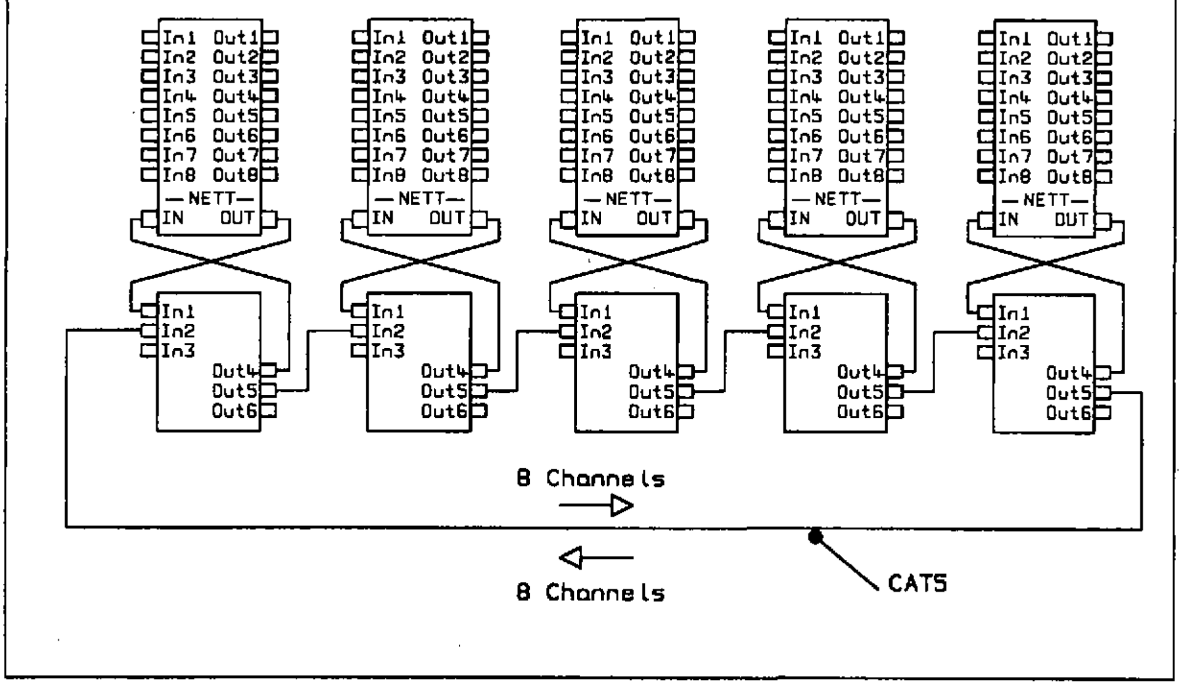


Diagram 4.9 - Redundent Rings

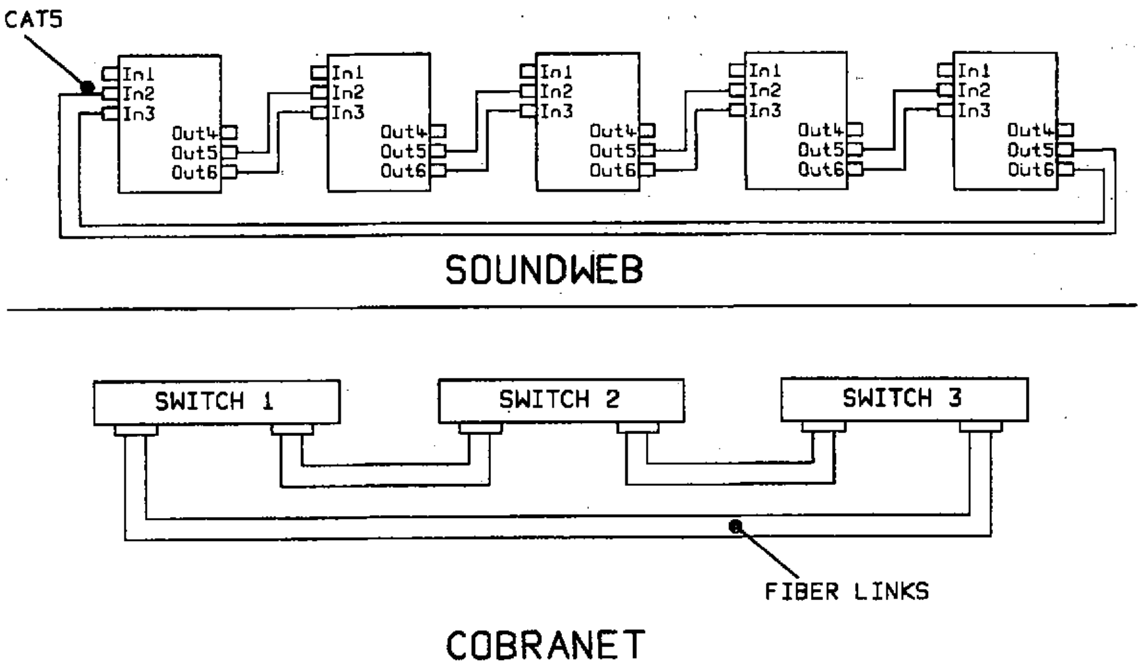
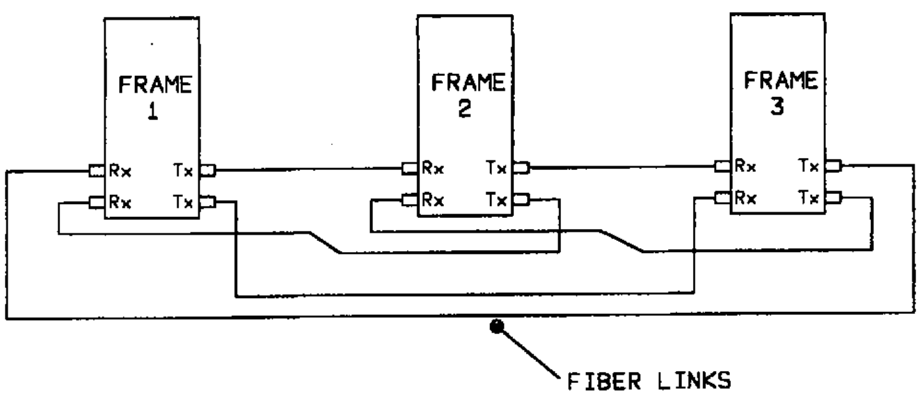


Diagram 4.10 - VADIS Redundent Ring



The simplest system on which to add a redundant path is the CobraNet. The approved switchers have the facility to add a dual fibre module to create the network backbone with the switchers own configuration software allowing automatic change over from main to redundant fibres. Only two fibres are required for the ring. (Diagram 4.9). The CobraNet system's control software allows automatic monitoring of both the primary and secondary network and provide an automatic change over should the primary network fail.

To create a redundant network with Soundweb requires at least four fibres as each link carries bi-directional data. Some larger Soundweb systems require in excess of this number to cater for additional requirements and to provide direct links to maintain network integrity. Always ensure that any proposed network is checked prior to laying fibres for it is a nasty shock to suddenly find you are short during installation of the equipment. (See section 5.2 on fibres). The Soundweb monitors the primary network and changes over if a loss of data is detected.

The Vadis redundant network also requires a ring of two fibres but uses an unusual looping back of data as per diagram 4.10. One advantage of the Vadis system over the others is that this format has the ability to use passive loop back transmitters provided there are no additional inputs on the frame. Loop back saves cost and is also faster. Software integration of dual rings is very easy only having to check a box to confirm the existence of the redundant path. Any changeover is automatic and seamless with remote notification of any network breaks.

5. INTERCONNECTION METHODS

5.1 Copper

For non-critical applications both the Soundweb and CobraNet networks can be created using Cat5 cable, or so we are told. This is correct for the Soundweb but the CobraNet with its higher channel capacity runs at over 100 Mbits/s and requires the use of enhanced Cat5 or Cat5+ cabling and connectors allowing use at up to 155 Mbits/s.

Use of the correct cable forms only part of the picture for how this is installed and terminated can have a severe impact on overall performance.

1. Use the correct terminations for solid of stranded cables as a mismatch will cause problems and normally in the most inaccessible location.

2. Cat5 cable has a lower pull force limitation than most other cables used in the audio industry. Typically a maximum length of 90m can be pulled without causing problems. If the cable is in a containment system ensure that access panels are available at approximately 75m maximum spacing.

3. Cat 5 cable is a loose construction. This is by design so when fixing to tray etc. don't over tighten cable ties as this will distort the structure and diminish the performance.

4. Whilst 90° corners look pretty, with high-speed data these can and will cause problems. A maximum bend radius of 25-30mm is recommended for Cat 5.

5. Cat5 cabling is susceptible to EMI and RFI and should be kept away from possible sources of interference.

5.2 Fibre-Optic

For critical applications the use of Fibre-Optic cabling is to be recommended. Not only is it impervious to EMI and RFI, but also by it's very nature it provides ground loop isolation between nodes. In most systems multimode fibre will be used which will allow up to approximately 2 Kilometres between nodes dependant upon the number of interconnections. Two fibres will be required for each link as other than certain specialist applications, fibre can only transmit in one direction at a time.

One of the most important aspects of designing a fibre-optic network is the available optical power budget. All fibre cable and terminations create a loss. There is nothing we can do about the losses incurred at both the transmitter and receiver or the loss in the cable itself which will normally be minimal. The greatest potential loss is the inclusion of two many patch fields on route. It may appear to be a good idea to insert intermediate cabinets to allow 'future expansion' but each additional pair of connectors and patch cord can loose between 2dB and 4dB. If you need to make provision for expansion leave a large diameter loop to allow insertion of a box at a later date when signal regeneration will be included.

From a practical point of view, it is normally recommended that wall or rack mounted patch boxes are used at both ends of the fibre run. These are used to convert the installed structural cable into a more flexible patch cord for linking into the equipment and also allow connector types to be changed. In normal circumstances the inclusion of these boxes at both ends will be within the available power budget.

When installing fibre optics remember:-

1. Install more fibres than you initially need, i.e. if you need 4 fibres install at least 6. The additional cost for the fibre itself is minimal if within the same cable.

2. Structural fibre terminations are fragile compared to patch cords. Ensure they are suitable protected and never take these directly onto the equipment. Use a patch panel or termination box with secure strain glands.

3. Whilst fibres can normally take a greater pull force than Cat5, try whenever possible to lay cables in particularly the end sections. The terminations are less prone to breakages caused by minute deformations. Avoid bend radiuses of less than 10 x diameter.

4. Remember that whilst a cable it is still glass. Handle off cuts with care and dispose of carefully.

Both the CobraNet and Soundweb recommend the use of 62.5/125 fibres whilst Vadis uses 50/125 fibres. The Vadis will operate successfully with 62.5/125 without any apparent loss of performance. Whatever fibre size is used, ensure that this is maintained throughout the network to avoid unnecessary attenuation. Similarly the number of intermediate terminations should also be kept to a minimum.

6. AUDIO SOURCES

In most instances the audio sources will be analogue at microphone or line level and other than ensuring the level is not excessive and likely to cause clipping, no particular precautions are normally required. The use of peak rather than RMS meters with associated overload indicators at critical stages will assist in maximising headroom and avoiding clipping.

Of our three example systems, at the time of writing only the Klotz and Peavey systems accept the direct connection of digital audio sources to suitable input modules. These digital sources can be from CD, DVD, DAT players etc and can be in various formats the most common being AES/EBU and S/P-DIF. The Vadis system will accept both formats whereas at present the Peavey system only accepts AES/EBU.

The major problem with interfacing digital sources is that various sample rates are used and even if the same sample rate is used, unless the clocks are synchronised audible clicking can occur. The Vadis system is equipped with a word clock input to achieve this synchronisation but in a distributed system this is not practical.

Fortunately a simple solution does exist in the form of sample rate converters. These are fitted as standard to the Peavey's AES input board and available as an option for the Vadis, A hardware adapter will still be required for linking S/P-DIF into the Peavey.

7. DSP REQUIREMENTS

Requirements for DSP processing, other that the number of inputs and outputs supported, are dependent on the actual system design as regards mixers, dynamic processing, equalisation etc. and are outside the scope of the paper.

The Vadis system is modular in format and has dedicated DSP cards for different functions. Whilst this is restrictive in that the system design is required before implementation, it does have the advantage of accurately defining the system functionality and ensuring that enough DSP is incorporated.

With the Soundweb and CobraNet, as these are fully configurable, there is a tendency to leave the dedicated system design until later, normally when it is known the tender / quote has been successful. Bad move, as if it has been assumed that having enough DSP cards or processor boxes to support the I/O requirements will always provide enough processing power for the EQ etc.. In distributed system this often proves incorrect and it is worth spending the extra time whilst planning the system to discuss with the electro-acoustics engineer what the requirements are and ensure that the proposed DSP handles all this with at least 10-20% spare for unanticipated changes.

8. NETWORK CONTROL

8.1 Network

A method of control is required for all our network examples. This control is used not only to allow adjustments to operational parameters and to select routing and paging but also as a means of reporting the operational status of the remote nodes.

The CobraNet and Soundweb units have both taken the approach of embedding control as a data packet within the main audio data. This is accessible as RS232 on the Soundweb and TCP/IP on the CobraNet. Whilst this is apparently a simple approach minimising interconnections, be wary, as the specifications of many life safety systems require an independent monitoring network to enable failures to be still reported, with location, even if the primary audio fails.

The Vadis approach is different in that the remote frames all have an independent RS422 network that automatically bypasses in the case of total failure and allows control and fault reporting when active. The disadvantage is that this will normally require an additional fibre or serial cable to daisy chain the frames but it does give the independent reporting.

8.2 Central Control

The CobraNet system sets itself apart from our other two examples in that it is purely a transport between I/O and processor components. In theory you should be able to intermix products by various manufacturers but in practice this has proved impractical or unnecessary. Soundweb and Vadis are both integrated systems encompassing transport and DSP functionality although the Vadis can be configured as only a I/O and transport system.

One area that all three systems share is the requirement for a PC to program and/or control the system. Soundweb and Vadis require the attachment for configuration and system adjustments but it can be removed after use. With both of these systems it is essential that a copy of the current configuration files are available for reconfiguration as if a previous version is logged on it will either be disabled, as per the Soundweb, or override the current configuration with the Vadis. Ensuring you always save the last configuration should eliminate this potential problem.

Our CobraNet example uses the Peavey MediaMatrix. This is the only one of the three that must have a PC connected for operation, in this case the PC within the MediaMatrix mainframe. As with all PC based systems you must save your current changes to avoid loosing them but system designers have the option to inhibit saving changes to ensure that the system always resets to a known state.
With the control software on the actual device, as long as you have the passwords, system adjustments are easy. A word of advise, whilst a small saving can be made by not including a monitor, keyboard and mouse as a permanent part of the installation, the inconvenience of lugging these up several flights of stares will so confirm that it is not worth the saving.

8.3 Network Control

All our examples allow control over the system to be carried out from virtually any part of the network without the necessity of visiting each remote node to configure the DSP. In all cases this can be from a laptop computer with a suitable network adapter. The degree of control available is determined by the software and varied from full configuration, through user-customised screens, to simple device control. It is always worth repeating any access port on the remote racks, as this will allow easy access for configuration from any location.

9. SUMMERY

New distributed systems scheduled for release in 2001 will address many of the issues raised and will widen designer options. Successful implementation of distributed digital networks need careful forward planning of both the network system itself as well as the method of installation. Choosing the most suitable product for the intended purpose will alleviate many potential problems but still leaves the system designer and installer with a number of important decisions if the process is to be as painless as possible.

10. ACKNOWLEDGEMENTS

Soundweb is a registered trademark of BSS Audio Ltd., www.bss.co.uk
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MediaMatrix is a registered trademark of Peavey Electronics Inc., www.peavey-eu.com
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