



SmartCAU Plus

A Comprehensive Product Description

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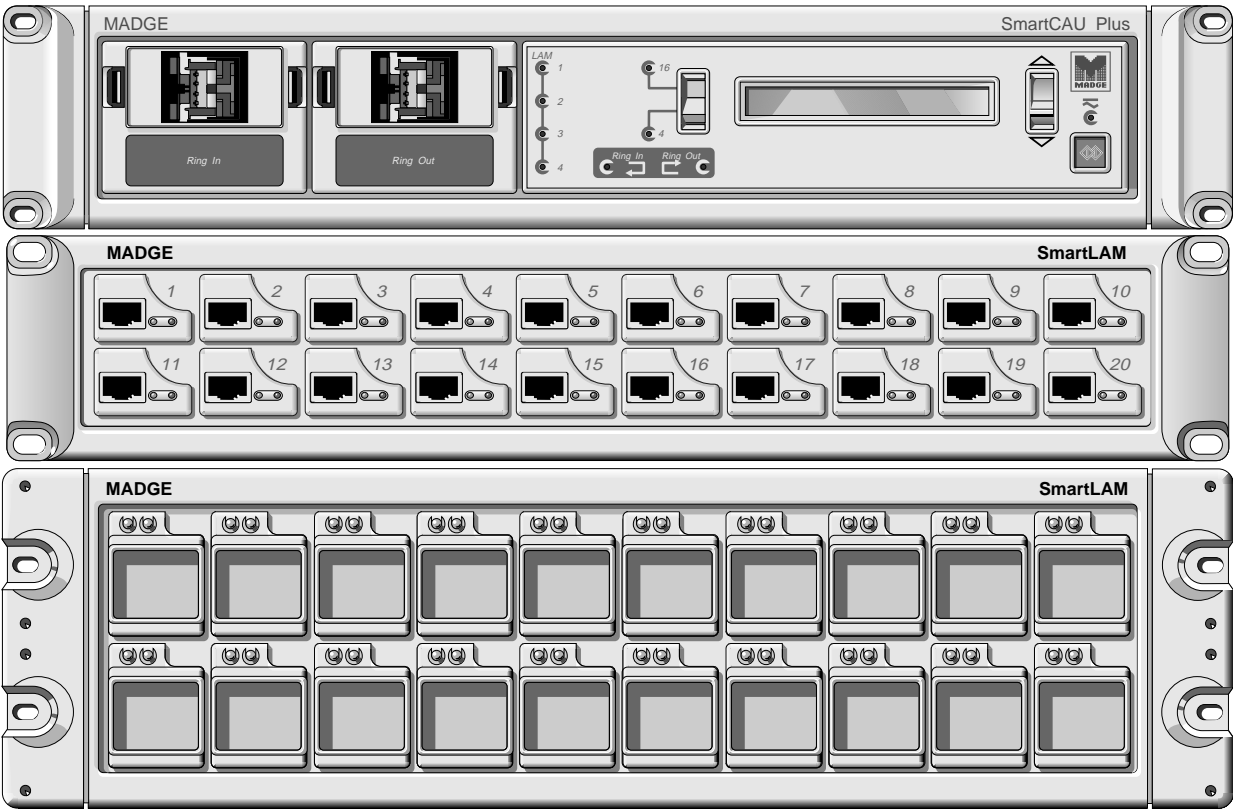
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SmartCAU Plus with attached SmartLAM/UTP and SmartLAM/STP

Introduction

Over the last few years, business I.T. strategy has undergone a major transformation. Driven by the need to be more customer oriented and faster at responding to a changing business environment, companies are downsizing applications and implementing PC-based client-server networks. Competitive advantage, in many areas of business, is now being achieved through an edge in I.T. strategy.

However, placing greater reliance on the network does have its problems: as a critical element within the I.T. strategy nothing less than total reliability will do. If the network goes down, however briefly, users cannot work and many business opportunities can be lost. Network down-time can directly affect business profitability - so providing a continuous network service is now a critical management concern.

Madge's SmartCAU Plus intelligent stackable hub provides the ideal cost-effective solution to this problem. Combining optimized fault recovery mechanisms with advanced network management capabilities, SmartCAU Plus not only increases network up-time but also improves the network administrator's visibility and control of the Token Ring infrastructure.

This product guide is aimed at network administrators and technical personnel who are evaluating or implementing SmartCAU Plus in their network and need detailed technical information about the operation of the product. More information on how the product is installed or how particular features can be used may be found in the relevant manual shipped with SmartCAU Plus.

Overview

The Madge Smart Controlled Access Unit (SmartCAU Plus) is an intelligent stackable hub for Token Ring networks, combining dual trunk ring connection with integral repeater function, choice of STP, UTP and fiber cable media support, automated fault detection and recovery, and powerful remote management capability.

SmartCAU Plus and Cabling

Token Ring cabling topology consists of two elements: trunk cabling and lobe cabling. Lobe cables provide the connection to Token Ring stations at the desktop, while trunk cabling is used to link together the wiring closets. The connection between trunk cabling and lobe cabling takes place at Token Ring hubs, usually located in wiring closets.

SmartCAU Plus fills the role that has traditionally been performed by the Multistation Access Unit (MAU) together with copper or fiber optic repeater units. Experience has shown that faults related to cabling are responsible for the greatest proportion of network downtime. The design of SmartCAU Plus has one overriding objective: to keep the Token Ring network running, even when multiple network fault conditions exist. SmartCAU Plus also offers powerful management facilities which allow an operator remotely to monitor and control the network infrastructure.

SmartCAU Plus and Management

SmartCAU Plus' internal management software applies a high degree of intelligence to the detection, location and isolation of fault conditions. This process is fully automatic, ensuring that the network stays up-and-running in the face of multiple faults without any kind of operator intervention.

The need for remote configuration, monitoring and control is met by TrueView CAU Manager, a Windows-based software package that communicates with the SmartCAU Plus management processor over the Token Ring network. With an easy-to-use intuitive Graphical User Interface, TrueView CAU Manager displays alerts and alarms, displays and controls the status of all ports, and offers a range of additional information, operator assistance and control features.

SmartCAU Plus - Flexibility

SmartCAU Plus' modular design provides great flexibility in the implementation and configuration of the network. It can be used both in backbone and workgroup rings at central sites, as well as in remote branch offices where a small workgroup concentrator is required. As the size of the network grows, additional stackables can be added to support the additional users.

SmartCAU Plus - Compatibility

SmartCAU Plus offers complete compatibility and interoperability with the IBM 8230 Controlled Access Unit. This compatibility extends to hardware and software. SmartCAU Plus and IBM 8230 units may be freely mixed in Token Ring networks, and each may be managed either by TrueView CAU Manager, or by IBM LAN Network Manager and IBM NetView.

SmartCAU Plus - the Solution

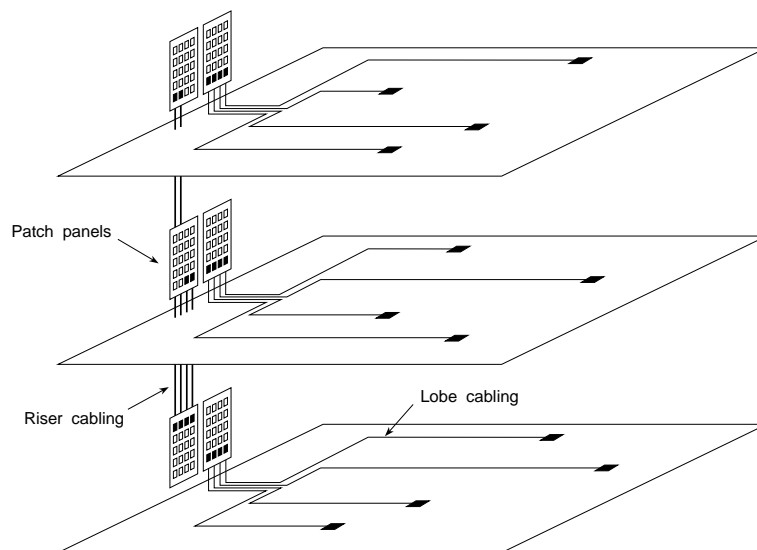
SmartCAU Plus is the most effective intelligent stackable hub solution available for Token Ring networks. It addresses today's primary concerns for the network administrator, by maximizing network productivity and minimizing costly downtime. Its state-of-the-art fault recovery intelligence is complemented by exceptionally powerful but easy to use remote management. In Token Ring network computing, SmartCAU Plus raises dependability to a higher plane.

Cabling

SmartCAU Plus supports all Token Ring cabling media, including shielded twisted pair or STP, such as IBM Type 1, unshielded twisted pair or UTP such as DIW, AT&T 2061A or Northern Telecom BDN, and fiber optic cables.

Token Ring cabling consists of two main elements: *trunk* cabling and *lobe* cabling.

Lobe cables provide the connection between the desktop and the wiring closet. Each lobe cable supports the connection of a single Token Ring station, and lobe cables are typically less than 100 m in length. Lobe cabling is sometimes known as the *horizontal cabling sub-system*, because a wiring closet and its lobe cables often serve a single floor in a building. Provided that the length limitations on lobe cables are observed, however, there is no reason why several floors or even an entire building cannot be served from a single wiring closet.



Layout of a typical in-building cabling to support Token Ring networking

The most common choice of medium for Token Ring lobe cabling is shielded twisted pair (STP). However UTP is sometimes used as it offers lower cost and space savings, though greater care is needed in design and installation than with STP, particularly for 16 Mbps operation.

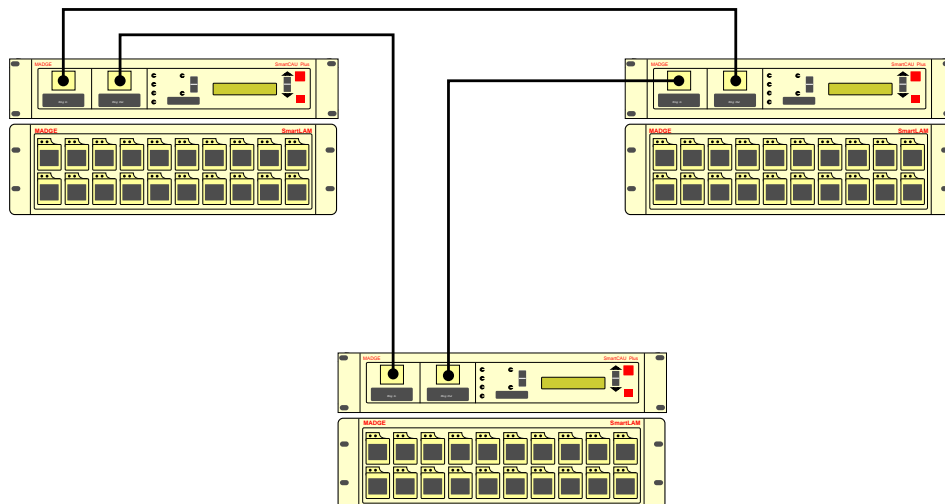
Trunk cables provide the links between wiring closets in a Token Ring cabling scheme. Trunk cabling is sometimes known as the *vertical* or *riser cabling sub-system* as it is often run in the risers of buildings to link the wiring closets on each floor. However, it may also extend horizontally between buildings in a campus-style network installation.

Token Ring trunk cabling is usually based on STP or fiber optic media, although UTP cable may be used within certain restrictions. Fiber is only really necessary for very extended cabling distances between wiring closets, but there is a growing preference for fiber in many installations because of its suitability for future FDDI or ATM backbone networking requirements, and because of its inherent reliability and immunity to interference.

Trunk cabling

Token Ring trunk cabling is connected to the Ring In and Ring Out ports of the SmartCAU Plus unit.

For Token Ring networks where a ring is served from a single wiring closet, and where there are 80 stations or fewer, a single SmartCAU Plus unit is all that is needed and trunk cabling is not required.

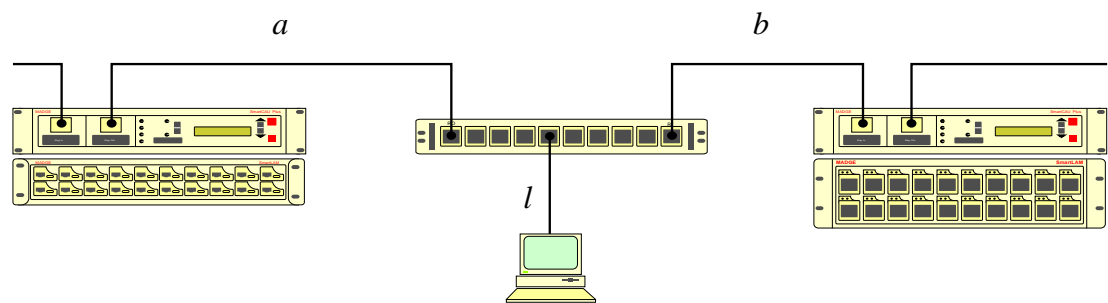


SmartCAU Plus units are connected in a ring by shielded twisted pair, unshielded twisted pair or fiber optic cables connected to the Ring In and Ring Out ports

For rings of more than 80 stations, and where there is more than one wiring closet, trunk cabling is needed to link the SmartCAU Plus units together into a ring. The Ring Out port of each SmartCAU Plus must be connected to the Ring In port of the next SmartCAU Plus unit in the ring.

SmartCAU Plus is supplied with Ring In and Ring Out ports fitted with 802.5 standard data connectors for connection of STP trunk cabling. The integral copper repeater function supports maximum STP trunk cable lengths between SmartCAU Plus units of 200 m at 16 Mbps and 400 m at 4 Mbps.

Multistation Access Units (MAUs), such as Madge's 8-Station Ringhub or IBM 8228, may be connected to STP trunk cabling between SmartCAU Plus units. An Adjusted Ring Length (ARL) calculation must be performed to determine the maximum distance between the MAU and SmartCAU Plus units.



MAU connected between SmartCAU Plus units using STP trunk cable

For instance, if a is the distance between Ring Out on the first SmartCAU Plus and Ring In on the MAU, b is the distance between Ring Out on the MAU and Ring In on the second SmartCAU Plus, and l is the longest lobe length on the MAU:

$$a + b + l + 5\text{m} < 200\text{m at 16 Mbps or} \\ < 400\text{m at 4 Mbps}$$

Where the cabling distance between SmartCAU Plus units exceeds the recommended maximum, or where fiber optic trunk cabling is preferred, then the optional Fiber Trunk Link module (FTL) may be fitted to SmartCAU Plus. One FTL is needed for each Ring In or Ring Out port to which fiber optic cable is to be connected. The FTL module has two standard ST connectors for the attachment of 62.5/125 multimode fiber. A fiber optic link between SmartCAU Plus units, with an FTL fitted at each end, will provide Token Ring trunk connection at distances of up to 2 km on standard grades of multimode fiber cable. 50/125 multimode fiber optic cables can be used, but the maximum distance between SmartCAU Plus units is reduced to 1 km.

UTP cabling may be connected to SmartCAU's Ring In and Ring Out ports by means of the optional UTP Trunk Link module (UTL). One UTL is needed for each Ring In or Ring Out port to which UTP cable is to be connected. Only Category 4 or 5 UTP cable should be used for trunk connections. The maximum safe distance for UTP trunk cabling is 100 m at both 4 and 16 Mbps.

The integral repeater function of SmartCAU Plus allows different trunk cable types to be mixed on the same unit. For instance, SmartCAU Plus can have STP trunk cable connected to Ring In and fiber optic trunk cable connected to Ring Out.

Copper and fiber trunk cabling links between SmartCAU Plus units both provide two physical paths for the Token Ring signal: the *primary path* for normal ring traffic, and a *secondary path* for back-up. The role of this secondary path in protecting against trunk cabling faults is described below in the section on fault recovery.

Lobe cabling

A SmartCAU Plus hub consists of a SmartCAU Plus unit together with one or more Smart Lobe Attachment Modules (SmartLAMs). SmartLAMs provide the connection ports for lobe cables at the wiring concentrator, and are attached to the SmartCAU Plus by means of short link cables, which carry both Token Ring traffic and management information between the units. Each SmartLAM can support up to 20 lobe cables. A single SmartCAU Plus has the capacity to support up to four SmartLAMs or 80 Token Ring stations.

There are two types of SmartLAM to suit the two main kinds of lobe cable media: SmartLAM/STP and SmartLAM/UTP.

SmartLAM/STP is equipped with 20 standard 802.5 data connector ports for the connection of standard 150 Ohm STP lobe cables. It supports up to 20 Token Ring stations over maximum cable lengths of 145 m at 16 Mbps, and 375 m at 4 Mbps.

The SmartLAM/UTP is equipped with 20 shielded RJ-45 ports for connection of 100 Ohm UTP or Shielded-UTP lobe cables. It can be used with Category 4 or Category 5 UTP media, and supports up to 20 Token Ring stations over a maximum cable length of 100 m at 16 Mbps and 160 m at 4 Mbps.

The SmartLAM/UTP may also be used with Category 3 or voice grade UTP media such as AT&T DIW, provided that care has been taken with the cable installation. Satisfactory operation over lobe cable lengths of up to 120 m at 4 Mbps may be achieved. The use of Category 3 UTP cabling is not recommended in 16 Mbps Token Ring networks. It may be possible to use Category 3 Cabling as long as it is installed correctly and is kept away from sources of interference (maximum distance 50 m). Temperatures above 50°C will reduce this distance, and it may be necessary to select specific pairs in the cable to achieve reliable operation of the ring.

The media filter needed at the wiring concentrator for operation over UTP is built into the SmartCAU Plus. There is no need to attach additional media filters to either SmartCAU Plus or SmartLAM. The stations to be attached to UTP lobe cables must be equipped with suitable media filters designed to operate at the correct network speed. These filters may be of the external type, or built in to the adapter card. All Madge Token Ring adapter cards incorporate a built-in UTP media filter.

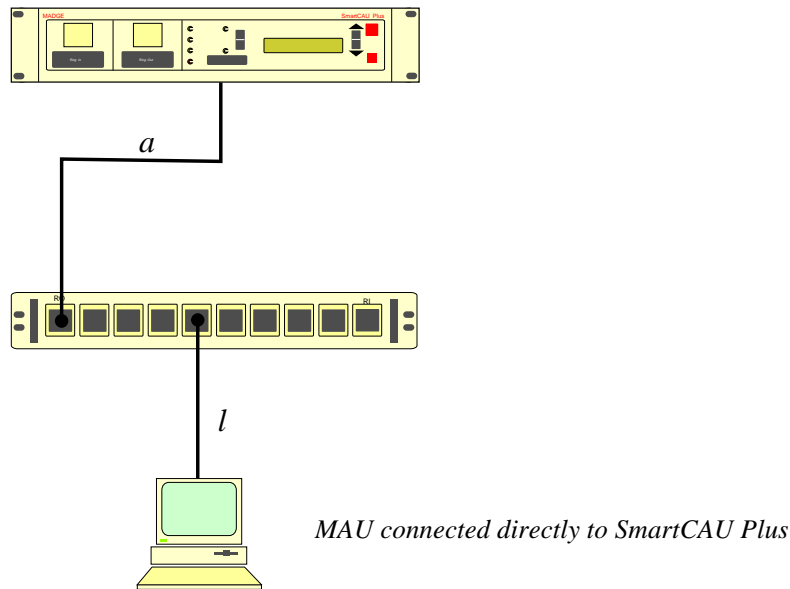
In environments where both STP and UTP lobe cables are used, SmartLAM/STP and SmartLAM/UTP can be mixed on the same SmartCAU Plus unit. However, the SmartLAM/UTPs should be placed *before* the SmartLAM/STPs on the SmartCAU Plus.

Direct Station Attachment

SmartCAU Plus is able to support up to four stations directly connected to it without the need of a SmartLAM. This cost saving feature is useful for backbone applications, where up to four bridges or routers may be directly attached to SmartCAU Plus, or for very small workgroups with less than four stations. The maximum recommended cabling distances with STP lobe cables are 145 m at 16 Mbps and 375 m at 4 Mbps. With Category 4 or Category 5 UTP lobe cable, the maximum cabling distances are 100 m at 16 Mbps and 160 m at 4 Mbps.

MAU Support

SmartCAU Plus offers the unique feature which allows MAUs to be directly attached to SmartCAU Plus in place of SmartLAMs. Up to two MAUs can be attached to each SmartCAU port, providing connection for up to 64 stations on a single hub. An Adjusted Ring Length (ARL) calculation must be performed to determine the maximum distance between the MAU and SmartCAU Plus unit.



For instance, if a is the distance between the rear of SmartCAU Plus and Ring In on the MAU, and l is the longest lobe length on the MAU:

$$a + l + 5\text{m} < 145 \text{ m at 16 Mbps or} \\ < 375 \text{ m at 4 Mbps}$$

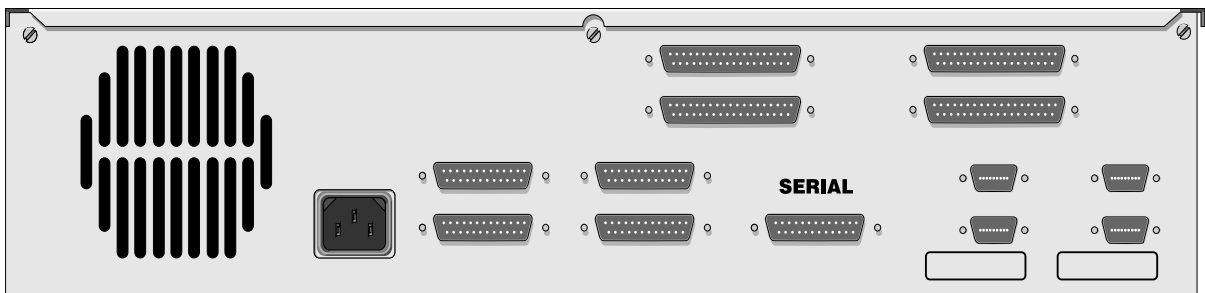
Summary - SmartCAU Plus Cabling

- Integral repeater function extends trunk cable distances without the need for additional external repeaters.
- Supports STP trunk links of up to 200 m at 16 Mbps and 400m at 4 Mbps.
- Optional Fiber Trunk Link module extends trunk link distance to 2,000 m using fiber optic cable.
- Optional UTP Trunk Link module supports connection to Category 4 or Category 5 UTP trunk cable. Cabling distances of up to 100 m at both 4 and 16 Mbps can be achieved.
- STP lobe cables may be up to 145 m long for 16 Mbps operation or 375 m for 4 Mbps.
- Category 4 or Category 5 UTP lobe cables may be up to 100 m long for 16 Mbps operation or 160 m for 4 Mbps.
- Category 3 UTP lobe cables may be up to 120 m long for 4 Mbps.

SmartCAU Plus Hardware

SmartCAU Plus is designed for mounting in a 19" rack, and incorporates integral mounting brackets for this purpose. It occupies a rack space 2U high.

The back panel of SmartCAU Plus is fitted with a power connector for mains power input, and four pairs of D-type connectors for the attachment of SmartLAMs. Each pair consists of one 9-pin D-type which provides the ring connection to the SmartLAM, and one 25-pin D-type which provides the management connection. In addition, SmartCAU Plus has four 37-pin D-type connectors for use with the IBM active UTP LAM, these connectors providing the power to the active LAMs.



Rear view of SmartCAU Plus

There is also a serial port on the rear of SmartCAU Plus. A standard VT-100 compatible terminal or PC running terminal emulation software can be attached for out-of-band management and configuration. For remote out-of-band management across a standard telecomms link a modem can be attached to the serial port.

The SmartCAU Plus front panel carries the Ring In and Ring Out connection ports for the trunk cabling, together with a number of LED status indicators and a liquid crystal alphanumeric display (LCD). SmartLAMs are equipped with two LED indicators on each lobe connection port. The various LED indicators and the LCD display together provide fully detailed status information about every aspect of the SmartCAU intelligent stackable hub.

Ring In and Ring Out ports

SmartCAU is supplied with Ring In and Ring Out ports equipped with standard 802.5 data connectors, for connection to STP trunk cabling.

Where fiber optic or UTP trunk cabling is to be used, then either or both ports may be converted to the required media by installing the Fiber Trunk Link (FTL) or UTP Trunk Link (UTL) modules. The compact design of these modules makes installation fast and easy: the plastic cover on the Ring In or Ring Out is unclipped and removed, then the module just slides in. Once the trunk cable has been connected to the module, SmartCAU Plan can be powered-on ready for use.

The FTL is a complete fiber optic transceiver unit which is fitted with two standard ST fiber optic connectors for transmit and receive respectively, and may be used with industry-standard 62.5/125 or 50/125 multimode fiber optic cables.

The UTL module has a shielded RJ-45 connector for attachment to standard 100 Ohm Category 4 or Category 5 UTP cable, or shielded-UTP cable.

Front panel controls

The reset button is used to re-initialize the SmartCAU Plus. All internal user-configured parameters, including details of disabled lobe ports and management passwords, are stored in non-volatile memory and will not be affected by resetting or by powering down.

A switch to select between ring speeds of 4 and 16 Mbps is fitted to the front panel. If the switch setting is changed whilst the SmartCAU Plus is in operation, SmartCAU Plus will re-boot automatically and come into operation at the selected ring speed.

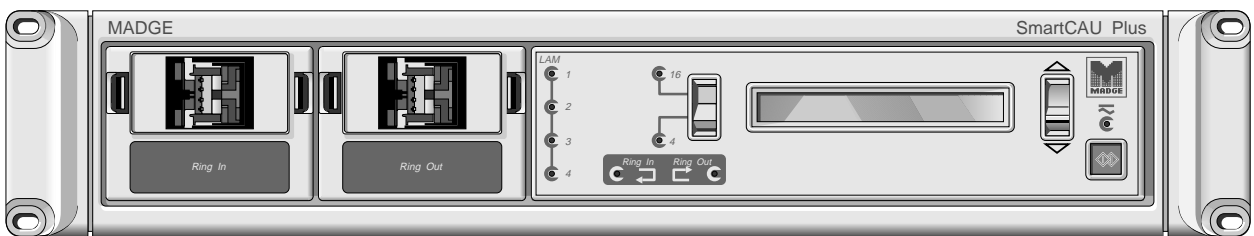
Note that all stations in a ring, including SmartCAU Plus, must be set to the same ring speed.

Status indicators

The SmartCAU Plus front panel is fitted with three groups of LED indicators which provide instant visual indication of the status of the SmartCAU Plus and its ports.

The four SmartLAM status LEDs indicate whether SmartLAMs are attached, and if so, whether they are functioning correctly.

The two ring speed status LEDs indicate whether the ring is running at 4 or 16 Mbps.



Front panel of SmartCAU Plus

The two wrap status LEDs indicate whether the Ring In and Ring Out ports are connected normally through the SmartCAU Plus or whether the data path has been wrapped onto the secondary ring. (The wrap process is described later in the section on trunk cable fault recovery.) If one of the LEDs is not illuminated it means the unit is not receiving a Token Ring signal, perhaps because it is not attached to another SmartCAU Plus; if the LED is green it means SmartCAU Plus is receiving a valid signal; if the LED is orange it means the SmartCAU Plus has been manually wrapped by the network administrator; and if the LED is red it means SmartCAU Plus has automatically wrapped because there is a fault on the trunk section of the ring.

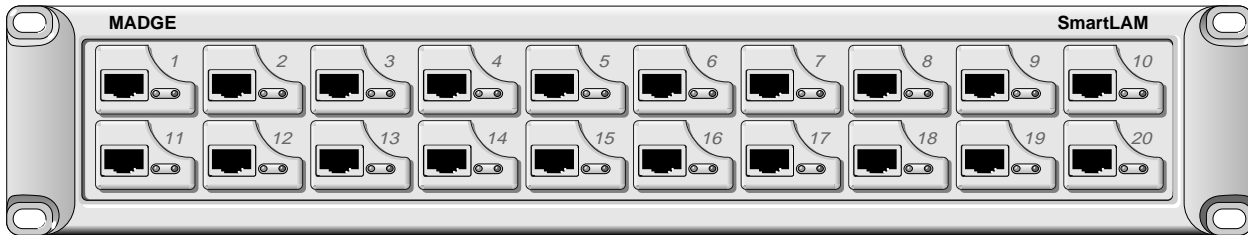
Diagnostic display

The LCD diagnostic display, which has 2 lines of 24 alphanumeric characters, provides a variety of status and diagnostic information. The display may be scrolled by means of the rocker switch situated next to it. Information on every aspect of SmartCAU Plus status is available at this display, including explanatory textual descriptions of all error conditions.

SmartLAM

The SmartLAM is shipped with short cables fitted with D-type connectors, for the ring and management connections to SmartCAU Plus. Because the internal bus in the SmartCAU Plus directly drives the signal down the management cable, the length of these cables should not be extended: spurious results may occur.

Each SmartLAM port has two associated LED indicators, which together indicate the port status: idle (not illuminated), inserted (constant green), or disabled. If the port is disabled, the LEDs will indicate the cause: disabled manually by the network operator (flashing green), or because a fault condition was detected (flashing red).



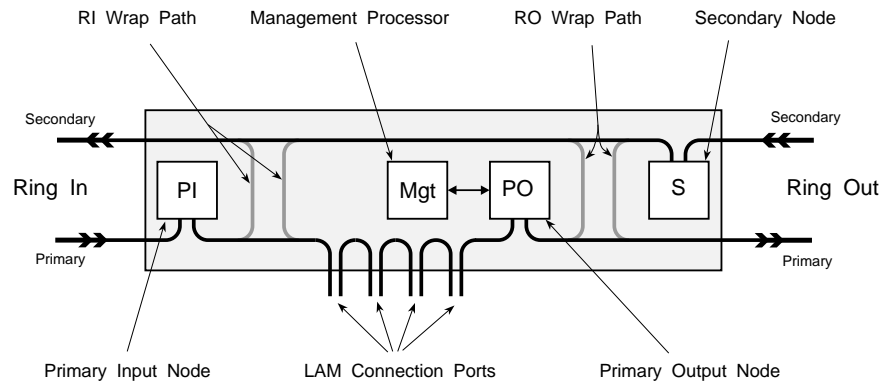
Front panel of SmartLAM/UTP

SmartCAU Plus Internals

At the heart of SmartCAU Plus is an NEC V50 processor running the SmartCAU Plus intelligent management and control software. The software is stored in flash EEPROM which allows it to be easily upgraded across the network when Madge implements new features. The software upgrade process uses the Remote Program Load (RPL) protocol and can be performed from a management station running Madge TrueView CAU Manager or IBM LAN Network Manager. In the case of TrueView CAU Manager, the RPL process can be performed across IPX routers as well as source routing bridges.

SmartCAU Plus contains three Token Ring Interfaces or MACs (most other intelligent hubs have only one MAC). These are based on standard Texas Instruments (TI) chipsets running special versions of Madge's Smart software. The Primary Out (PO) MAC also runs extra software which allows it to monitor network traffic (see section on network management for more details).

The three MACs are positioned in such a way that they can monitor all aspects of the physical Token Ring: the PI MAC monitors the signal entering SmartCAU Plus, the PO MAC monitors the stations attached to the SmartLAMs, and the S MAC monitors the signal entering the SmartCAU Plus on the trunk backup path.



SmartCAU Plus contains three Token Ring interfaces, together with a management processor

In addition, the PI and PO MACs are able to repeat and regenerate the Token Ring signal entering and leaving the SmartCAU Plus on Ring In and Ring Out. The PI MAC repeats and regenerates the Token Ring signal going to the stations attached to the SmartLAMs; the PO MAC repeats and regenerates the Token Ring signal travelling down the trunk cable, attached to Ring Out, to the next SmartCAU Plus.

SmartCAU Plus can change the network configuration to use the backup path - a process called *wrapping*. This can be done manually by the network administrator or automatically by SmartCAU Plus when it detects a problem. SmartCAU Plus can wrap the ring at either Ring In, Ring Out or both. The position of the MAC means that it is still able to monitor all aspects of the network even when wrapped.

Power Supply

The SmartCAU Plus power supply has a mean time between failures (MTBF) of 200,000 hours. This means on average the power supply unit will last over 22 years. Having a high MTBF removes the need for additional redundant power supply units in SmartCAU Plus, which not only reduces the cost of the hub but avoids having complex switching components that can add more potential points of failure to the overall system.

All the relays on the SmartLAM are powered by SmartCAU Plus. If the power to SmartCAU Plus fails, all users will be removed from the ring and SmartCAU Plus will wrap at both Ring In and Ring Out. The reason for this is that SmartCAU Plus acts as a repeater for the Token Ring signal. Power failure means the repeater function is lost and the ring could exceed the maximum Adjusted Ring Length (ARL), resulting in the whole network segment becoming inoperable. Wrapping Ring In and Ring Out prevents other hubs on the network being affected and allows the users connected to them to continue to operate normally.

If the user is concerned about possible power failures, an Uninterruptable Power Supply (UPS) should be used to power the SmartCAU Plus.

Monitoring Sensors

SmartCAU Plus has special sensors which measure the temperature of the inside of the unit and the fan speed of the SmartCAU Plus power supply. These measurements are displayed graphically by TrueView CAU Manager (see section on network management). The only moving component in SmartCAU Plus is the cooling fan in the power supply. In the unlikely event that this fan starts to fail, the decrease in fan speed and subsequent rise in temperature will be detected by the sensors. An alert will be sent to the network management console, allowing the network administrator to replace the unit before the situation becomes critical.

MTBFs

The calculated MTBFs for the individual SmartCAU Plus components are as follows:

■ SmartCAU Plus	38,000 hours
■ SmartLAM/STP	160,000 hours
■ SmartLAM/UTP	160,000 hours
■ Fiber Trunk Link Module	4,000,000 hours
■ UTP Trunk Link Module	3,000,000 hours

Summary - SmartCAU Plus Hardware

- All units are designed for 19" rack mounting; SmartCAU Plus and SmartLAM/UTP occupy 2U height in the rack while SmartLAM/STP occupies 3U
- Optional user-installable Fiber Trunk Link or UTP Trunk Link modules
- Three Token Ring MACs monitor all sections of the physical ring
- All configuration data is stored in non-volatile memory, and preserved when the unit is powered down or reset
- SmartCAU Plus software is held in flash EEPROM, and new software versions may be downloaded over the network
- Comprehensive self-test program is held in SmartCAU Plus' ROM, and is executed on power-up to check internal functions

Fault Recovery

SmartCAU Plus makes full use of the MAC management frames defined in the IEEE 802.5 Token Ring standard to monitor the operation of the ring, and to detect, locate and isolate fault conditions. This is done automatically under control of SmartCAU Plus' internal management processor, and requires no operator intervention. The process is fully distributed and does not depend upon a centralized network management station.

All fault recovery actions taken by SmartCAU Plus are visible at the network management workstation, where the operator can monitor the status of SmartCAU Plus, and take any additional remedial action that may be necessary. This is described in the section on network management.

Token Ring Errors

Each Token Ring adapter card on the network has intelligent features that allow it to continually monitor the status of the network and the quality of data on it. If any problems are identified, the adapter card immediately alerts the network management station of the fault and, in most cases, where it is located.

There are two types of alerts that can be sent depending on the severity of the problem: *soft errors* and *beacon errors*.

Soft errors are the lowest level of alert that can be generated. They simply indicate that there is a problem on the network but the network is still managing to operate and carry data. Such errors may, for instance, be generated by a station whose receive buffers are full and can no longer receive data from the network (this is called a *congestion soft error*). Soft errors help the network administrator to monitor the network and resolve problems before they become critical to the operation of the network.

Beacon errors are generated if the network is no longer operating or carrying data. Beacon faults occur, for example, when a cable is broken: the adapter card downstream of the break detects that it is not receiving a signal and sends beacon packets to the network management station to alert the network administrator of the problem and indicate where the fault is located.

Lobe Faults

Before a Token Ring adapter card inserts into the ring, it tests the lobe cable for faults or breaks. This test is known as a *lobe test* and is one of the fault prevention mechanisms built into the Token Ring standard. If the lobe cable is broken, the station will detect this during the lobe test and will not insert into the ring, therefore preventing disruption to other network users.

However, there are certain types of fault conditions which cannot be recovered by the Token Ring network alone. These include:

- Connecting a lobe cable into the VGA socket of the PC
- Knocking the lobe cable so that it only makes partial contact with the adapter card
- Faulty Token Ring adapter cards
- Partial breaks in the lobe cable
- Very long or poor quality lobe cables

If passive MAUs are used on the network, the network administrator has to identify where the fault is located and manually remove it. This process can take some time, during which the network remains inoperable and users cannot work.

SmartCAU Plus has intelligent beacon detection, location and isolation capabilities that will automatically identify which lobe is causing the problem and remove it. This is achieved by SmartCAU Plus continually monitoring the network status. If beaconing is detected, SmartCAU Plus systematically removes the attached nodes until the network recovers: the last node inserted is the one causing the problem and the associated port on the hub is disabled. The remaining nodes are then allowed back into the network for normal operation.

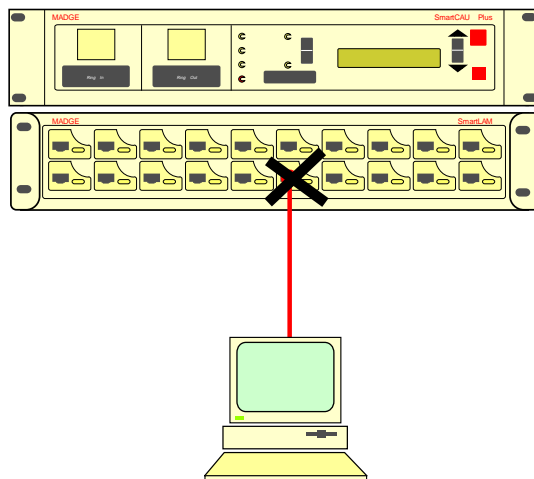
This process usually takes a few seconds and is normally transparent to other network users. Once the fault has been removed, the network administrator is immediately informed of the problem and its location.

Speed Faults

A very common cause of faults on Token Ring is an adapter card set to the wrong ring speed inserting into the network. This can happen, for instance, when a portable PC user returns after a business trip and forgets to set the portable adapter card to the correct speed before connecting to the network. Another example is a network being upgraded from 4 Mbps to 16 Mbps: if any of the PCs are not upgraded, for any reason, the network will be brought down as soon as the station inserts into the ring.

To prevent this from happening, SmartCAU Plus has special speed detection hardware built into every SmartLAM port to measure the ring speed of the station *before* it inserts into the ring. If the adapter is set to the wrong speed, the station is not allowed in to the ring and there is *absolutely* no disruption to other users on the network. The network administrator is again immediately informed of the speed fault and where it is located.

The speed detection hardware operates by measuring the frequency of the Token Ring signal coming from the adapter card. This is then compared with the expected frequency for a 4 Mbps or 16 Mbps network, and used in the decision of whether to allow the station into the ring or not. This method also prevents malfunctioning adapters, which are not sending valid Token Ring signals, from attaching to the network.



Faults in lobe cables, adapter cards or wrong speed faults are automatically identified by SmartCAU Plus and removed from the network - preventing disruption to other network users

Trunk Faults

Trunk faults are faults on the trunk section of the ring, between hubs. They are generated in a number of ways:

- Breaks in the trunk cable
- Badly connected trunk cable
- Poor quality or deteriorating trunk cable
- Trunk cables located near to strong sources of electromagnetic radiation
- Incorrectly configured trunk cable, for instance by connecting Ring-In of one hub to Ring-In of another

Such faults can cause the network to enter a beaconing state. On a MAU-based network, the network administrator has to manually locate and remove the problem to restore the network to full operation. This may take quite some time, during which users are unable to work.

Many intelligent hubs are able to recover the ring automatically if the trunk cable is completely broken. A common method for doing this is to send a DC voltage (in addition to the normal Token Ring signal) down the trunk cable to the adjacent hub. If the cable is broken, the DC voltage is lost and the hubs either side of the fault wrap. However, this method has a number of major disadvantages:

- It is proprietary and ties the customer into a single vendor's products
- It requires all the hubs on the network to be of the same type
- The hub will only recover from a subset of possible trunk faults i.e. there are conditions from which the hub will never recover
- It does not use any of the fault detection mechanisms already built into Token Ring

To overcome these problem, the IEEE standards committee has defined a method of recovering from all Token Ring trunk cable faults. The method is called the *IEEE 802.5c Dual Reconfiguring Ring Standard* and is implemented in Madge's SmartCAU Plus intelligent hub. Being an open standard, it does not tie customers into a proprietary, closed solution. In fact, IEEE 802.5c is very similar to the dual ring system built into the FDDI standard.

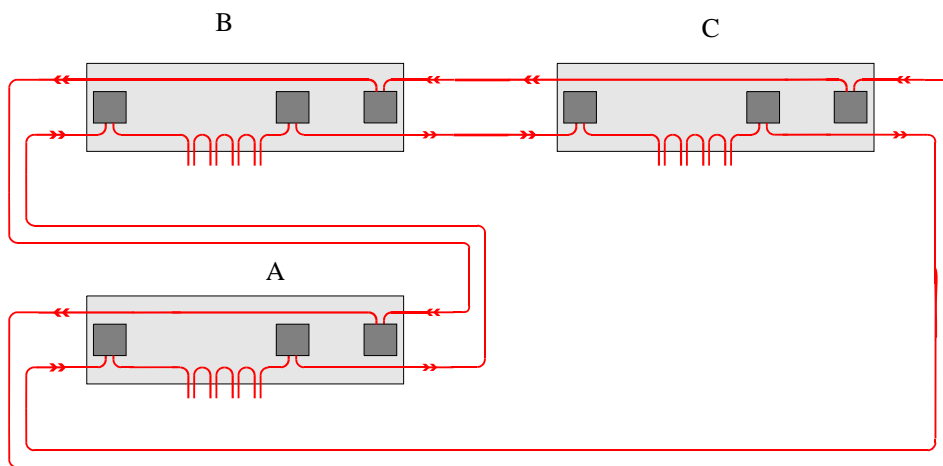
IEEE 802.5c Standard

IEEE 802.5c uses two ingredients that are part of every Token Ring network: beacon frames and the trunk cable backup path.

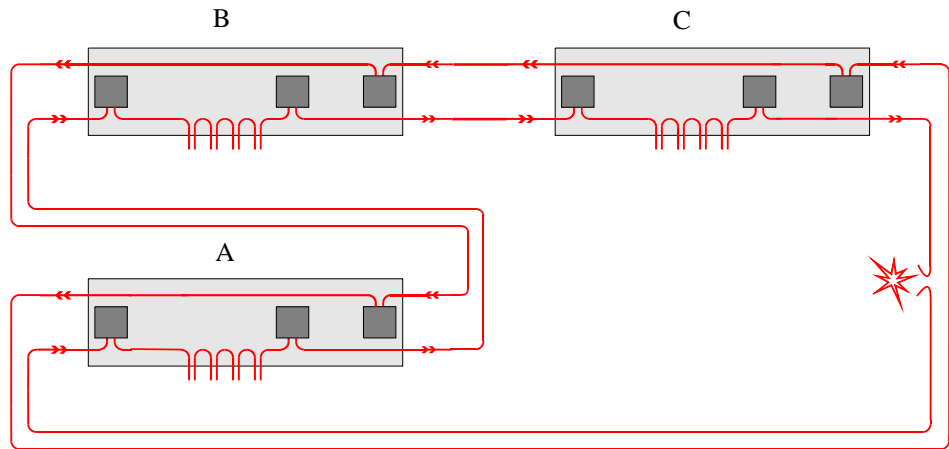
Beacon frames contain a field, called the *beacon priority field*, which indicates the severity of the fault and type of station generating the beacon frames. Normal Token Ring end-stations can generate beacon frames of priority 2, 3 or 4 - these are called *beacon normal* frames. Intelligent hubs which support IEEE 802.5c, such as Madge's SmartCAU Plus, can generate priority 1 beacon frames - called *beacon reconfigure* frames.

Intelligent hubs that implement 802.5c, such as Madge's SmartCAU Plus, contain two or more Token Ring interfaces or MACs. In fact, Madge's SmartCAU Plus has three Token Ring interfaces which monitor all sections of the ring including the primary and backup paths.

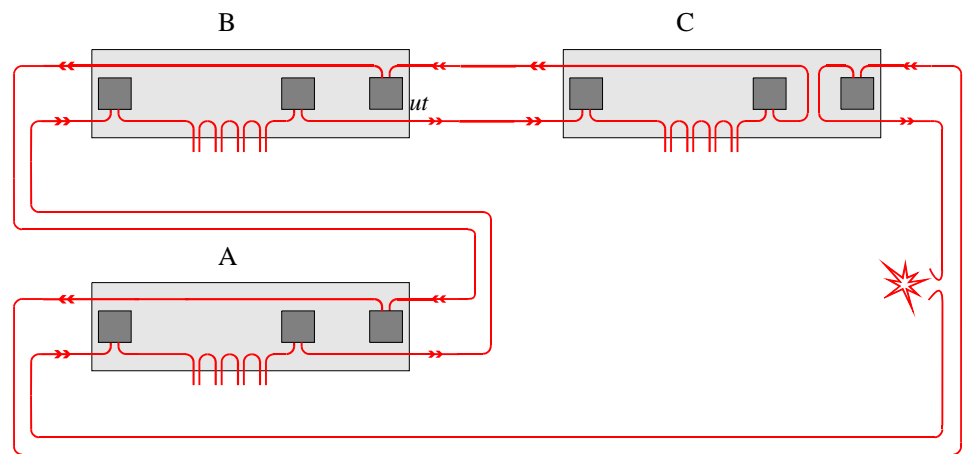
The following diagrams illustrate how 802.5c operates when there is a break in the trunk cable:



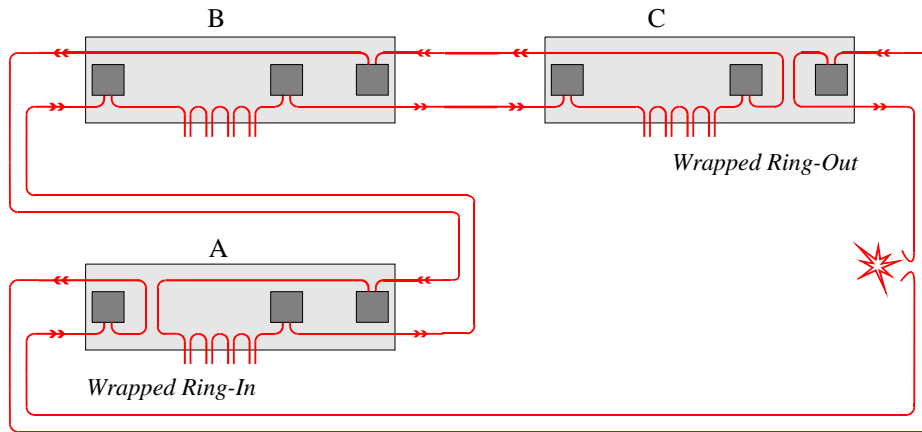
Stage 1: No faults present. Network data traffic travels on the primary path, with the SmartCAU Plus intelligent hubs (A, B, C) continually monitoring the network for faults.



Stage 2: Break in the primary path. SmartCAU Plus A's PI MAC, downstream of fault, starts to transmit beacon reconfigure frames to alert the other SmartCAUs of the problem. In addition, A breaks the signal path on the backup path which is used by the SmartCAU Plus upstream of A (SmartCAU Plus C) to determine if it should wrap.



Stage 3: SmartCAU Plus C detects A's beacon reconfigure frames. In addition, it detects that it is not receiving a valid signal on the backup path and automatically decides to wrap at Ring-Out to avoid the fault zone.



Stage 4: With the ring wrapped at C, SmartCAU Plus A starts to receive its own beacon frames on its Secondary MAC. From this it knows that the ring has wrapped downstream and it can now wrap at Ring-In to avoid the fault zone. There are now two ring segments: one fully operational containing the users on the SmartLAMs, and the other inoperable containing the fault.

IEEE 802.5c offers a number of major advantages over other fault recovery mechanisms: being an open standard, it does not tie customers into a single vendor, proprietary solution; it is part of the IEEE 802.5 Token Ring standard which means it is compatible with all Token Ring equipment; it uses beacon frames that form the basis of Token Ring technology; it is designed to recover from all trunk cable faults, not just broken cables, so providing higher levels of network fault resilience; and it allows passive MAUs to be mixed with the intelligent hubs on the same ring segment.

Summary - SmartCAU Plus Fault Recovery

- Faults that result in the loss of network services are recovered automatically
- Trunk faults are recovered using the non-proprietary IEEE 802.5c Dual Reconfiguring Standard
- Wrong ring speed faults recovered using hardware speed detection
- Beacons nodes are removed using intelligent beaconing detection and isolation software in SmartCAU Plus

Management

SmartCAU Plus offers a wide range of network management capabilities giving customers unparalleled choice in the way they manage the network. It can be managed by:

- Madge TrueView CAU Manager shipped with SmartCAU Plus
- IBM LAN Network Manager and NetView
- SNMP management systems such as IBM NetView/6000, HP OpenView for UNIX, SunNet Manager, Novell NMS
- Workstations running TCP/IP and Telnet
- A VT100 terminal or terminal emulator via out-of-band connection to the serial port of SmartCAU Plus

In addition, SmartCAU Plus can be managed from two DOS text-based management applications: the IBM Maintenance Facility and the Madge CAU Control Program (CAUCP). CAUCP is available free of charge to SmartCAU Plus customers by contacting the Madge Technical Support Hotline (part number 85-07).

HLM-based Management

SmartCAU Plus management communication uses the Heterogeneous LAN Management protocol (HLM), which is a version of the ISO standard Common Management Information Protocol (CMIP) running over the IEEE 802.2 LLC protocol. SmartCAU Plus implements an enhanced version of HLM which makes optional use of the Novell NetWare protocol IPX. This allows SmartCAU Plus to be managed across source routing bridges as well as IPX routers in Novell NetWare environments.

The IBM 8230 CAU and IBM LAN Network Manager support HLM. As a result, SmartCAU Plus can be managed from IBM LAN Network Manager, and the IBM 8230 can be managed by Madge's CAU management applications.

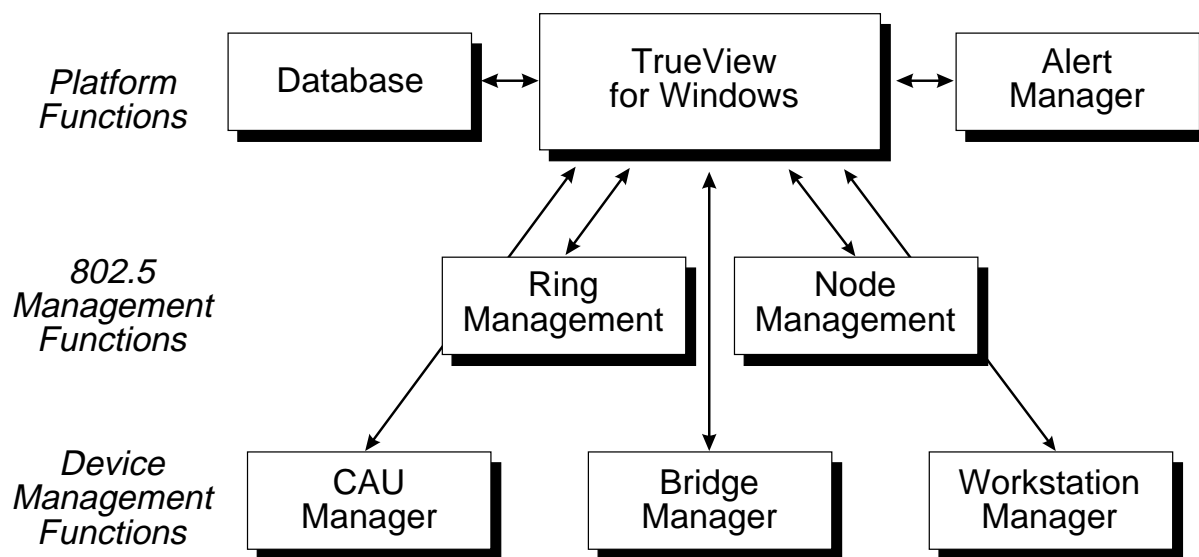
TrueView Windows Management

TrueView is Madge's management architecture for Token Ring networks. Utilizing the Windows graphical interface to the full, TrueView delivers powerful, yet easy-to-use management for Token Ring network environments.

TrueView consists of a number of management applications which manage the individual components of the network:

- TrueView CAU Manager manages SmartCAU Plus and the IBM 8230 CAU
- TrueView Bridge Manager manages the Madge Smart Ringbridge and other IBM-compatible bridges
- TrueView Workstation Manager manages network stations running the Madge Workstation Manager Agent
- TrueView Alert Manager collects alerts from the other management applications and stores them in a common database

The management applications are fully integrated to make management of the network even easier. For example, TrueView CAU Manager is able to launch the TrueView Workstation Manager application if the station on a particular SmartLAM port is running the Workstation Manager agent.

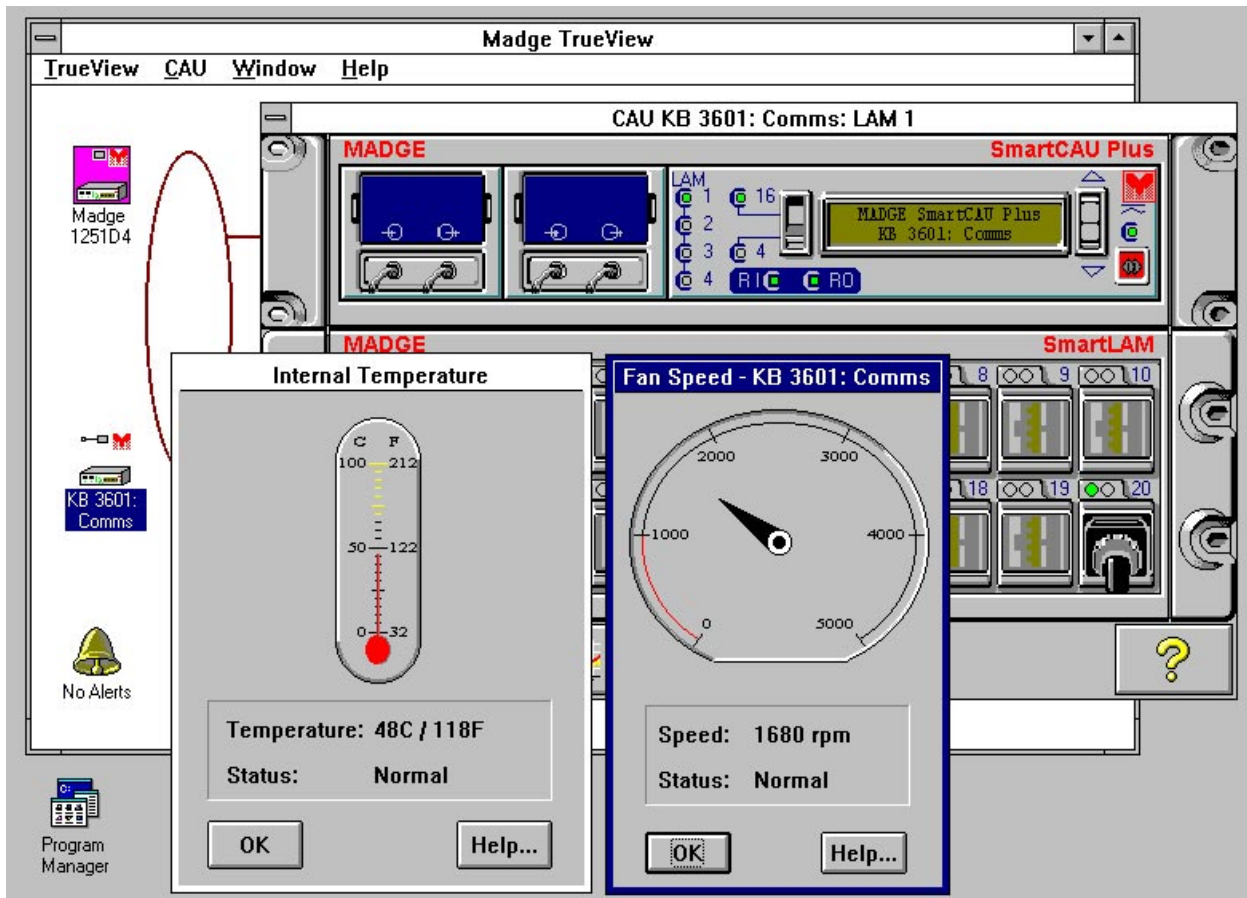


TrueView management architecture

In the future, Madge's TrueView Ring Manager application will provide management the physical Token Ring network, including soft error reporting and detailed analysis of the nodes attached to it.

TrueView CAU Manager displays graphical pictures that exactly resemble the status of the SmartCAU Plus and attached SmartLAMs on the network. This "wiring closet view" allows the network administrator to see all status indicators and identify which users are attached to the SmartLAM ports. TrueView CAU Manager is shipped with SmartCAU Plus.

Control and configuration of SmartCAU Plus could not be easier. On the SmartCAU Plus and SmartLAM pictures there are a series of hot spots, where actions can be performed by simply clicking the mouse pointer. A SmartLAM port, for instance, can be disabled by selecting the relevant port in the picture and confirming the action. Password protection on both the management software and SmartCAU Plus prevent unauthorized persons from gaining control.



Example TrueView CAU Manager display

Also shipped with SmartCAU Plus is TrueView Alert Manager. TrueView Alert Manager collects alerts from TrueView CAU Manager and logs them in a database. The user can define a series of actions to be performed when a particular alert occurs, including generating sound or voice stored in a Windows sound file; running another program, such as a modem driver to dial someone's pager; and opening an alert window on the TrueView management station.

OpenView for Windows Support

HP OpenView for Windows is a Windows-based management platform which allows different vendors' management applications to run concurrently in the same management workstation at the same time. This is particularly useful for environments where multiple vendors' devices are installed on the network since OpenView for Windows allows complete management of all these devices from a single management workstation. In addition, alerts from network devices can be logged in a single alert database, making management of the network easier.

TrueView CAU Manager is fully compatible with OpenView for Windows. When installing TrueView CAU Manager, the software will automatically detect if OpenView for Windows is already installed and will automatically add TrueView CAU Manager to OpenView if the user requested this option.

DOS management

CAU Control Program (CAUCP) for DOS provides a simple text-based interface for managing SmartCAU Plus' and IBM 8230 CAUs. It uses text windows, offers support for mouse-based operation, and includes comprehensive context-sensitive help.

```

Wed Jan 22nd 1992  SmartCAU control program v0.00.01alpha          4:25:00pm

Identifier-----Type-----Status-----
1-----IBM CAU 10005A985AFA-----
»1-----Detailed CAU information-----

Node addresses      Media types      Wrap states
P0: 10005A985AFA    R0: Copper      Current:  Wrap Normal
PI: 10005A985AFB    RI: Copper      Requested: Wrap Normal
SEC: 10005A985AFC

Back-up path:      Working      Route type:  SR
Microcode loaded:  8230R1V0.BIN    Ring number: 123

This window gives more information about the CAU. Press F4 to
change the wrap state, press F5 to change passwords.

Th
to
F4

F4=change wrap state  F5=change password  ESC=exit

F1=help      F2=help index      F3=exit      F10=program information
Change the CAUs wrap state                                Open

```

Example CAUCP display

IBM Management Connectivity

The HLM protocol used for communication between SmartCAU Plus and the CAU management applications, and the definitions of managed objects within the SmartCAU Plus, are fully compatible with those used in the IBM 8230 CAU. This means that IBM network management applications, including IBM LAN Network Manager and IBM 8230 CAU Maintenance Facility, may be used to manage SmartCAU Plus.

SmartCAU Plus appears to IBM network management applications just like an IBM 8230 CAU. Those features of SmartCAU Plus that are not supported in the IBM 8230 CAU will not, of course, be visible to the IBM application.

As an example, SmartCAU Plus implements a more detailed description of lobe port status than the IBM 8230. With SmartCAU Plus, a SmartLAM port may be idle, inserted, disabled by operator, disabled in fault condition, or disabled due to attempted insertion at incorrect ring speed. On an IBM 8230 CAU, the LAM port status may only be idle, inserted or disabled; there is no distinction between manually disabled ports and ports which were disabled automatically due to a fault condition. When SmartCAU Plus is managed by an IBM network management application, all disabled ports show the same disabled status.

Using IBM LAN Network Manager to manage SmartCAU Plus is useful when NetView connectivity is required. LAN Network Manager's capability to report alerts and faults directly to NetView provides NetView visibility for SmartCAU Plus'. And unlike the IBM 8230 CAU, SmartCAU Plus can register with more than one management application concurrently. In fact, SmartCAU Plus will support up to four registered managers giving much greater flexibility. This means that TrueView CAU Manager can be used to manage SmartCAU Plus' locally whilst a simultaneous link to NetView exists via IBM LAN Network Manager.

SNMP Management Connectivity

In addition to IBM compatible management, SmartCAU Plus can be managed using the industry standard Simple Network Management Protocol (SNMP). This means that general SNMP management systems, such as HP OpenView for UNIX, IBM NetView/6000, SunNet Manager and Novell NMS, may be used to manage SmartCAU Plus. The SNMP agent supports both IP and Novell's IPX protocol. Thus SmartCAU Plus can be managed using SNMP across source routing bridges, IP routers, and IPX routers.

The SmartCAU Plus SNMP agent uses three standard SNMP Management Information Bases (MIBs):

- MIB-II (RFC1213)
- Internet Hub MIB (RFC1368)
- Remote Monitoring RMON MIB (RFC1271 and RFC1513)

More information on RMON can be found later in the section on network monitoring.

Using the Internet Hub MIB, the user can query which ports are enabled or disabled on the SmartLAMs as well as the node addresses of the attached stations. The user can also disable individual ports. Password protection using Community Strings prevents unauthorized persons gaining control of the SmartCAU Plus.

SmartCAU Plus generates SNMP traps (alerts) which are sent to the SNMP management stations on the network. For instance, if SmartCAU Plus automatically disables a port due to a fault, it will send a trap to the SNMP management system giving details of the cause and location of the problem.

SmartCAU Plus can be managed concurrently by up to 20 management stations using SNMP over IP, and up to 10 management stations using SNMP over IPX.

Telnet Management

SmartCAU Plus supports the Telnet protocol for remote login sessions across the network. Telnet is available on most PC and UNIX workstations equipped with TCP/IP and provides a useful addition to SmartCAU Plus' SNMP management capabilities. For example, if SmartCAU Plus sends an SNMP trap to the SNMP management system, the network administrator can use Telnet to login into SmartCAU Plus and obtain more information about the cause of the alert and the exact status of the hub.

The information is displayed through a simple text-based picture which makes it easy to identify any problems that have been detected and removed by SmartCAU Plus. The network administrator has complete control of SmartCAU Plus, such as changing its wrap status or disabling a SmartLAM port, through an easy-to-use command line interface. An on-line help facility, which gives details of the available commands, makes the Telnet session even easier to use. To maintain security and prevent unauthorized persons from gaining control of SmartCAU Plus, the network administrator is prompted for a password during login. If an incorrect password is entered, access to SmartCAU Plus is denied.

Telnet is based on IP which means SmartCAU Plus can be managed across IP routers. Up to two concurrent Telnet sessions are supported.

Out-of-band Management

The serial port on the rear of SmartCAU Plus allows it to be managed with a VT100 compatible terminal or PC running terminal emulation software. The management communication is *out-of-band*, which means the management information does not travel across the network but through the serial cable connected directly into SmartCAU Plus.

The user interface provided through the out-of-band connection is similar to the Telnet session interface described above. A text-based picture displays the status of the SmartCAU Plus and the network administrator can control it using a simple command line interface. Again, an on-line help facility makes using the interface even easier. To prevent unauthorized persons from gaining control of SmartCAU Plus, the network administrator is prompted for a password during login.

Network Monitoring

As local area networks expand and more users are connected to the network, the amount of network traffic can increase enormously. This may result in slower network response times and reduced network efficiency. Being able to identify bottlenecks and highly utilized LAN segments is critical to improving the overall performance of the network, and in planning a migration strategy to other technologies such as FDDI and ATM.

In addition, with the growth in multi-vendor LAN-based applications and associated network protocols, the variety and complexity of network traffic is increasing dramatically. The network administrator often requires intelligent and flexible monitoring tools to help diagnose network problems and maintain a fully operational network.

The SNMP Remote Monitoring (RMON) standard has been designed to help with both of these problems. Being an open standard, RMON can be used in multi-vendor network environments. It is also highly flexible, ensuring its continued usefulness as the needs of the network administrator change.

The RMON MIB (Management Information Base) resides in devices, often called RMON probes, that are connected to the network. Such devices monitor and process the data on the network, and store it in the RMON MIB. The network administrator can view the contents of the MIB from any SNMP management station.

There are specialized management systems that are able to interpret the contents of the RMON MIB and provide the results of the analysis graphically e.g. as a moving graph. Many of these systems are also able to collate the information from several RMON probes - this is very useful for building models of how the traffic flows across the network.

The RMON MIB is divided into 9 general groups of information. There are also additional, technology specific groups that contain information relevant to the technology. Currently, there are additional groups defined for Token Ring and FDDI.

All the groups are *optional*, which means different RMON probes can implement various levels of the standard. The main reason for this is that a full RMON implementation requires significant amounts of processor power and memory, making such devices very expensive. Having a highly flexible RMON definition means that the customer only needs to use devices which implement the sub-set of RMON that is required.

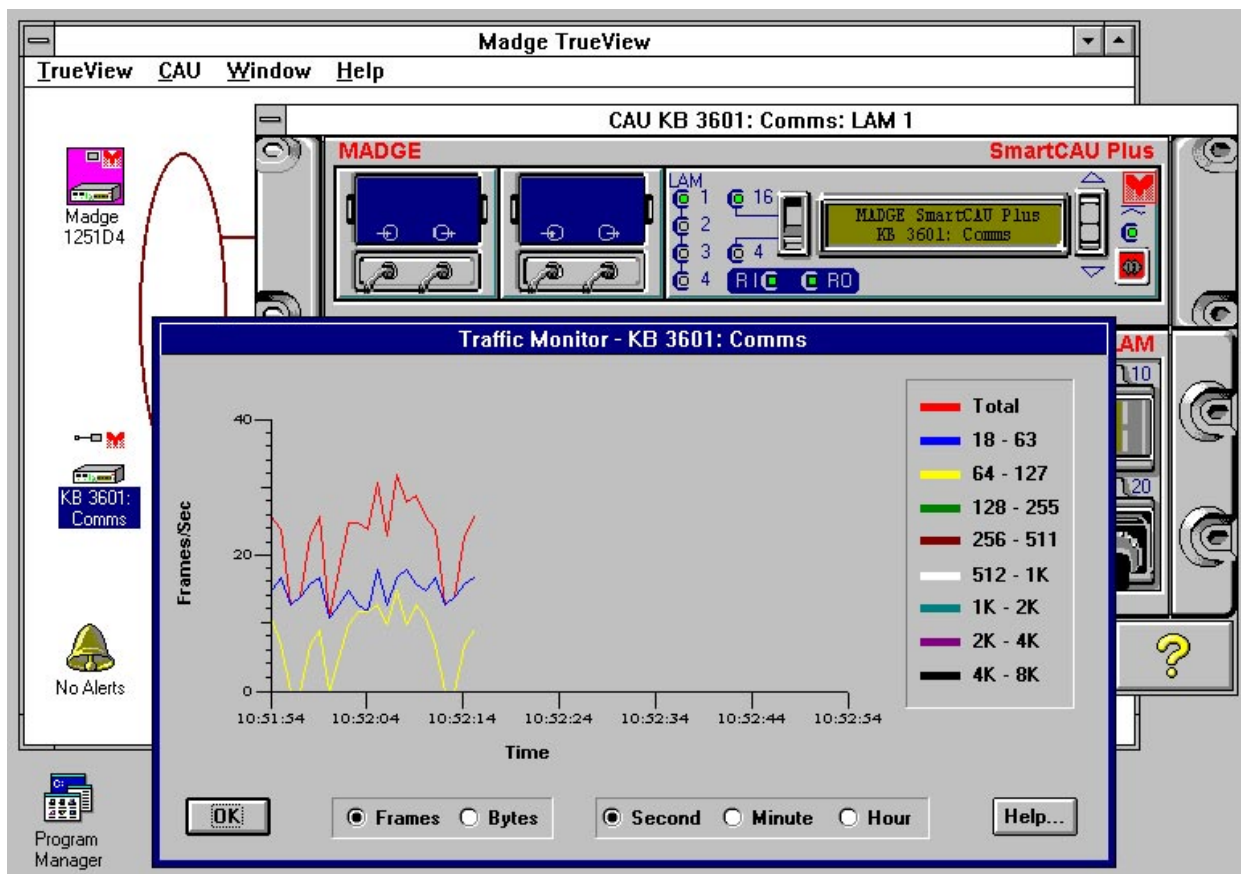
The 9 general RMON groups are as follows:

1. *Segment Statistics*: This group provides packet statistics, including number of packets, number of broadcast packets etc., as well as packet size distribution.
2. *History*: The history group provides historical views of network statistical information. This group allows the user to define sample intervals for trend analysis.
3. *Host Table*: RMON defines a host table which contains information such as packets sent and received, number of broadcasts, number of errors, as well as the order each node was located by the RMON probe on the network.
4. *Host Top N*: This is an extension of the host table, where the information is sorted into a list. For instance, the top 10 stations transmitting data, or a list of stations generating network errors sorted by the number of errors generated.
5. *Traffic Matrix*: The traffic matrix group provides information about the traffic and errors generated between pairs of stations, according to source and destination addresses.
6. *Alarms*: This group allows the user to define thresholds for counters stored in other RMON groups. If this threshold is exceeded an alert is sent to the management station.
7. *Filters*: The filter group allows the user to define general conditions for the capture of network data packets (see capture group below).
8. *Packet Capture*: The packet capture group contains captured network packets which match the conditions in the filter group. The information can be used to analyze individual network packets.
9. *Events*: This group allows the user to create entries in a monitor log and send SNMP alerts to the management station when a particular event occurs.

As can be seen, the information in the RMON MIB is very general. The real power of RMON comes from the management applications which interpret the contents of the RMON MIB and display the results graphically.

In addition to the nine general groups above, there is also a Token Ring group which contains information specific to Token Ring. The information includes network soft error counts, individual station soft error counts, beacon information and ring speed. This information can be used by Token Ring management systems to analyze the status of remote Token Ring networks.

Madge's SmartCAU Plus intelligent stackable Token Ring hub currently supports the History group and Token Ring group of the RMON standard. It does this by utilizing the processing power of the TI-chipset on the PO MAC and Madge's Smart technology. These allow it to monitor network traffic levels at user-definable sampling periods, with the last 60 samples being stored by SmartCAU Plus. On request, this information is sent to the management station. SmartCAU Plus can monitor traffic levels up to 2,500 pps for small packet sizes.



TrueView CAU Manager displaying network traffic graphs

TrueView CAU Manager can collect the network traffic information from SmartCAU Plus and display the results as moving graphs, giving the network administrator useful information about the level and distribution of network traffic. The user can view either the number of packets on the network, according to packet size, or the total amount of data, as well as being able to vary the data sample rate.

This functionality not only allows the network administrator to identify which LAN segments are highly utilised, but also the periods of the day when the most network traffic is generated, and the distribution of network packet sizes.

Madge plans to enhance the RMON support in SmartCAU Plus to provide even more detailed information about the Token Ring network, including soft error counts and the stations generating them.

Summary - Management Connectivity

- Graphical Windows-based TrueView CAU Manager shipped with SmartCAU Plus
- DOS text-based CAU Control Program (CAUCP) available free of charge on request
- SmartCAU Plus can be managed by IBM LAN Network Manager and IBM NetView
- SmartCAU Plus supports SNMP-based management from IBM NetView/6000, HP OpenView for UNIX, SunNet Manager and Novell NMS
- SmartCAU Plus can be managed from a TCP/IP workstation using Telnet
- Out-of-band management possible using serial port on the rear of SmartCAU Plus

The Stackable Hub Concept

SmartCAU Plus is based on the concept of a stackable hub. The modular design of stackable hubs enables companies to build larger networks by just connecting multiple units together in a "stack". As a result, intelligent stackable hubs offer a highly cost-effective solution for all network environments - companies need only buy the number of stackables required to meet their current needs. Not only are entry costs lower, but as the network expands additional stackables can simply be added to the existing network to accommodate the new users.

Intelligent stackable hubs can be used in a wide range of network configurations, which means companies can standardise on one hub throughout the organisation. Intelligent stackable hubs can be used both in central corporate sites, as a backbone or workgroup concentrator, and in remote branch offices, where a small workgroup hub is required. Integrated management software ensures all the different locations can be managed from a single management station, reducing maintenance and support costs.

On the surface, chassis-based hubs appear to provide a better migration path to higher speed LAN technologies by offering optional backplanes for high speed network access, such as FDDI and ATM, within the same enclosure. However, a LAN infrastructure that is designed around a chassis-based system ties the customer into a single vendor's products. Furthermore, plug-in cards from one vendor cannot be installed into another vendor's hub. As a result, a company will have absolutely no choice when it decides to move to FDDI or ATM: it has to buy the chosen chassis hub vendor's products. Even worse, the FDDI or ATM offerings of that vendor may not be the best or lowest cost on the market when the time comes - there may be other much better solutions available.

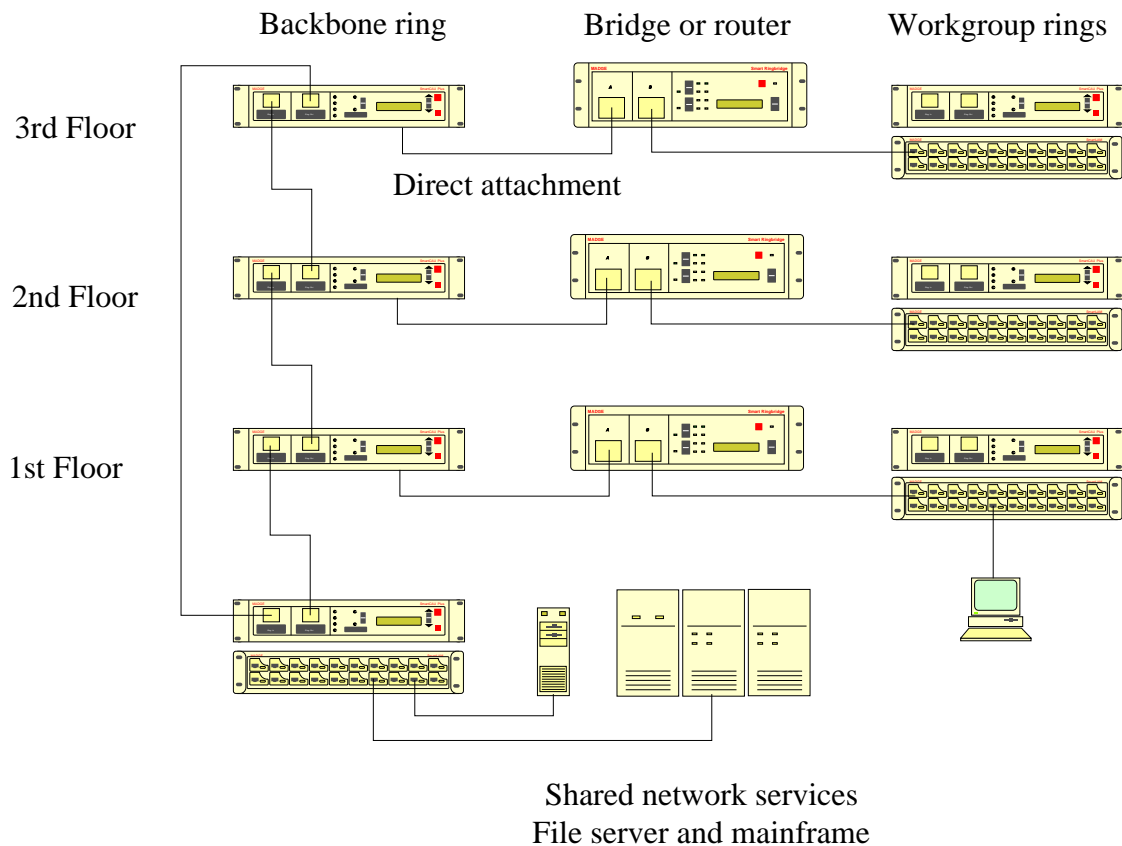
In contrast, stackable hubs deliver a solution that is completely open. They provide customers with flexibility to select the best solution to meet the needs of the network today and avoid any unnecessary commitment to technologies that may not be appropriate for the future. When the time comes, customers are absolutely free to choose the high speed solution that best addresses their networking needs. The vendor selected at this point does not need to be the same as the current network hub supplier.

Implementation Examples

Direct Station Attachment

SmartCAU Plus is able to support the direct attachment of up to 4 stations without the need of a SmartLAM. The stations are attached to the 9-pin D-type connectors on the rear of SmartCAU Plus using two back-to-back Token Ring lobe cables. This cost saving feature is particularly useful when SmartCAU Plus is used on a backbone. Up to four bridges or routers may be directly connected to SmartCAU Plus. SmartCAU Plus' internal repeater function and support for STP, UTP or fiber optic trunk cable makes SmartCAU Plus the ideal backbone solution.

Stations connected to the rear of SmartCAU Plus are fully visible to the network management system and can be managed in a similar way to stations connected to SmartLAMs. In addition, SmartCAU Plus' fault recovery mechanisms, including speed detection, extend to directly attached stations.

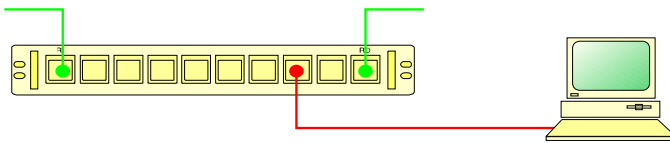


SmartCAU Plus used both as a backbone hub and as a workgroup concentrator

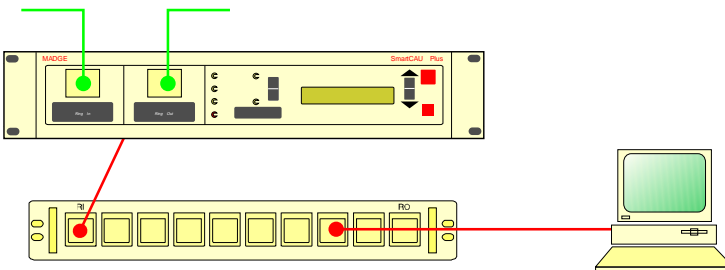
Management of MAUs

Many Token Ring networks use passive MAUs as the basis for the network connectivity. MAUs offer no management or fault recovery capabilities: if a fault develops, the network administrator has to identify where it is located and manually remove it from the network. While he is doing this, the network remains inoperable and users cannot work.

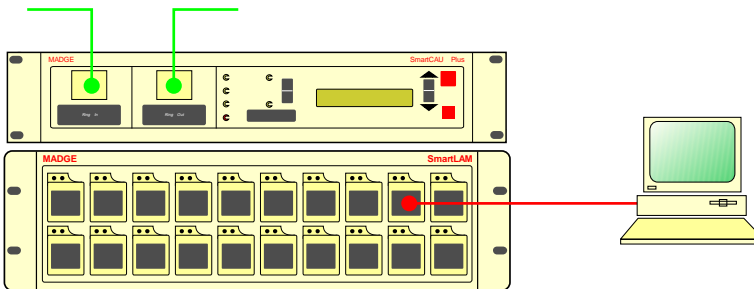
Although intelligent hubs resolve this problem with their fault recovery and management features, the implementation of such devices often involves a large initial investment and scrapping of the installed base of MAUs.



***Today:** Stations connected to MAUs -
no management or fault resilience*



***First step:** attach MAUs directly to SmartCAU Plus -
limited fault resilience and management*



***Final step:** replace MAUs with SmartLAMs -
maximum fault resilience and management*

SmartCAU Plus provides a unique solution to this problem: MAUs can be directly attached to SmartCAU Plus in place of SmartLAMs. Up to two MAUs can be attached to each SmartCAU Plus port, providing connection for up to 64 stations on a single hub. This not only reduces the cost of upgrading the network to intelligent hubs, but means the installed base of MAUs does not have to be discarded.

TrueView CAU Manager allows the user to view graphically which stations are attached to the MAU. Although individual ports cannot be disabled on the MAU, control is still available since the chain of MAUs connected to a SmartCAU Plus port can be removed by the network administrator. Also, if a fault develops on a MAU, SmartCAU Plus will identify on which group of MAUs it is located and automatically remove the group to restore the network to full operation.

At a later stage, the whole network can be upgraded to maximum management and fault resilience by replacing the MAUs with SmartLAMs.

Local Ringhub Support

Splitter devices, such as Madge's Local Ringhub, can be used to connect multiple stations to individual SmartLAM ports. TrueView CAU Manager will detect this and, when the user selects the SmartLAM port, will display the attached addresses in a list. This provides the network administrator with greater management and control where such devices are used.

Amsterdam
 Atlanta
 Bangkok
 Berlin
 Boston
 Brussels
 Capetown
 Chicago
 Cologne
 Copenhagen
 Dallas
 Denver
 Detroit
 Frankfurt
 Hong Kong
 Johannesburg
 Kuala Lumpur
 London
 Los Angeles
 Madrid
 Minneapolis
 Munich
 Oceania
 Nashville
 New York
 Paris
 Philadelphia
 San Jose
 Seattle
 Singapore
 Stockholm
 Sydney
 Tokyo
 Toronto
 Vancouver
 Washington DC



Madge Europe

Madge Networks Ltd
 Loudwater
 High Wycombe
 Bucks HP10 9QZ
 England
 Tel: (44) 0628 858000
 Fax: (44) 0628 858011

Madge Americas

Madge Networks Inc
 2310 North First Street
 San Jose
 Calif. 95131-1011
 United States
 Tel: (408) 955 0700
 Fax: (408) 955 0970

Madge Asia

Madge International Ltd
 64-01 Central Plaza
 18 Harbour Road
 Wanchai
 Hong Kong
 Tel: (852) 593 9888
 Fax: (852) 519 8022

Madge Japan

Madge Japan KK
 Believe Mita
 43-16 Shiba 3-chome
 Minato-ku, Tokyo 105
 Japan
 Tel: (81) 3 5232 3281
 Fax: (81) 3 5232 3208

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