C-Bus Networks

Document Number:	CBUS-NET
Issue:	2
Date:	14 Aug 2005

Prepared By:	D Snodgrass Clipsal Integrated Systems Pty Ltd
Authorised By:	J A Gerard Clipsal Integrated Systems Pty Ltd Engineering Manager

Comments on this document should be addressed to:

Engineering Manager
Clipsal Integrated Systems Pty Ltd
PO Box 103 Hindmarsh
South Australia 5007

Date	Change Reference	Comments
25 May 2005	Draft	Original
21 Jun 2005	Issue 1	Updated section 8.5
14 Aug 2005	Issue 2	Updated Colour C-Touch network modelling

TABLE OF CONTENTS

1 INTRODUCTION

1.1 Document Purpose

This document provides information regarding how C-Bus Networks and related units operate.

1.2 Usage

This document should be used for guidance for designing complex C-Bus systems and resolving system related issues.

This document refers to the latest versions of relevant products at the time of publication.

2 DEFINITIONS

2.1 Terms Used

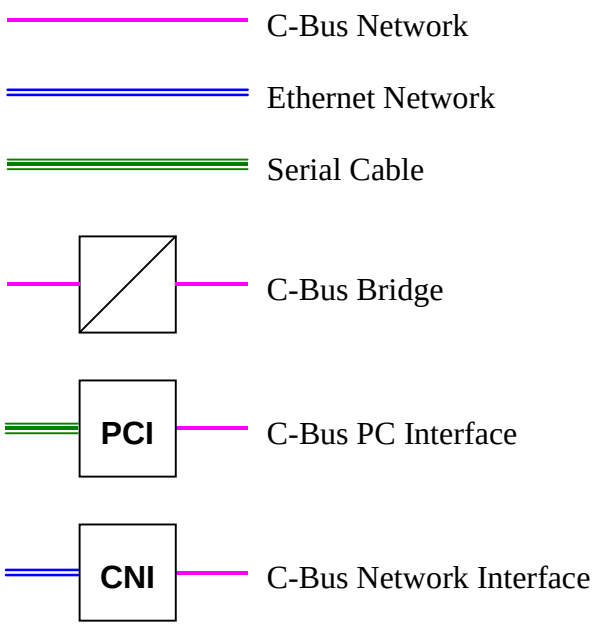
Term	Definition
Application Connect Mode	A mode of operation for a C-Bus Bridge where the selected C-Bus Application(s) on either side of a Bridge are effectively connected together. Messages on the selected C-Bus Application(s) are routed across the Bridge automatically to the other side.
C-Bus	A home and building automation system compromising of a communication bus network, the hardware units on that network, as well as the software that ties in all together. Developed by Clipsal Integrated Systems. A protocol used by C-Bus Units to talk on a C-Bus network.
C-Bus Application (Application)	A well-defined set of behaviours for one or more devices connected to a C-Bus network. A C-Bus Application is a name given to a set of C-Bus commands with related behaviour. A C-Bus Application is assigned a unique Application Address, and contains one or more commands specific to the domain of that C-Bus Application.
C-Bus Bridge	A C-Bus Unit which connects two C-Bus Networks together. Used to transfer messages from one C-Bus Network to another.
C-Bus Command (Command)	A C-Bus Command is the part of a C-Bus Message containing the action to be performed or the data. The terms “Message” and “Command” are often used interchangeably, but do have distinct meanings. Each C-Bus Application has a predefined list of commands for that C-Bus Application.

Term	Definition
C-Bus Message (Message)	C-Bus messages are used to communicate between C-Bus Units. A message contains Protocol Control Information, followed by zero or more C-Bus Commands. The terms “Message” and “Command” are often used interchangeably, but do have distinct meanings.
C-Bus Network	The physical installation of C-Bus Units on the same wiring circuit.
C-Bus Protocol	The patented format of C-Bus Messages. See http://www.cbus-enabled.com/cbus-open.htm for more details.
C-Bus Unit	A physical device attached to a C-Bus network. Sometimes also called a node.
C-Gate	A high level “driver” for C-Bus providing a TCP/IP interface.
CNI	C-Bus Network Interface. An Interface between an Ethernet network (TCP/IP) and C-Bus.
Connected Network	A Network connected to a unit via a Connection.
Far Side	A reference to the side of a C-Bus Bridge which is not connected to the network in question. Not the Gary Larson cartoon.
Fully Connected Network	A C-Bus Topology where every C-Bus Network is connected to every other C-Bus Network in an Installation via a C-Bus Bridge.
Group / Group Address	Group Addresses are the Network Variables used on the C-Bus Lighting Application. Group Addresses are generally used to create an association between an Input Unit Key and an Output Unit Terminal. Each Group Address has a Level associated with it, which is the Value of the Group Address Network Variable.
Hexadecimal	A Hexadecimal number is a number represented in "base 16". Everyday numbers are represented in decimal, which is base 10. In the decimal system numbers are expressed with 10 symbols; the familiar digits 0-9. The hexadecimal system uses 16 symbols, the ten digits plus five letters (A to F) to stand for "digits". Hexadecimal numbers are often used to represent C-Bus Entities, but it is usually clearer to use decimal numbers or Tags.
Installation	A physical location with a C-Bus system installed. An Installation will have a C-Bus Project associated with it.
Key	A Key is a physical switch used for the control of a Key Input Unit. Keys are usually push buttons.
Level	A Level is the Value of a Group Address Network Variable. It corresponds to the intensity of a Lighting Load. A Level has a value between 0 (0%) and 255 (100%). See also On and Off.
Local Network	The C-Bus Network connected to the PC with the Installation Software running on it. This term is replaced with the concept of a Connected Network for Version 3 of the Installation Software onwards.

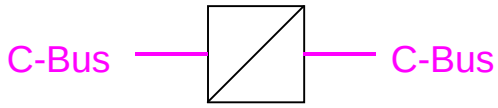
Term	Definition
Message Tunnelling (SAL Tunnelling)	A mode of operation of a C-Bus Bridge where messages on a C-Bus Network can be forwarded (Tunnelled) to a Remote Network.
Near Side	A reference to the side of a C-Bus Bridge which is connected to the network in question.
Network	Abbreviation of C-Bus Network. Other (incorrect) uses of the term “Network” include : • Abbreviation of Network Address. • The collective total of all C-Bus Networks in a C-Bus Project can also be referred to as a Network. (This much the same way that corporate computer networks are referred to as a Network, when they actually contain many networks that interoperate.)
Network Address	Every C-Bus Network has a Network Address. This is a number assigned to the C-Bus Network and must be unique to all C-Bus Networks that are joined by a Network Bridge. A Network Address corresponds to the Unit Address on the Far Side of a C-Bus Bridge. A Network Address ranges from 0 to 255 decimal ($00 to $FF hexadecimal).
Network Route	A path from one C-Bus Network to another, containing the address(es) of the C-Bus bridge(s) joining them. The Local Network has no Network Route.
Network Variable	A network wide control variable maintained and/or controlled by C-Bus units. Within the Lighting Application, a Network Variable is called a Group Address Variable (GAV), and its value is called a Group Address Level.
PC Interface	An Interface between a Personal Computer (PC) serial port (RS232) and C-Bus. Also called a Serial Interface.
PCI	Abbreviation for PC Interface.
Protocol Control Information	The first part of a C-Bus Message, encoding the message type (CAL or SAL), source unit address, control information and the destination of the message. The destination contains the Network Route and either: • The destination Unit Address (for CAL messages); or • The C-Bus Application Address (for SAL messages)
Remote Network	A network connected to the Network in question via a C-Bus Bridge.
Scene	A combination of Group Addresses and corresponding Levels and Ramp Rates. Setting a Scene involves setting a series of Group Addresses to pre-defined Levels.
Schedule	An Event which is to occur at a particular time and (optionally) dates.

Term	Definition
Serial Interface	An Interface between a Personal Computer (PC) serial port (RS232) and C-Bus. Also called a PC Interface.
Topology	Topology is a mathematical term meaning the way that things are connected together. A C-Bus topology represents the way that the C-Bus Networks are connected to each other (via C-Bus Bridges) and to the PC.
Triggering Scenes	A method of broadcasting a message (usually on the Trigger Control Application) to trigger (activate) a Scene stored in another Unit.
Unit	Abbreviation of C-Bus Unit

2.2 Diagram Symbols Used



3 C-BUS BRIDGES



A C-Bus Bridge is used to connect two C-Bus Networks together and to transmit messages from one Network to the other.

4 C-BUS MESSAGE ROUTING

4.1 C-Bus Message Structure

A C-Bus message contains the following parts :

- Header – the type of message and priority
- Routing – the path the message needs to take to get to the destination Network
- Command(s) – this is what the message does

For this document, the only important part of the message is the Routing. This contains a list of C-Bus Bridges which need to be crossed to get to the destination Network.

4.2 Network Route

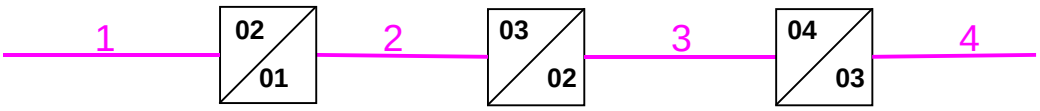
To get a message to go to a particular Network, the Network Route is included with the Message.

Explicitly routed messages only go to the destination network.

The diagram below shows the unit addresses of the two halves of the C-Bus Bridges. By convention, the unit address of one side of a C-Bus Bridge corresponds to the address of the Network on the other side.

To get a message from Network 1 to Network 4, the Network Route would be 02 03 04. To get a message from Network 4 to Network 2, the Network Route would be 03 02.

It is not necessary for the user to be involved directly with Network Routes. These are automatically generated by the software.



Messages containing no Network Route are destined for the Network in which they originate.

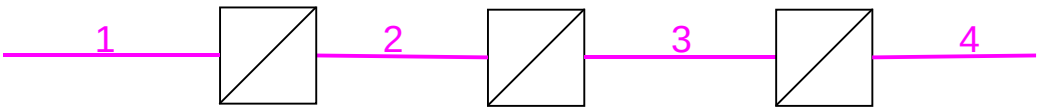
Key Input Units are not capable of generating messages routed to other Networks. C-Touch, PAC and C-Gate (and clients using C-Gate) are capable of this.

4.3 Application Connect Mode

Application Connect Mode is a setting in a C-Bus Bridge. When set, the bridge will automatically send messages from one of its Networks to the other. This makes the two Networks behave as if they were connected (there are some limitations though).

Only messages which have not been across a C-Bus Bridge will be forwarded in Application Connect Mode. This prevents messages from going back and forth between Networks and creating havoc.

In the diagram below, if a unit on Network 3 generates a message for Network 3, the bridges could forward this message to networks 2 and 4. When the message arrives in Network 2, it has a Network Route and so the Bridge does not forward it to Network 1 (or back to Network 3).



4.4 SAL Message Tunnelling

SAL Message Tunnelling is a little like Application Connect Mode – it is another setting in a C-Bus Bridge. When set, the bridge will automatically send messages from one of its Networks to some other network.

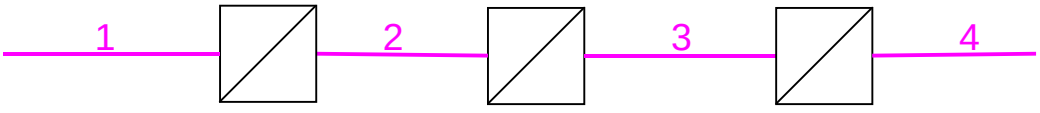
If the bridges are set to send messages from remote networks back to the local network, you can monitor the state of the remote networks. (Networks that are adjacent to the Local Network can send messages back to the Local Network using Application Connect Mode). Networks that are further away can use SAL Message Tunnelling to send messages back to the Local Network.

Only messages which have not been across a C-Bus Bridge will be forwarded by SAL Message Tunnelling.

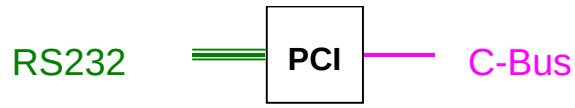
4.5 Observed Messages

If a message on a network is not destined for that network, any units connected to the network will not see the message.

In the diagram below, if a C-Touch on Network 1 generates a message destined for Network 4, only devices on Network 4 will see the message. Devices on Networks 1, 2 and 3 will not see the message.



5 SERIAL INTERFACES



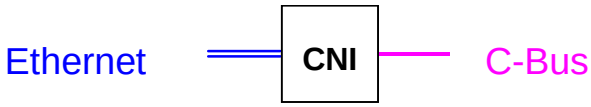
Serial Interfaces are an RS232 to C-Bus Interface. Examples of Serial Interfaces are the C-Bus PC Interface and the C-Bus SIM. The Serial Interfaces use the C-Bus serial protocol.

Many C-Bus Devices contain a Serial Interface, including the C-Touch Touchscreens, PAC, General Input Unit and Telephone Interface.

A Serial Interface acts a bit like half of a C-Bus Bridge. When a message is sent onto C-Bus, it contains a Network Route as if it has been across a bridge. This has the effect that the messages will not be forwarded by Application Connect or Message Tunnelling. This behaviour can be changed by setting "Local SAL Mode" in the Serial Interface.

C-Gate, C-Touch, PAC, GIU and Telephone Interface all set Local SAL Mode automatically, but other devices using Serial Interfaces may not. Local SAL Mode is available in PCI V3.12 and later. See the C-Bus Diagnostic Utility for more information.

6 CNI

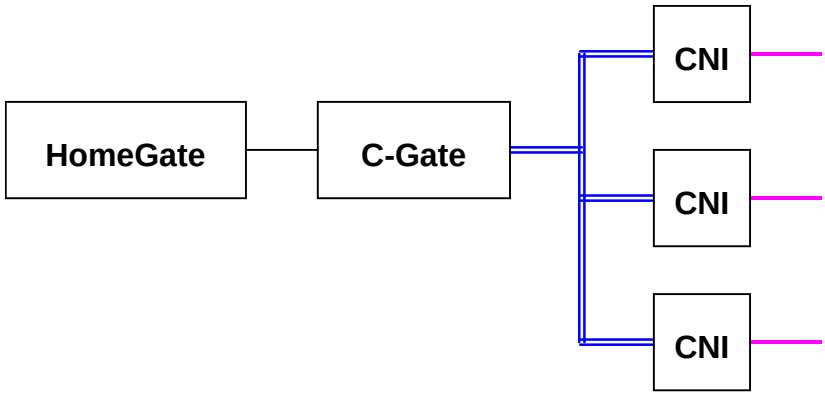


A C-Bus Network Interface (CNI) is an Ethernet to C-Bus interface. CNIs use the same serial protocol as a PCI, but communicate via TCP/IP instead of RS232.

CNIs have no message forwarding like Application Connect mode in a C-Bus Bridge.

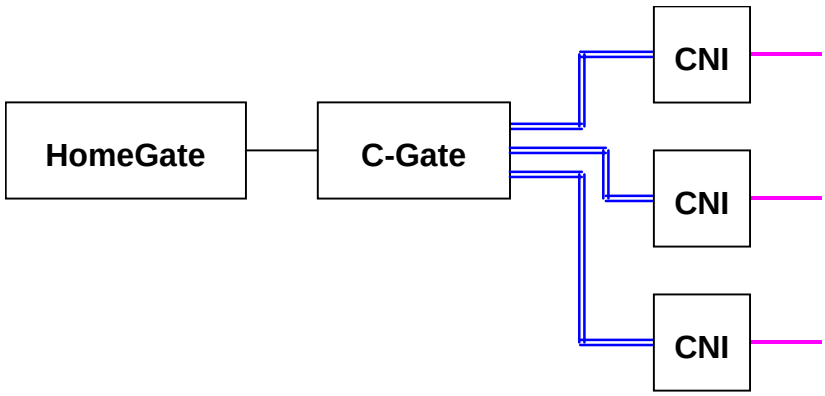
Only one client can use a CNI at a time: a CNI provides a connection between a single Client and a single C-Bus network.

This kind of diagram which shows a client connected to multiple CNIs:



is a little misleading. It looks like the CNIs are all connected to each other and that messages can pass between them. Although they are connected together via Ethernet, the CNIs do not communicate with each other.

A more accurate way to show what's really going on is:



7 NETWORK MODELLING

7.1 Basic C-Bus Units

Basic C-Bus Units (Key Input Units, sensors etc) can only send messages to their own network (Network routing is not possible).

When these units receive a message, they ignore any network routing that may be present.

Following a power failure, the levels of relevant Group Addresses are restored from memory.

7.2 C-Touch / PAC

Black and White C-Touch and PAC use a Serial Interface and can send messages across C-Bus Bridges to other networks.

When these units receive a message, any network routing is generally ignored (unless a reply is to be sent back to the originator).

These devices assume a fully connected network (see section 8.1). The amount of processing power, memory and network knowledge required to support the modelling of independent networks is too great for small devices such as these (see section 10 for details of what would be required).

The consequence of assuming fully connected Networks is that these devices can not distinguish between the same Group Address on different Networks. For example, if it receives a message from a Network that Group Address 1 has gone on, it will assume that Group Address 1 on all other Networks is also on.

Following a power failure, the levels of relevant Group Addresses are restored from memory.

7.3 C-Gate

C-Gate models networks independently. This allows a Group Address to be used on different Networks and have different levels. C-Gate models the Networks in accordance with the requirements of section 10.

C-Gate can send messages to remote networks. Received messages contain network information.

C-Gate can connect to C-Bus via one or more PC Interfaces and/or CNIs.

C-Gate needs to scan networks on power-up to get levels of Group Addresses. This can take a considerable time depending on the size and number of Networks.

C-Gate is used by HomeGate, Schedule Plus, the C-Bus ToolKit and by various third-party software.

7.4 Colour C-Touch

Although Colour C-Touch does not use C-Gate, it can model networks independently. It also takes a little time to interrogate the local network to determine Group Address levels.

8 NETWORK TOPOLOGIES

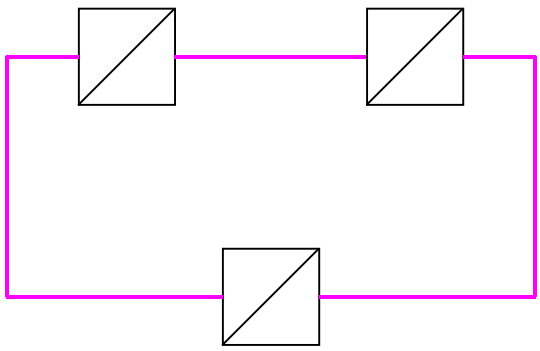
Where a project exceeds the physical limitations of a single C-Bus network, the project may need to be segregated into several networks. Each network will need to be connected to one or more other networks via bridges. The reasons for needing to separate into separate networks include:

- Too many units for one Network
- Too many Group Addresses for one Network
- Too much cable length for one Network
- Need electrical isolation between Networks
- Need message isolation between networks (to avoid excessive network traffic)

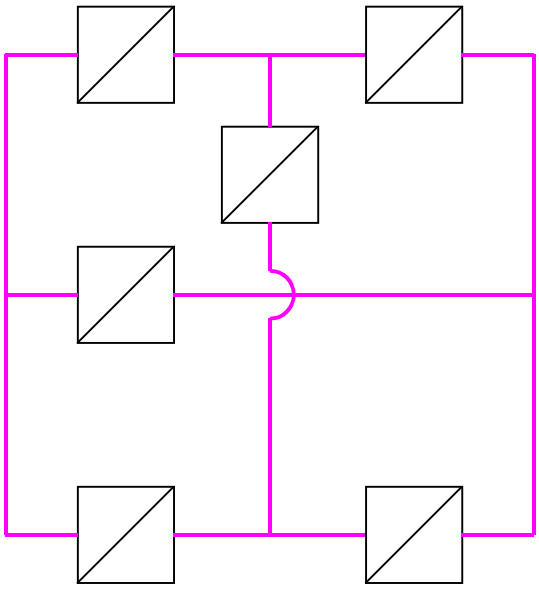
8.1 Fully Connected Networks

A Fully Connected Network has every Network connected to every other Network via a C-Bus Bridge, and behaves like one large C-Bus Network.

To fully connect 3 networks, 3 bridges are needed:



To fully connect 4 networks, 6 bridges are needed:



Uses

- Mainly small to medium installations

Advantages :

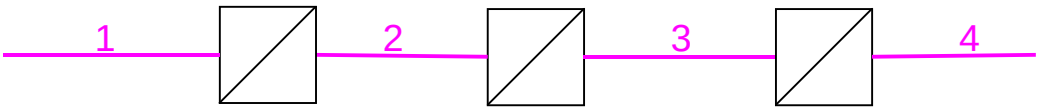
- You can mostly ignore issues regarding networks, as it behaves very much like one big network.
- Easy to model.

Disadvantages :

- As the number of networks increases, the number of bridges needed to make it fully connected increases rapidly.
- Too much Network traffic can become a problem

8.2 Partially Connected Networks

A partially connected network topology is where some networks are not connected to other networks. For example:



Uses

- Mainly small to medium installations

Advantages

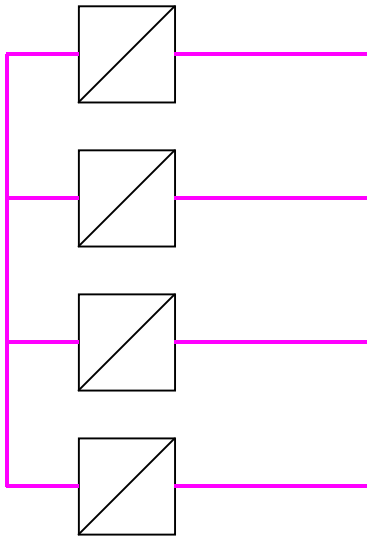
- Minimum number of C-Bus Bridges needed.

Disadvantages

- Not all messages get to all other networks
- More difficult to model

8.3 C-Bus Backbone

In a C-Bus “backbone” network, one network (the backbone network) is connected to all other networks via C-Bus Bridges:



Uses

- Commonly used with large sites

Advantages:

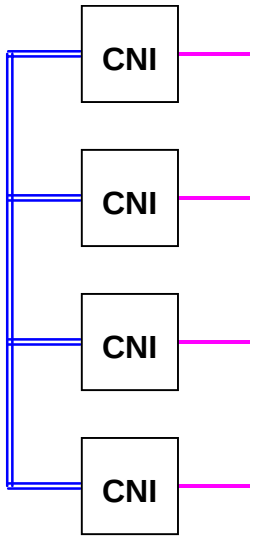
- Simple
- Devices on the backbone can operate with all other networks
- Individual networks do not disturb each other

Disadvantages:

- Not all messages get to all other networks
- The backbone Network gets a lot of traffic

8.4 CNI Backbone

In a CNI “backbone” network, an Ethernet network (the backbone network) is connected to all C-Bus networks via CNIs :



Uses

- Commonly used with very large sites
- Generally only used when C-Gate is used (on the backbone)

Advantages :

- Can use existing Ethernet infrastructure
- Ethernet has wide bandwidth, so this is suitable when there is a lot of traffic
- Individual networks do not disturb each other

Disadvantages :

- Difficult to route messages between C-Bus Networks
- Ethernet and TCP/IP can be difficult to set up.

8.5 Using More than 255 Group Addresses

The maximum number of Group Addresses available is 255 per Application per Network.

If you need to use more than 255 Group Addresses, there are two options :

- Use another Application – Application numbers 48 to 95 ($30 to $5F Hexadecimal) are available for lighting
- Use another Network

Using multiple Networks adds complications, but may be necessary anyway if there are too many units for a single Network. Even if multiple Networks are used, it may be desirable to use a different Application on each Network so that there are not unforeseen interactions between the Networks.

For example, if you use Group Address 20 on Application 56 ($38 hexadecimal) on two different Networks which are connected by a C-Bus bridge, then these two Group Addresses may or may not be independent, depending on the bridge configuration. C-Touch (and most other units) will assume that the Networks are fully connected with C-Bus bridges and hence that these Group Addresses are the same level. This means that it will assume Group Address 20 on one Network is the same as Group Address 20 on another Network, although in reality they may be different. If you use Group Address 20 on different Applications, then C-Touch will always treat them as being independent (which they will be).

C-Gate will correctly model Networks which are connected with C-Bus bridges or which are completely independent.

Refer to Table 1 for guidance on how to configure different installations.

Table 1 – Network Configurations

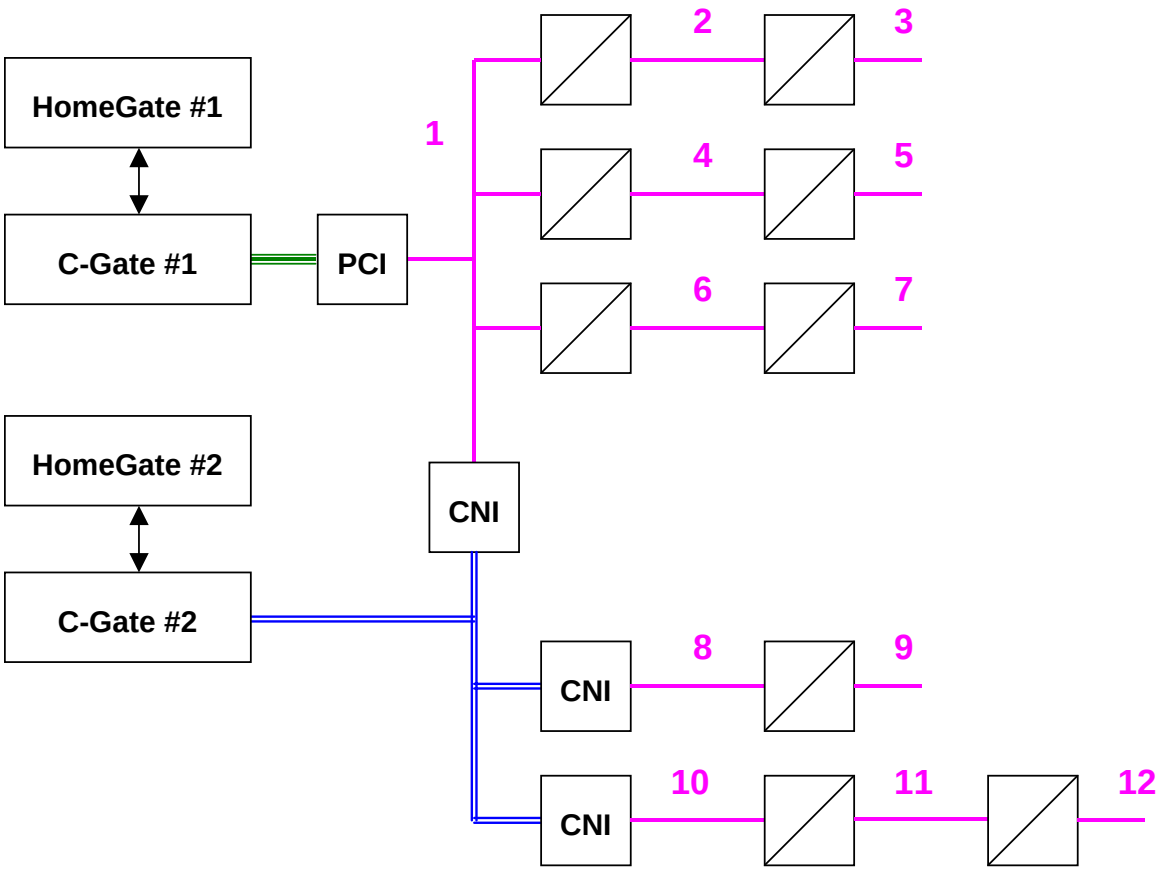
Installation Type	Preferred Configuration
Small multi-nework. Less than 255 Group Addresses needed.	Use a single Lighting Application. Interconnect Networks with C-Bus Bridges in Application Connect Mode.
Medium multi-nework. More than 255 Group Addresses needed.	Use a Lighting Application per C-Bus network. Interconnect Networks with C-Bus Bridges in Application Connect Mode.
Large multi-nework. More than 255 Group Addresses needed.	Use a single Lighting Application. Interconnect Networks with CNIs. Use C-Gate with a Building Management System (such as Schedule Plus).

9 TUTORIAL

The following self-test can be used to evaluate your understanding of C-Bus Networks.

9.1 Questions

For the following questions, the following Network topology applies. Two instances of HomeGate are connected to a series of C-Bus networks via Bridges and CNIs. Units are connected to each Network, which are not shown. All C-Bus Bridges are in Application Connect Mode.



9.1.1 Message Routing

1. Which Networks can a C-Touch on Network 1 send messages to?
2. Which Networks can a C-Touch on Network 1 receive messages from?
3. Which Networks can a Key Input Unit on Network 1 send messages to?
4. Which Networks can a Key Input Unit on Network 1 receive messages from?
5. Which Networks can a C-Touch on Network 8 send messages to?
6. Which Networks can a C-Touch on Network 8 receive messages from?
7. Which Networks can a Key Input Unit on Network 8 send messages to?
8. Which Networks can a Key Input Unit on Network 8 receive messages from?

9. Which Networks can HomeGate #1 send messages to?
10. Which Networks can HomeGate #1 receive messages from?
11. Which Networks can HomeGate #2 send messages to?
12. Which Networks can HomeGate #2 receive messages from?
13. If a unit on Network 2 sends a message to Network 4, which units will see the message?
14. What can be done in order for HomeGate #2 to see all messages occurring on Network 12?
15. How can messages be sent from Network 8 to Network 10?

9.1.2 C-Touch Behaviour

1. C-Touch is installed on Network 1 and has buttons controlling Group Address 5 on Network 2 and Network 3. A user presses the button controlling Group Address 5 on Network 2 and switches it on. What will happen?
2. C-Touch needs to switch on Group Address 3 on its Network and on an adjacent Network which is connected via a C-Bus Bridge with Application Connect set. How can this be done?
3. C-Touch needs to switch on Group Address 3 on its Network and on a Network separated by two C-Bus Bridges. How can this be done?
4. A C-Touch has been moved from one Network to another, but the messages to remote Networks are no longer working. Why?
5. A large site with a C-Bus backbone is to use C-Touch to provide limited control of some Group Addresses on each Network. Where should the C-Touch be connected?
6. A site needs 300 Group Addresses spread across separate Networks. They all need to be controlled independently from a C-Touch. What is the best method of implementing more than 255 Group Addresses?

9.1.3 C-Gate Behaviour

1. It is desired to have three copies of Schedule Plus running on a site. C-Gate will connect to C-Bus via CNIs. What hardware will be necessary?
2. A multi-story building is to be controlled by Schedule Plus. Each floor has a different C-Bus Network. No communication is required between floors. A lot of Scheduling is required. What is the best topology?

9.1.4 Other Unit Behaviour

1. C-Touch is installed on Network 1 and controls Group Address 5 on Network 1 and Network 2. A Key Input Unit on Network 1 also controls Group Address 5. A user presses the C-Touch button controlling Group Address 5 on Network 2 and switches it on. What will happen?
2. A third party device can send messages to its Network, but the messages are not being forwarded by Application Connect Mode. Why ?

3. Can a Key Input Unit send a message to a Remote Network?
4. Can a Key Input Unit respond to a message from a Remote Network?
5. Key Input Units controlling Group Address 4 are connected to Networks 1, 2 & 3. When the Key on Network 2 changes Group Address 4, the indicators on Network 1 and 3 change. When the Key on Network 1 changes Group Address 4, the indicator on Network 2 changes but the indicator on Network 3 does not change. Why?
6. How can this be fixed?

9.2 Answers

9.2.1 Message Routing

1. Networks 1, 2, 3, 4, 5, 6 & 7. HomeGate # 1 and #2 will also see any messages sent to Network 1.
2. Networks 1, 2, 4 & 6. If a unit capable of transmitting messages to remote networks is used (such as C-Touch), then also Networks 3, 5, & 7*. It will also see any messages sent from HomeGate #1 or #2 to Network 1.
3. Network 1. A Key Input Unit can only send messages to its own network. Due to the C-Bus Bridges being in Application Connect Mode, Networks 2, 4 & 6 will also see the messages. HomeGate # 1 and #2 will also see any messages.
4. As for Question 2.
5. Networks 8 & 9. HomeGate #2 will also see any messages sent to Network 8.
6. Networks 8 & 9. It will also see any messages sent from HomeGate #2 to Network 8.
7. Network 8. A Key Input Unit can only send messages to its own network. Due to the C-Bus Bridges being in Application Connect Mode, Network 9 will also see the messages. HomeGate #2 will also see any messages.
8. As for question 6.
9. Networks 1, 2, 3, 4, 5, 6 & 7. HomeGate #2 will also see any messages sent to Network 1.
10. Networks 1, 2, 4 & 6. If a unit capable of transmitting messages to remote networks is used (such as C-Touch), then also Networks 3, 5, & 7*. It will also see any messages sent from HomeGate #2 to Network 1.
11. All Networks. HomeGate #1 will also see any messages sent to Network 1.
12. Networks 1, 2, 4, 6, 8 & 10. If a unit capable of transmitting messages to remote networks is used (such as C-Touch), then also Networks 3, 5, 7, 9, 11 & 12*. It will also see any messages sent from HomeGate #1 to Network 1.
13. Only units on Network 4. Units on Network 1 & 2 and HomeGate #1 and #2 can not see the message.
14. The bridge on Network 12 can to be set up to use Message Tunnelling to send messages to Network 10. Alternatively, add a C-Bus Bridge between Network 8 and 12.
15. They can't be sent directly as the CNIs are not connected to each other, but to C-Gate. HomeGate #2 could have some logic code written to route messages received from Network 8 to Network 10 and vice versa.

* assuming that the C-Bus messages are routed to the correct destination Network.

9.2.2 C-Touch Behaviour

1. Group Address 5 on Network 2 will switch on. Group Address 5 on Network 3 will not change. The indicators for both Network 2 and 3 will show Group Address 5 being on (as C-Touch assumes they are the same).
2. The message should be sent to the C-Touch's own Network. The message will be automatically forwarded to the adjacent Network by the C-Bus Bridge. If the message is sent to the adjacent Network, it will not also appear on the C-Touch's Network.
3. The message should be sent to both the C-Touch's own Network and the remote Network. This can be achieved by the use of Scenes (see PICED documentation for details).
4. C-Touch contains the Network Routes from a particular network only. By moving C-Touch, the Network Routes are now wrong.
5. It is best to connect it to the backbone Network. That way it can see messages from every Network.
6. Use two Applications. Do not use the same Group Address on separate Networks, as the C-Touch will not be able to distinguish them (neither will any other units).

9.2.3 C-Gate Behaviour

1. A CNI can only have one C-Gate communicating with it. You could have three PCs each running Schedule Plus and C-Gate, each having their own CNI. A more efficient method would be to have a single copy of C-Gate with a single CNI, and have each copy of Schedule Plus connected to the same C-Gate. In this case, you would need to ensure that the PC running C-Gate is either always on, or is always on before the PCs running Schedule Plus.
2. A CNI backbone (see 8.4). This will handle a lot of messages.

9.2.4 Other Unit Behaviour

1. Group Address 5 on Network 2 will switch on. The indicator on the Key Input Unit will not change, as it does not see the message (because it is destined for another network). C-Touch will show that Group Address 5 on both Networks is on.
2. Local SAL Mode has not been set. See section 5.
3. Yes
4. No
5. When the message is generated on Network 2, it is forwarded by the C-Bus Bridges to Networks 1 and 3. When the message is generated on Network 1, it is forwarded by the C-Bus Bridge to Network 2. The C-Bus Bridge does not forward the message to Network 3 because the message has already been across one C-Bus Bridge.
6. Add a C-Bus Bridge connecting Network 1 to Network 3.

10 APPENDIX – FULLY MODELLING C-BUS NETWORKS

Modelling the level of all Lighting Group Addresses in an installation just requires that the rules outlined in this document are followed. There are some subtle points which could easily be missed, so this section describes how a full C-Bus model needs to handle Network related issues. Most readers can skip this section as it is not of any relevance.

C-Gate applies all of these rules in its modelling.

10.1 Model Requirements

To fully model the Lighting Application aspects of a C-Bus installation, the model needs to:

- Have a multi-dimensional data storage to store the status of each Network / Application / Group Address combination
- Store any changes as a result of any received or transmitted messages
- Maintain the dynamic level of each ramping Group Address
- Know the Network topology and apply the rules outlined in the next sections

10.2 Received Messages

The way that received messages are handled depends on where they were generated, as described in the following sections.

10.2.1 From Connected Network

If a message was received from a connected network, then the message will not have any Network routing. This message will be sent across any bridges with Application Connect Mode set to their adjacent networks. The model needs to ensure that the relevant group Addresses in these adjacent Networks are also set.

10.2.2 From Remote Network

If a message was received from a remote network, there are two possibilities:

1. The message was forwarded by a bridge in Application Connect Mode, or by SAL Tunnelling
2. The message was transmitted with Network routing to the Local Network (probably by a C-Touch or device with similar capability)

Unfortunately, there is no way of distinguishing between these two cases. This is a problem because in reality the result will be slightly different.

In case 1, the message will be forwarded by bridges in Application Connect mode to Networks which are adjacent to the message source Network. In case 2 they won't.

The safest bet is probably to assume case 1 and model it as if the messages are sent to the source Network's adjacent Networks.

10.3 Transmitted Messages

When a message is sent, the model needs to be updated to reflect the change, as described in the following sections.

10.3.1 To Connected Network

Messages transmitted to a Connected Network will be forwarded by Bridges in Application Connect Mode or using Message Tunnelling only if the PCI/CNI is set to Local SAL Mode (see 5). The model needs to ensure that the relevant group Addresses in these adjacent Networks are also set.

10.3.2 To Remote Network

Messages transmitted to a remote network will arrive with routing and hence will not be forwarded by bridges in Application Connect Mode or with Message Tunnelling.

10.4 Messages Which Will Not Be Seen

In the following situations, messages will not be seen, and hence can not be modelled. The C-Bus system should be designed to avoid these situations if possible. The simplest way to avoid these problems is to use fully connected Networks (see 8.1) or to use a backbone Network (see 8.3 and 8.4) with only one C-Bus Network in depth.

10.4.1 Transmitted to a Remote Network

If a device on a Connected Network (probably a C-Touch) sends a message routed to a remote Network, then this message will not be seen.

10.4.2 Passing Through

If a message passes through a Connected Network on the way from the source Network to the destination Network, it will not be seen.

10.4.3 Routed Around

If a message is routed from one network to another and does not pass through a Connected Network, it will not be seen.

10.4.4 Not Forwarded

If a message on a remote Network is not forwarded by Application Connect or Message Tunnelling, then it will not be seen.