



Walt Disney Imagineering

IEEE 802 LAN/WAN Standards Committee
20th Anniversary
March 6 - 10, 2000



Walt Disney Imagineering

Non-traditional Ethernet Applications at Disney Theme Parks

Presented By

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Walt Disney Imagineering
subtitled

Ohmygosh!
You can't do that
with Ethernet!

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Current Projects Building The Parkwide Dream

Tokyo DisneySea
Disney's California Adventure
Disney Studios at Disneyland Paris

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Obtaining the Perfect TLA

Three Letter Acronyms

Design Requirements Specification

Section 1.3

ABBREVIATIONS AND ACRONYMS

- **ASC** Area Show Control System (outdoor areas)
- **ATM** Asynchronous Transfer Mode: High speed packet data communications standard that provides a scaleable backbone network offering a variety of classes of service quality
- **CAC** Central Audio Console (for Parkwide Audio System)
- **CCF** Central Communications Facility in TDL also referred to as the Old CCF.
- **CEP** The Central Energy Plant
- **CLC** Central Lighting Console (for Parkwide Lighting System)
- **CMC** Central Message Console (for Central Show/Ride Message System)
- **CNS** The Central Network Station which is the Show and Ride Operations and Maintenance base for the TDS theme park.
- **CSM** Central Show/Ride Message system
- **CWC** Central Weather/Seismic Monitor Console
- **DRS** Design Requirements Specification

- **ECB** Entertainment Control Booth
- **EER** Electronic Equipment Room
- **EMS** Energy Management System
- **GbE** Gigabit Ethernet, High speed data communications standard that provides a scaleable backbone network.
- **Hot swap** Equipment and software designed specifically to allow plug-in modules to be removed and replaced while the remainder of the system is operating normally with power turned on.
- **MIS** Maihama Information Services: The Local Area Network used by the NTIS.
- **NMS** Network Management System: A computer programmed to configure, control, monitor, and troubleshoot the PIC Network from a remote location.
- **NTIS** New Total Information System: OLC's new Information Services system which includes the MIS Network
- **OMC** Operations Master Console: Monitors all Show/Ride Parkwide Systems, interfaces to EMS and keeps park calendar/clock.
- **PAS** Parkwide Audio System: The system that sources and controls all outdoor and restaurant Background Music and Area Public Address, and monitors all parkwide audio and attraction audio including PES audio.

- **PES** Parkwide Entertainment System: The system that controls the Parade and Nighttime Spectacular events including audio, lighting and show control elements. The system central is called the ECB and is located on the 5th floor of the Hotel.
- **PIC** Parkwide Integrated Communications Network: Data communications network used by all show/ride systems including PAS, PLS, PES, CSM, ACS and OMC.
- **PLS** Parkwide Lighting System: The system that controls all on-stage lighting and monitors all attraction and show lighting in TDS except lighting dedicated to the PES.
- **OMC** Operations Master Console: Central workstation which keeps the park operating clock and calendar; and provides the ability to select Show/Ride system presets that support Live Entertainment, special events and operational changes.
- **QoS** Quality of Service: The various classes of service required by network users. There are QoS levels that provide constant bit rate service for audio and SMPTE shows, and available bit rate service for less critical uses such as status monitoring.
- **SMPTE** Society of Motion Picture Engineers: Thirty frames per second control used for animation and interactive control applications.
- **TDS** Tokyo DisneySea
- **VLAN** Virtual Local Area Network: A logical, not physical, dedicated LAN circuit provided by the PIC Network that is compliant with all applicable ATM Forum specifications including LAN Emulation and Quality of Service levels.
- **WDI** Walt Disney Imagineering
- **WMS** Parkwide Weather/Seismic Monitor System

This Presentation

- **Walt Disney Imagineering**
- **The Projects**
- **Ethernet Networking at Disney**
- **Ethernet Networks for Theme Parks**

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WDI - Walt Disney Imagineering

Part of Walt Disney Attractions

In Top 5 A&FE Firms in US

Theme Park, Resort & Real Estate Development

- **Concept**
- **Business Plan - Life Cycle Cost**
- **Design**
- **Construction**
- **Testing & Commissioning**
- **Training**
- **On-going QA**

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WDI Theme Park Projects

	1955	Disneyland
	1971	Magic Kingdom WDW
	1982	EPCOT WDW
	1983	Tokyo Disneyland
	1989	Disney-MGM Studios WDW
	1992	Disneyland Paris
Ethernet in the Design	1998	Disney's Animal Kingdom WDW
	2001	Disney California Adventure
	2001	Tokyo DisneySea
	2002	Disney Studios at Disneyland Paris
	2005	Hong Kong Disneyland

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WDI Resort Projects

	1955 - 1996	Disneyland - 2 Hotels
	1971 - 1999	WDW - 19 Hotels
	1971 - 1999	WDW - 3 Water Parks
	1971 - 1999	Downtown Disney at WDW
	1992	Disneyland Paris - 6 Hotels
Ethernet in the Design	1998 - 1999	Disney Cruise Line - 2 Ships
	2001	Disneyland Resort - Grand Californian
	2001	Downtown Disney at Disneyland Resort
	2001	Hotel MiraCosta at Tokyo DisneySea

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Elements of a Major Project

All Project Elements are Inter-related

- Guest and Cast Access
- Permits and Land Use Plan
- Site and Area Development
- Facilities
- Shows and Rides
- Live Entertainment

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Ethernet Networking at WDI

- Design & Development
 - * CAD
 - * CAM
 - * Modeling
 - * Management
 - * Administration
- Attraction Systems
 - * Show Control - Real Time
 - * Show Audio - Real Time
- Distributed - Parkwide Systems
 - * Information Services
 - * Show/Audio/Lighting - Real Time

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Parkwide Systems Scope

Shared Electronic Infrastructure (Campus-level Systems)

- Information Services
- Facility Management
- Phones
- Broadcast & Production
- Show/Ride & Entertainment

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Parkwide Systems

IS	- Office Automation
	- Point of Sale - Food, Shops, Tickets
	- Dining Reservations
	- Employee Time Clock
	- IS Network
Facility	- Energy Management
	- Fire/Security
	- Irrigation
	- Walkie-Talkie
Phones	- PBX (park)
	- Pay
	- Cell

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TDS Parkwide Systems

Broadcast

- TV Remotes
- Radio Remotes
- Video/Film Production

Show & Ride

- Background Music
 - Public Address
 - Area Lighting
 - S/R Message
 - Area Show
 - Atmosphere Show
 - Closing Show
 - PIC Network
- Parkwide Integrated Communications

Systems Design

Network Ready ➡
Ethernet ➡

IS

- ➡➡➡ Office Automation
- ➡➡➡ Point of Sale - Food, Shops, Tickets
- ➡➡➡ Dining Reservations
- ➡➡➡ Employee Time Clock
- ➡➡➡ IS Network

Facility

- ➡➡➡ Energy Management
- ➡➡➡ Fire/Security
- ➡➡➡ Irrigation
- ➡➡➡ Walkie-Talkie

Phones

- ➡➡➡ PBX (park)
- ➡➡➡ Pay
- ➡➡➡ Cell

Broadcast

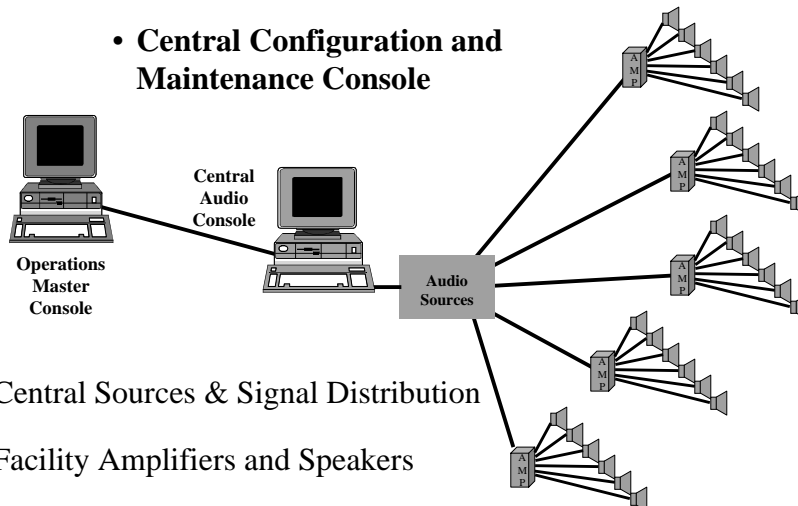
- ➡➡➡ TV Remotes
- ➡➡➡ Radio Remotes
- ➡➡➡ Video/Film Production

Show/Ride

- ➡➡➡ Background Music
- ➡➡➡ Public Address
- ➡➡➡ Area Lighting
- ➡➡➡ S/R Message
- ➡➡➡ Area Show
- ➡➡➡ Atmosphere Show
- ➡➡➡ Closing Show
- ➡➡➡ PIC Network

Parkwide Audio System

- Central Configuration and Maintenance Console

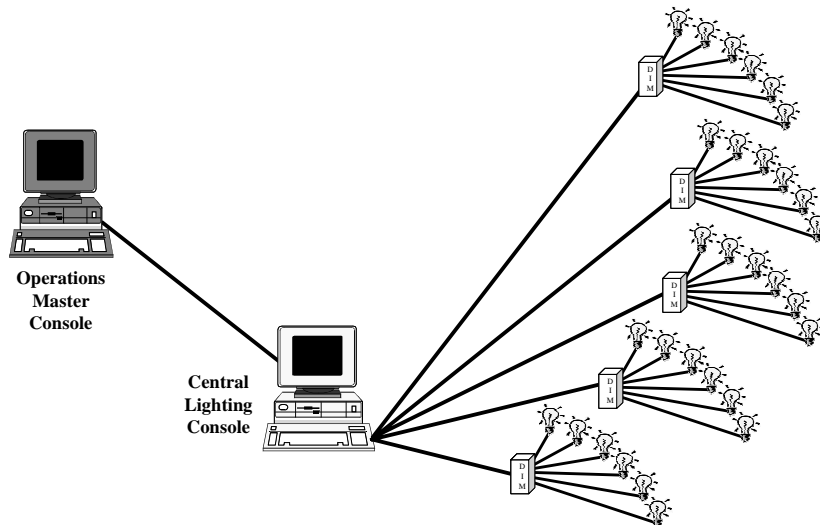


- Central Sources & Signal Distribution
- Facility Amplifiers and Speakers

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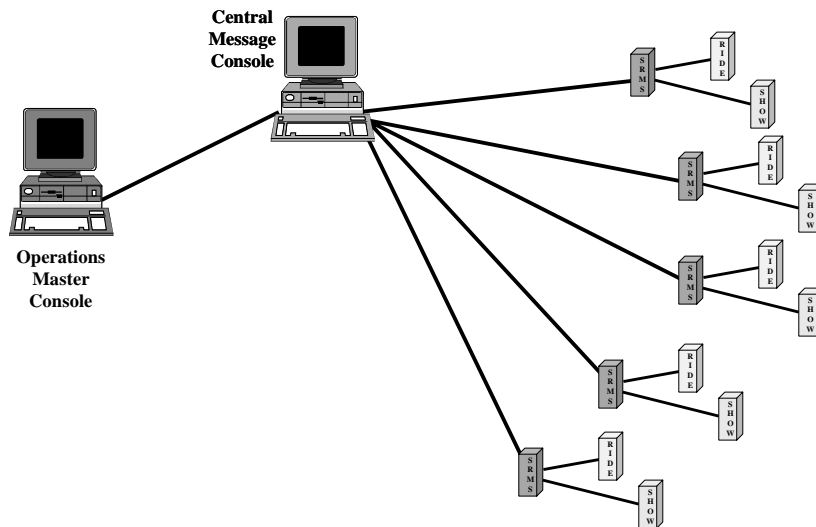
Parkwide Lighting System



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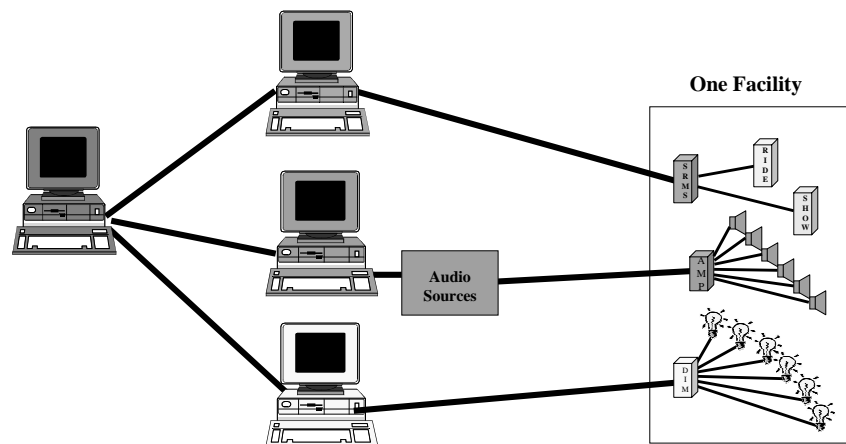
Central Show/Ride Message System



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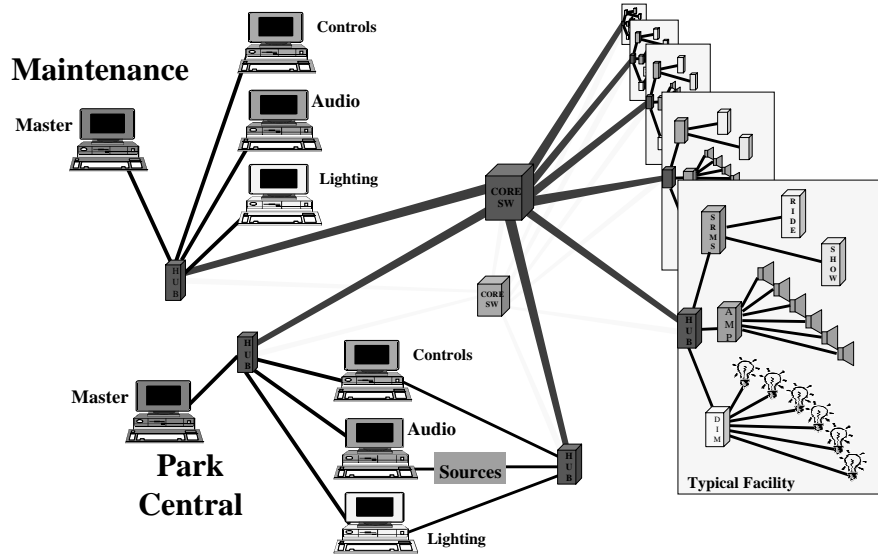
Parkwide System Communications



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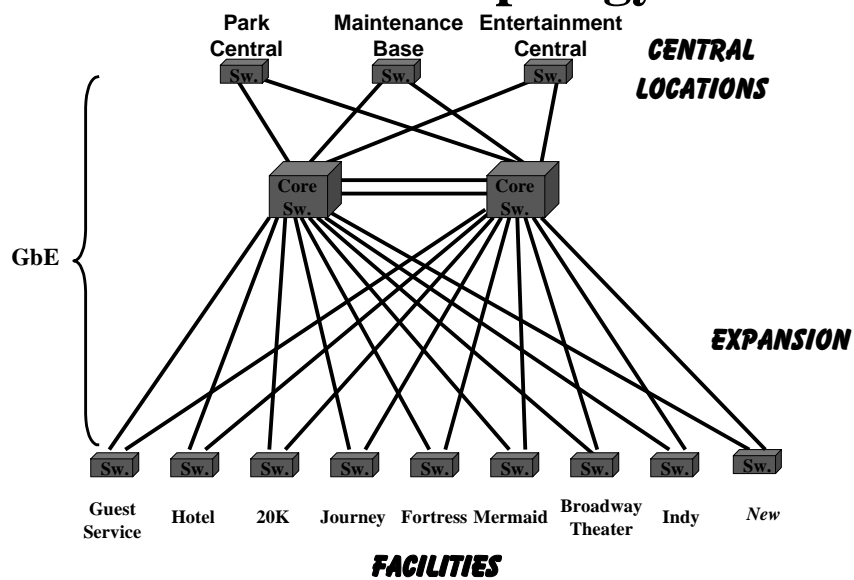
Parkwide Networking



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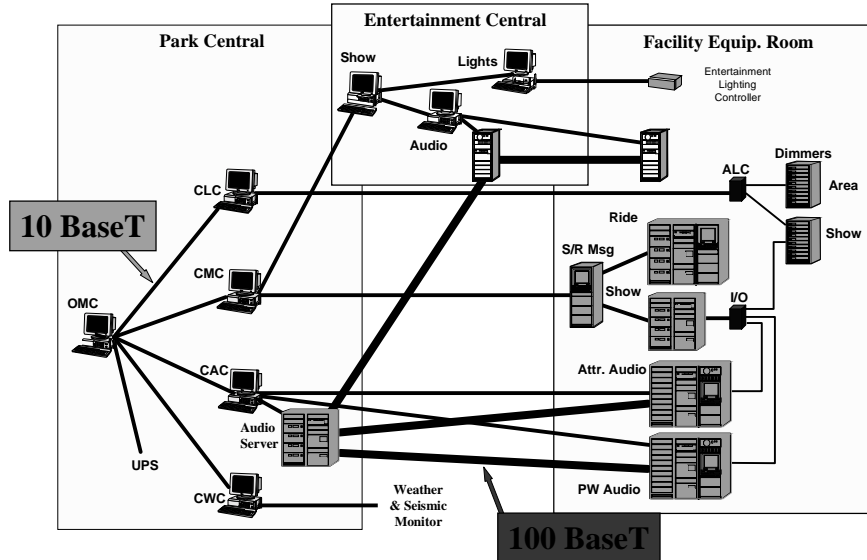
Network Topology



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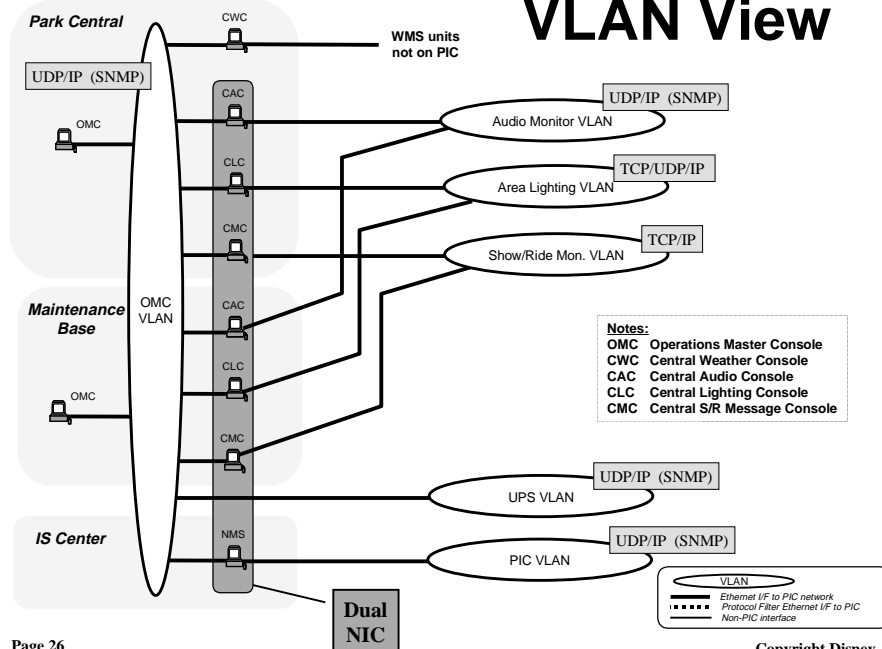
Control & Monitor



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VLAN View



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Parkwide Entertainment & Attraction Lighting

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Lighting Control Using Ethernet

- Parkwide Area Development
- Show/Ride Attractions
- Entertainment

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What is Lighting To WDI

- Ride and show areas
- Queues
- Load and unload areas
- Shops
- Restaurants
- Landscaping and area development
- Entrance plazas
- Exterior architecture
- Parades
- Theatrical Productions
- Nighttime entertainment spectacles

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“If we don’t light it,
you don’t see it”

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Parkwide Area Development

- Landscaping and area development
- Entrance plazas
- Exterior architecture
- Shops
- Restaurants

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PLS Requirements

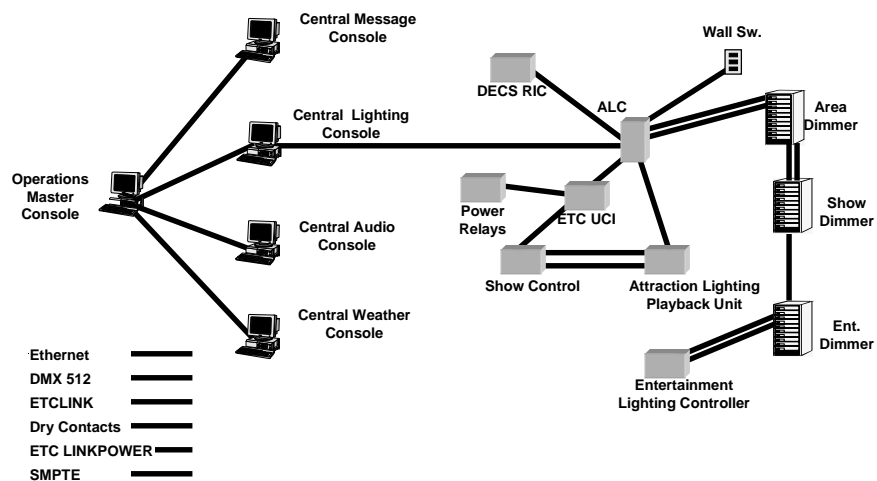
Park Wide Lighting System (PLS) Requirements

- Non-real time system
 - Area development lighting
 - Support Live Entertainment events
- The PLS requires two (2) 10BaseT interfaces as follows:
 - CLC Interface to Node Processors 1 x 10 b-T control
 - OMC/CLC Interface 1 x 100 b-T control
- Traffic Overview
 - Configuration from CLC to ALC
 - ALC sends status to CLC
 - TCP/IP traffic

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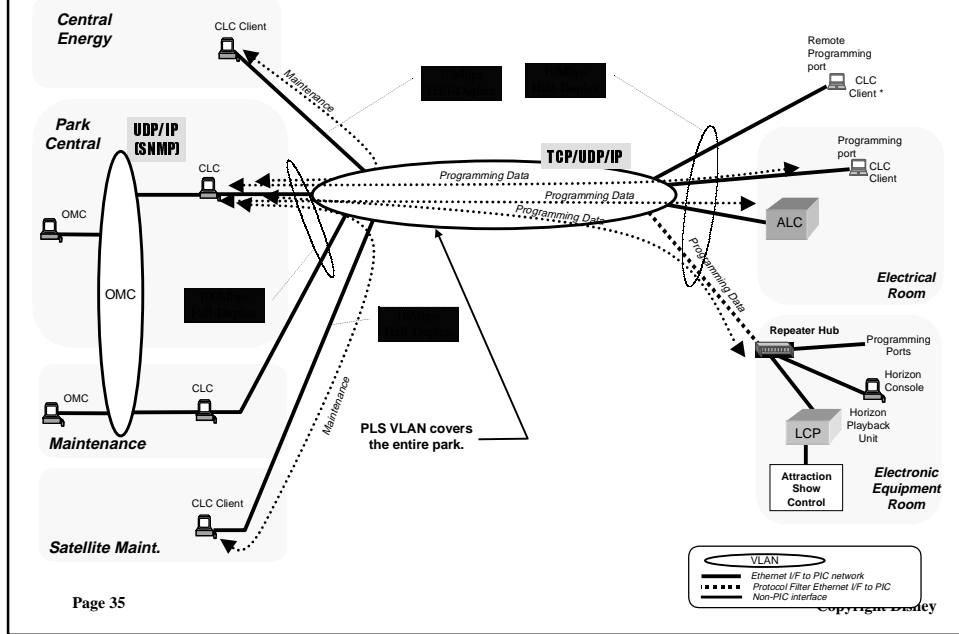
Lighting System Detail



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Theme Park Lighting Control



Entertainment

- Parades
- Theatrical Productions
- Nighttime entertainment spectacles

PES Requirements

■ Park Wide Entertainment System (PES) – Lighting

- Real Time Control & Monitors
- DMX to Ethernet converters
- Industry standard DMX components
- Ethernet Networking

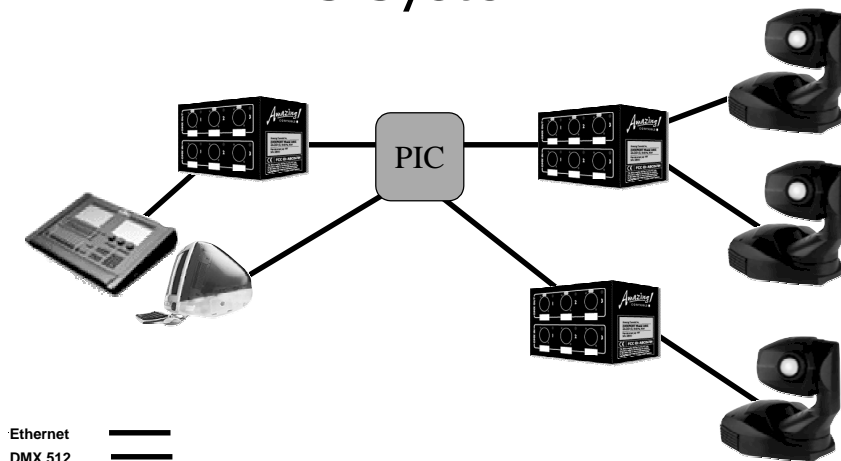
■ Traffic Overview

- AppleTalk (Unicast, Broadcast)
- VLAN covers entire park.
 - < 1 Mbps.
 - Isynchronous communication

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PES System



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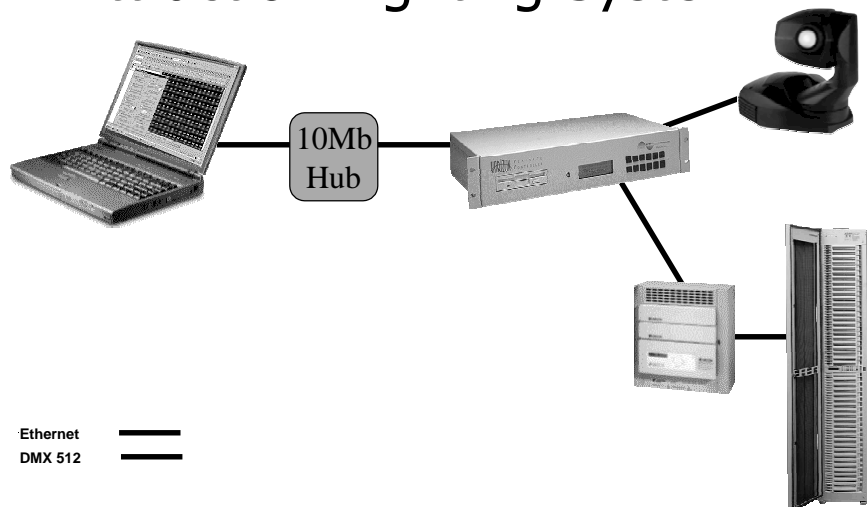
Show/Ride Attractions

- Ride and show areas
- Queues
- Load and unload areas

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Attraction Lighting System



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TDS Lighting Trivia

8,510	Themed Light Fixtures
18,954	Show Light Fixtures
38	Architectural Lighting Controllers
40	Horizon Lighting Controllers
5	Whole Hog II Lighting Controllers
73,728	Channels of Control
136	Dimmer Cabinets
8,000+	Dimmers
19.2	M Watts
522	Automated Lighting Fixtures/Accessories



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Parkwide Audio

Background Music
Area Public Address
Entertainment Music

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What is Audio To WDI

- Ride and show areas
- On-board ride vehicles
- Queues
- Shops
- Restaurants
- Outdoor areas
- Theatrical Productions
- Nighttime entertainment spectacles

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Dimensions of Audio Distribution

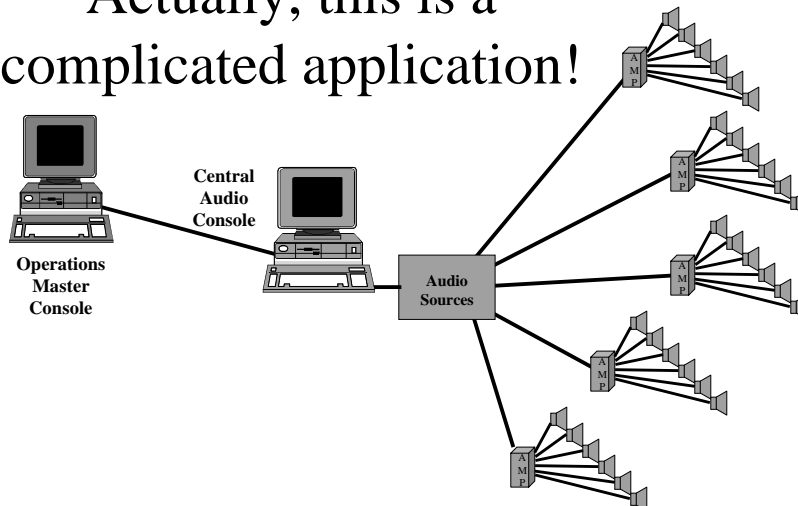
- 3900 Speakers
- 1200 two-channel Audio Amplifiers
- 1.6 MW output capability
- Real-time monitor of any source or output
- 30 Channels of Background Music
- 30 Channels of Entertainment Music
- 24 bit Audio @ 48K Samples/sec
(CD is 16 bits @ 44.1K)
- < 20 milli sec. End-to-end Latency
- < 10 micro sec. Jitter

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Parkwide Audio System

Actually, this is a complicated application!

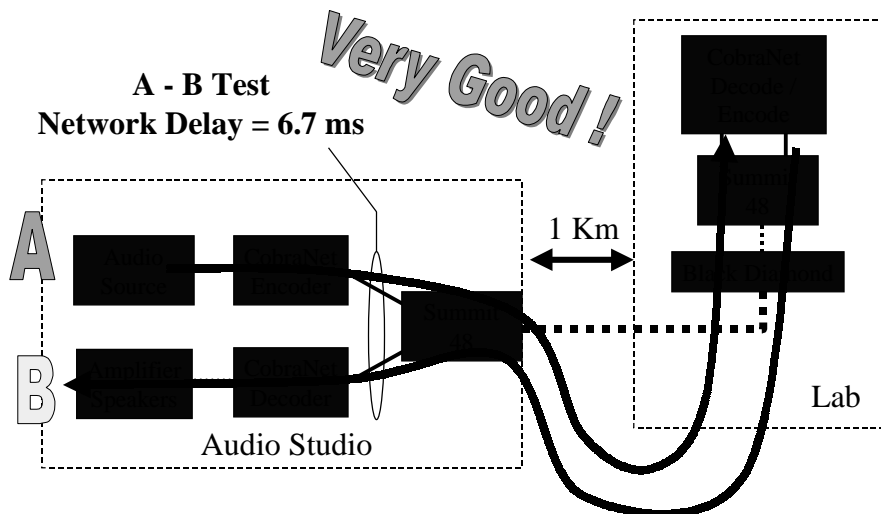


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Parkwide Audio Test Setup

A - B Test
Network Delay = 6.7 ms



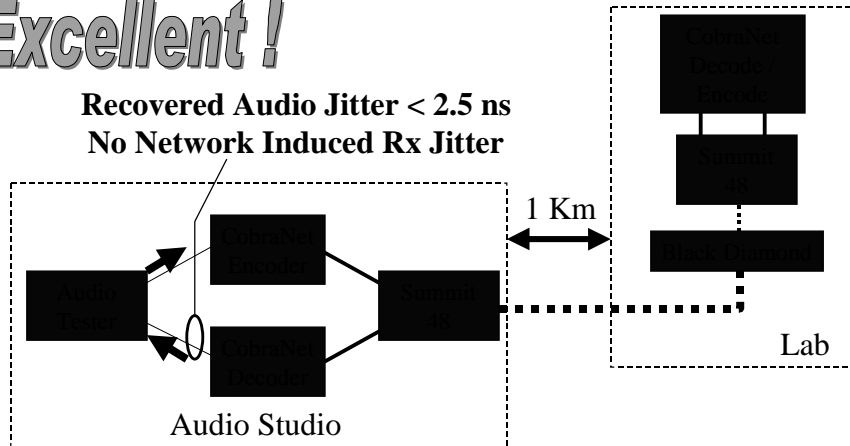
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Parkwide Audio Performance

Excellent!

Recovered Audio Jitter < 2.5 ns
No Network Induced Rx Jitter

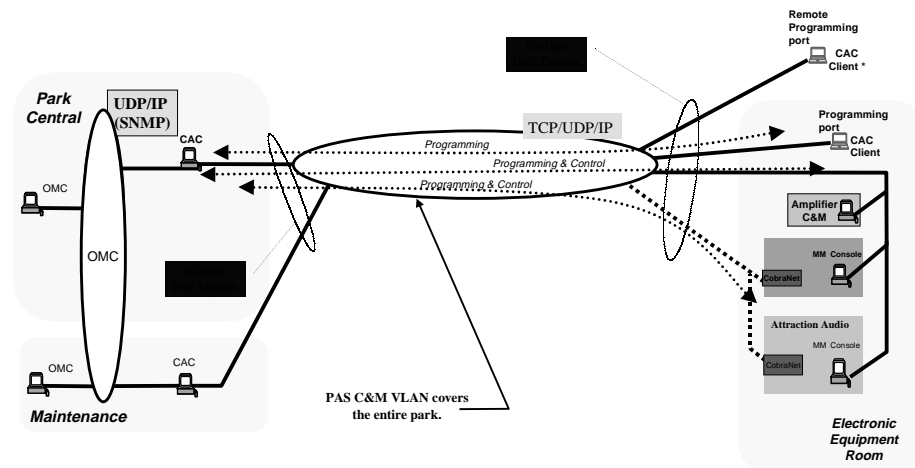


— Category 5 - 100 Base T
- - - Multi-mode - Gigabit
— Digital Audio AES/EBU

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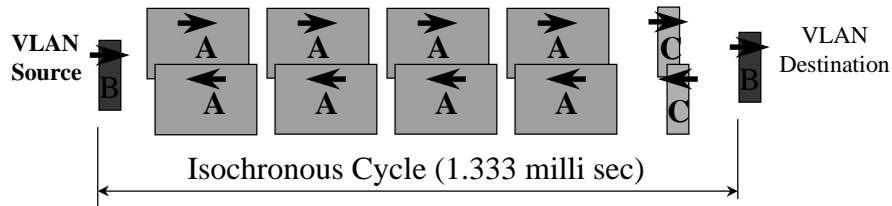
Theme Park Audio Control



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CobraNet® Message Format

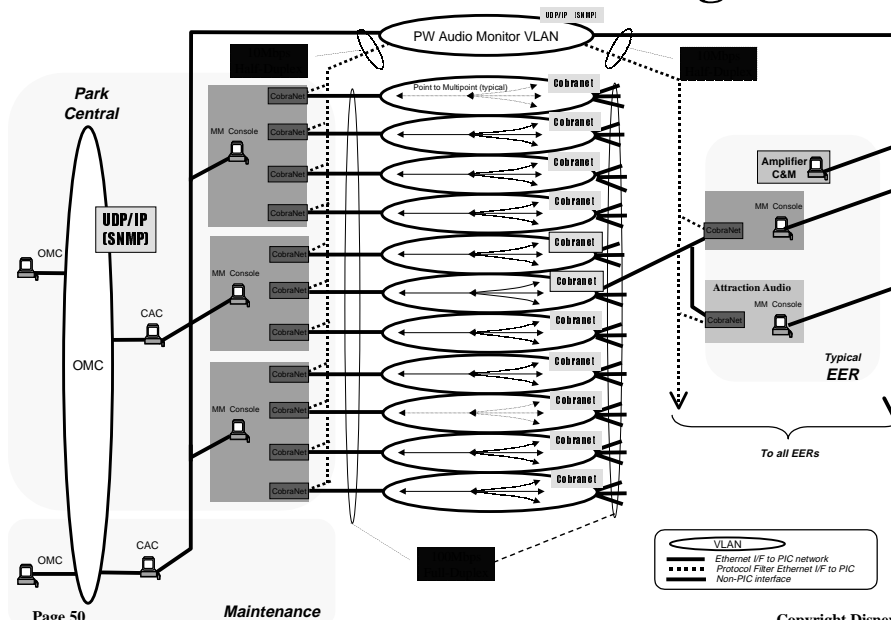


B = Beat Packet: 100 byte, Proprietary MAC Broadcast by Source, Sensitive to delay variation

A = Audio Packet bi-directional: 1340 byte, Proprietary Uni-cast
8 audio channels (24 bit @ 48K) per "A" packet
Max "A" packets = 4 = 32 Channels FDX

C = Control Packet : 100 byte, TCP/IP Unicast as required
1 pkt/sec (not transmitted every cycle)

Audio Distribution & Mgt.



Well! Who brought some music?



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Show Programming

- Audio-Animatronic Figures**
- Special Effects**
- Show Lights**
- Show Audio**

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Show Control Brainstorming

- **Must be Synchronous**
- **Slow Speed (30 fps)**
- **Ethernet = Low Cost Physical Layer**
 - 10 Mbit & 100 Mbit on UTP**
 - Full Duplex**
 - 100 Meter cabling**
 - Fiber options**
 - Multiple sources**
 - Complete diagnostic tools**
 - Network compatible**

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Distributed Control Networks

- **Show/Ride Network - TCP/IP**
 - Full compliance**
 - 10 Mbit FDX**
- **Animation Network - UDP**
 - Interface Agreement - SPC 1st**
 - FDX**
 - Buffered ports**
 - Fast Ethernet to Remote Hubs**
 - 10 Mbit in Scenes**

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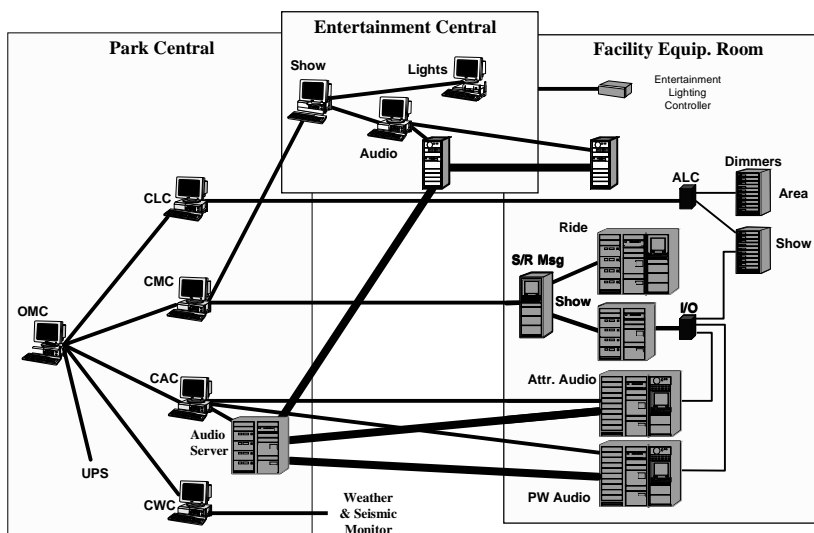
Animation Network

- Animation Data to Distributed I/Os
- Feedback Data from Distributed I/Os
- SMPTE Frame Rate - 30 Frames per Sec.
- Option for 24 fps
- Framing is Modulo 16 bit
- All other devices wait for SPC Tx Frames

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Show Control & Monitor



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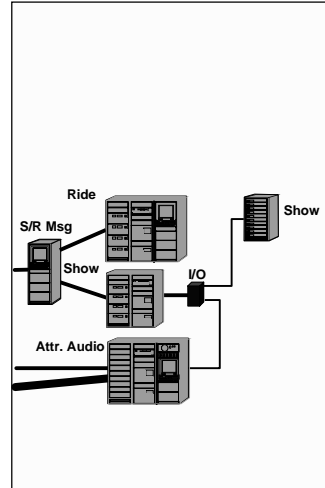
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Show Control & Monitor

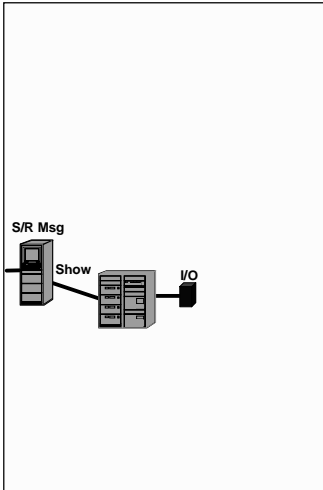
The diagram illustrates a show control system architecture. It features a central vertical line representing the 'Attr. Audio' bus. A 'Show' control unit is connected to this bus. This 'Show' unit is also connected to an 'S/R Msg' (Send/Receive Message) unit. The 'S/R Msg' unit is connected to a 'Ride' control unit. The 'Ride' control unit is connected to another 'Show' control unit. This second 'Show' unit is connected to an 'I/O' (Input/Output) unit. The 'I/O' unit is connected to a third 'Show' control unit. The 'I/O' unit is also connected to a fourth 'Show' control unit.

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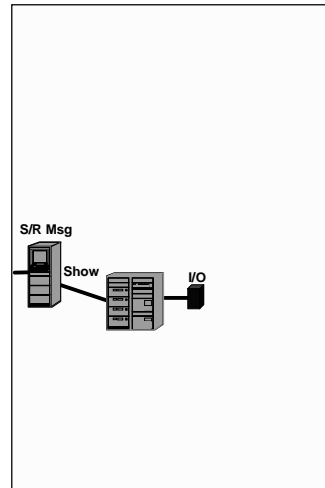
Show Control & Monitor



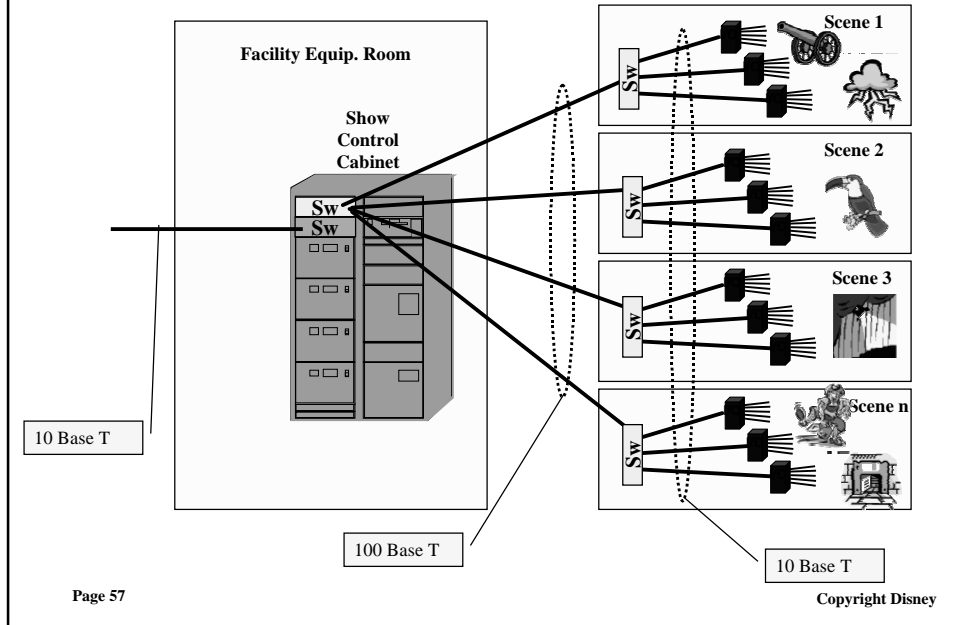
The diagram illustrates a system architecture for show control and monitoring. It features three main components: a control unit on the left, a central processing unit in the middle, and an I/O unit on the right. The control unit is labeled 'S/R Msg' and has a 'Show' button. The central unit is a rack of server-like equipment. The I/O unit is a small black box labeled 'I/O'. A line connects the control unit to the central unit, and another line connects the central unit to the I/O unit.

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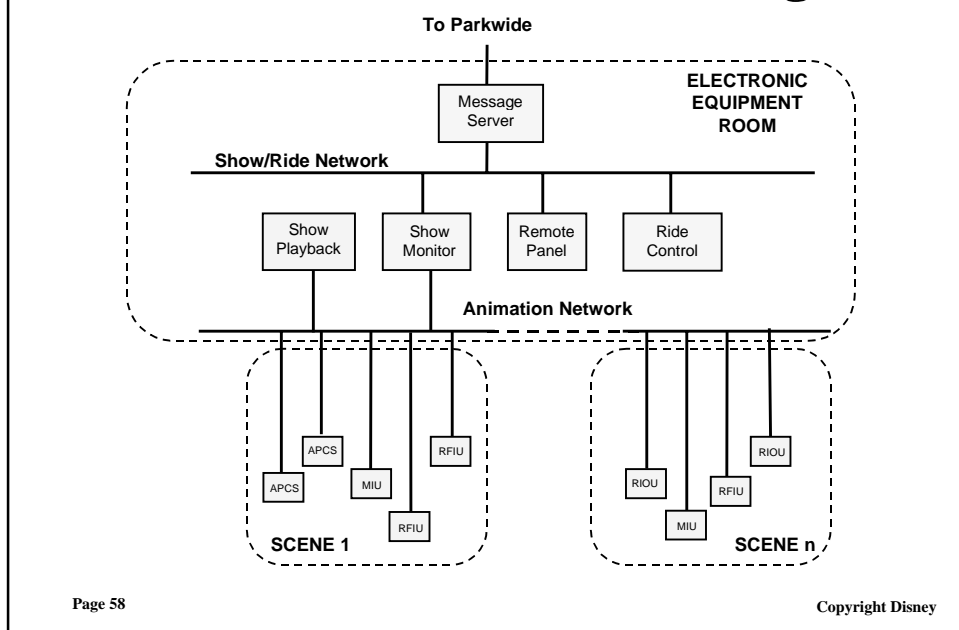
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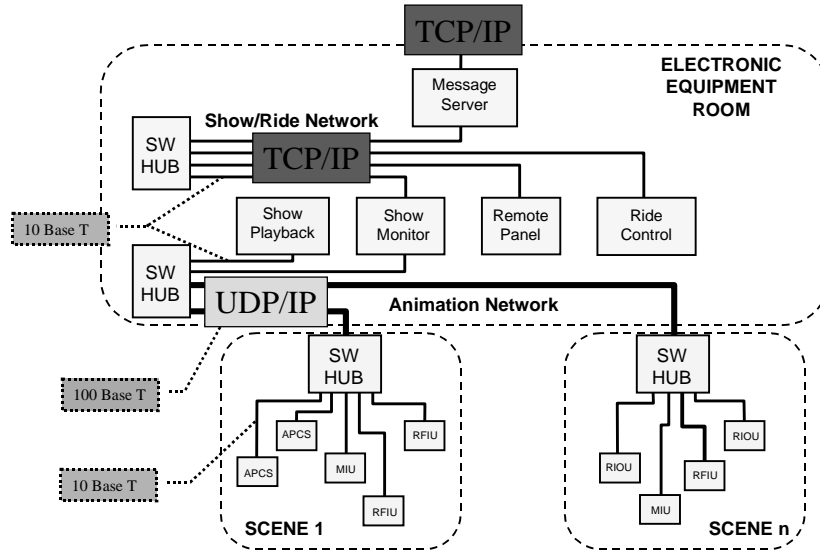
Ethernet to Remote I/O



DCS Functional Block Diagram



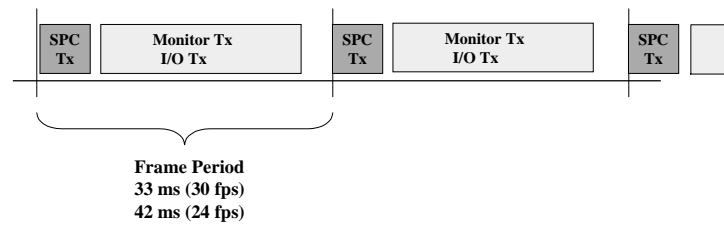
DCS Facility Network



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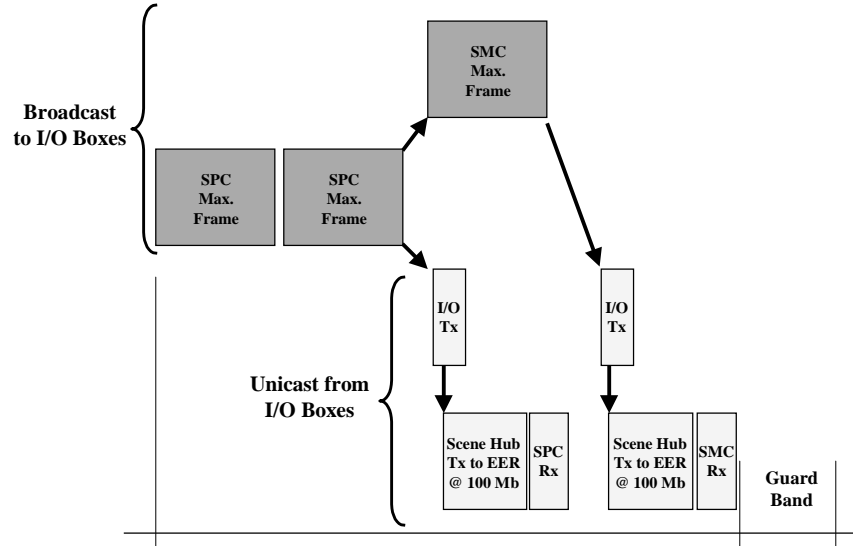
Animation Network Timing



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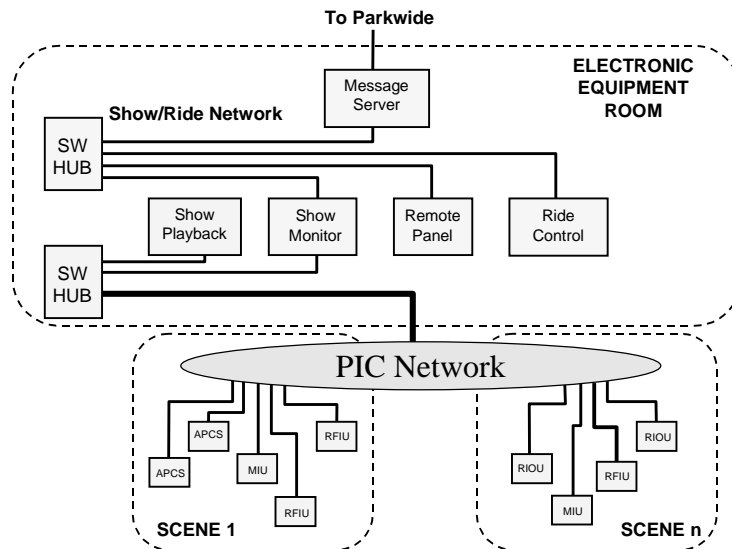
Detail Animation Timing



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Pushing DCS a Little Further



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Summary

Non-Traditional Ethernet Uses

Isochronous Studio Quality Audio

Synchronous SMTP Rate Show Control

MAC, Appletalk, and IP

Traditional Ethernet Uses

Show Monitor

Ride Control

Audio Monitor & Control

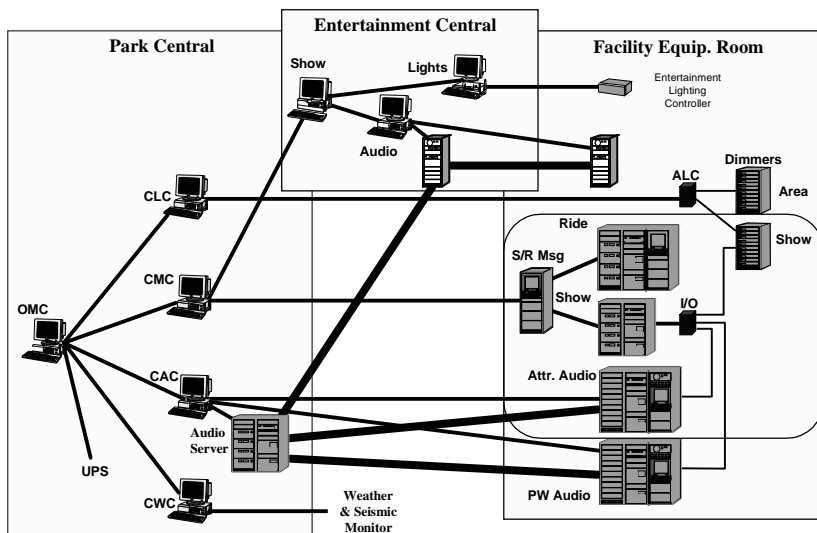
Lighting Monitor & Control

Inter-discipline Communications

IP

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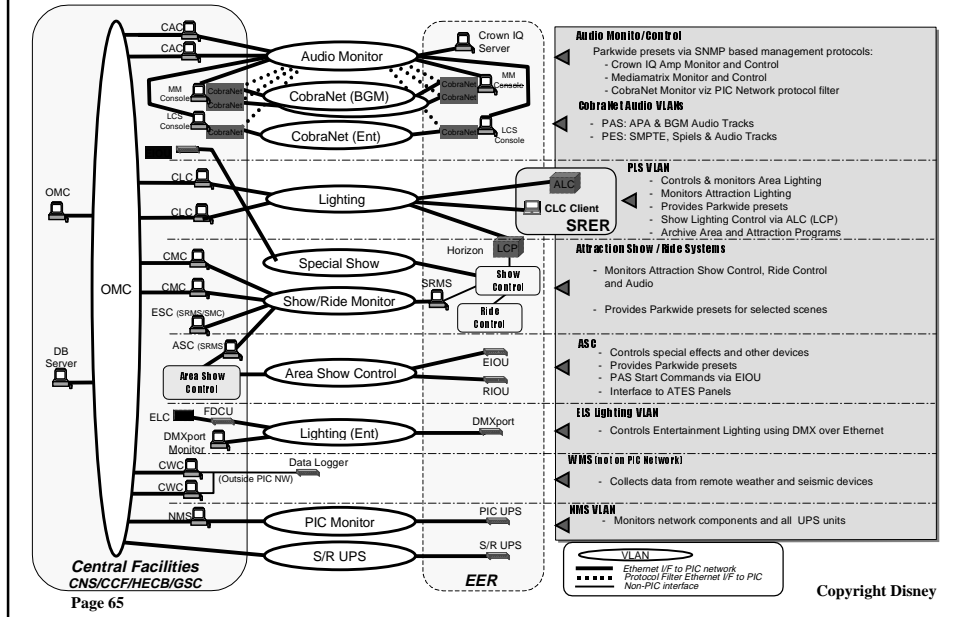
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Theme Park VLAN Overview



PIC Core - Extreme Networks Dual Black Diamonds



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TDS Parkwide Team



The End

Lighting Hardware

Unison Architectural Lighting Controller (a.k.a. ALC)

- ER4-Wall Mounted Rack with four slots
- CMEi-(Control Module Electronics with I/O)
- Air Flow Modules



Unison Contact Interface (a.k.a. UICI, CIU...)

- 24 Input
- 24 Output

Unison Gadgets

- Preset Button Stations
- Portable Button Stations



Tokyo DisneySea Dimmers D20AFJ

- 100vac/50hz
- 30ma RCD (Residual Current Device)
- Neutral Disconnect

Disney Studios at Disneyland Paris Dimmers D20AFN

- 230vac/50hz
- 300ma RCD (Residual Current Device) Per Module
- Neutral Disconnect

Disney's California Adventure Dimmers D20AF

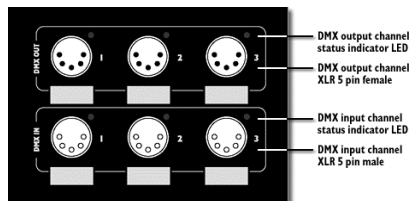
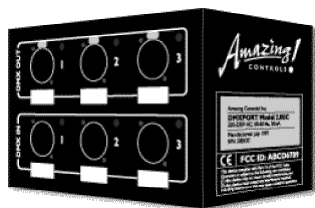
- 120vac/60hz
- 6ma GFI (Ground Fault Interrupt)



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www.amazingcontrols.com

DMX Port - Amazing Controls

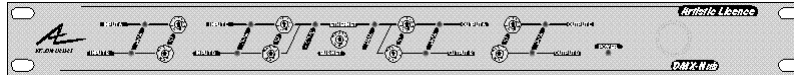


Standard Product Specifications:

- 3 Ports individually configurable as DMX input or DMX output.
- Each port handles an individual DMX Universe.
- Each output port can merge up to 3 Universes.
- Merging can be done by using any combination of LTP, HTP or Priority rules.
- Real Time Clock for AutoScheduling (when used as lighting controller).
- 1 MByte NOVRAM (up to 4 MByte optional).
- 230 Volts AC, 50Hz or 110 Volts AC, 60Hz versions available.
- IEEE 802.2/802.3 Ethernet compatible.
- RJ-45 connector for standard Cat. 5 cabling.
- LED indicators for each input/output port.
- 4 LED EtherNet link indicators.
- 2 LED DMXPort status indicators.
- Dimensions: 160 x 115 x 100 mm.
- CE or UL Certification.

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DMX Hub - Artistic License



DMX-Hub is the first truly Plug and Play solution for DMX512 cabling and distribution

in all applications needing fast and robust transmission of lighting control data.

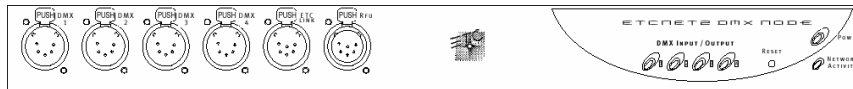
- DMX-Hub provides the gateway to transfer DMX512 data to and from a 10BaseT Ethernet link.
- Standard Ethernet cabling and transceivers can then be used for the data distribution infrastructure.
- The Ethernet protocol is designed to allow distribution of up to 256 DMX512 Universes (a total of over 32,000 channels).
- The DMX Universes are organized as 16 Sub-nets each containing 16 Universes.
- Front panel controls allow the user to easily select the Sub-Net for each DMX-Hub and Universe for each of the
- four DMX512 inputs and outputs.

Major features include:

- DMX routing by Ethernet
- Connect up to 256 DMX-Hubs to one network
- 4096 channels of DMX per DMX-Hub.
- Four independently Isolated DMX512 inputs.
- Four DMX512 outputs.
- 10BaseT Ethernet Port.
- Compatible with DMX512, DMX512 (1990)
- Power indicator.
- Receive data activity indicators.
- Ethernet data activity indicators.
- Transmit data activity indicators.

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DMX Node - Electronic Theater Controls



DMX Node
lighting network data distribution device

APPLICATIONS

- Road House
- Touring
- University/Professional Theatre
- Convention Hall
- Tech Tables
- Stage Managers Panels

FEATURES

- 2048 DMX In or DMX Out channels
- Configurable to over 32,000 EDMX addresses
- Distributes DMX, RFU and ETCLink over Ethernet
- Employs ETCNet1 and ETCNet2 protocols
- Distributes DMX data to any input/output device such as dimmers, scrollers, moving lights, or RFUs
- Rack mount/Portable and
- Wall mount configuration
- Supports any USITT DMX512/1990
- compatible console
- LED configuration indicators
- Supports 16bit DMX values
- Power supply and mounting bracket
- included with rack mount and portable

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Horizon LPU - Rosco-ET



Features

- ◆ Timebase per channel
- ◆ Multiple asynchronous Cue Lists
- ◆ Unlimited overlapping fades
- ◆ Active Magic Sheets TM
- ◆ Graphical user interface
- ◆ Ethernet network node
- ◆ Two DMX universes (1024 Channels)
- ◆ Time of day events
- ◆ Astronomical time clock
- ◆ Pushbutton events
- ◆ External trigger events (track triggers)
- ◆ Serial command port (RS-232/RS-485)

Options

- ◆ Complete moving light support
- ◆ SMPTE time code events
- ◆ MIDI show control events
- ◆ System wide network events

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Tools of the Parkwide Lighting Designer

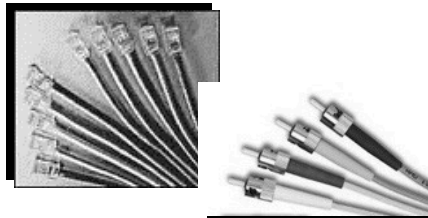
Field Laptop

- Windows 2000
- 200 Mhz or better processor
- 128Meg RAM
- CUDI Light Manager Application



Network Connectivity

- 5 port mini Ethernet hub
- Media Converter 10Base-T to 10Base-FL
- 10Base-T Patch Cords
- 10Base-T Crossover Patch Cords



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