Machinery Control System – Load Controller Interface for "Smart Loads"

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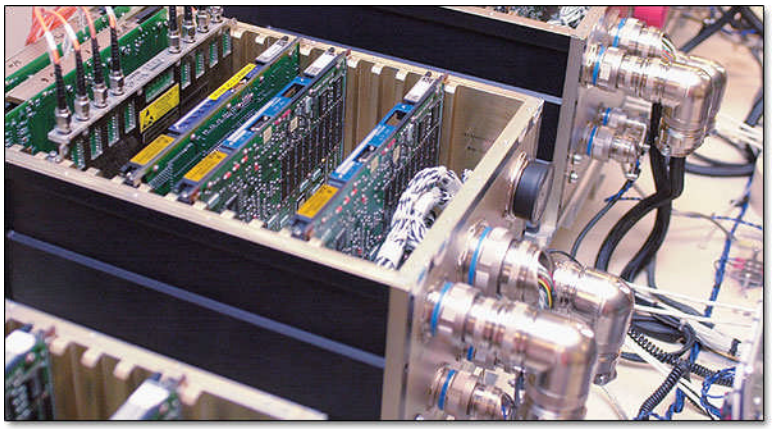
Issue

- The Load Equipment to Machinery Control System (MCS) interface is typically not specified and the associated Vendor Furnished Information (VFI) is not available until detail design and construction
  - Greatly complicates MCS integration
  - MCS functionality typically limited to what can be accomplished during the available design time.
- Lack of interface standards complicates in-service engineering support.

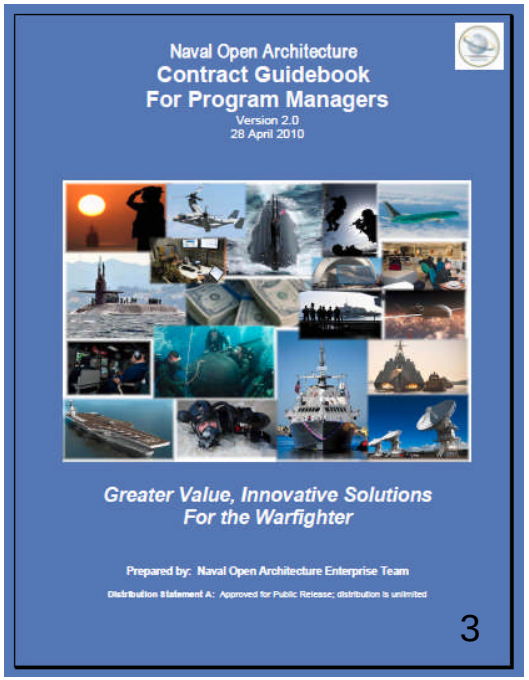
http://www.marinetalk.com

Opportunity

- Affordability of embedded controllers enables a distributed approach to many MCS Functions
  - Simplify system integration
- An Open Architecture (OA) standards based approach to MCS interfaces enables decoupling MCS design from selection of specific equipment.
  - Enables more MCS design to occur earlier, during Preliminary and Contract Design.
  - Include interface standards, functionality, and a defined architecture.
  - Enables re-use of common software elements across ship classes.
  - Enables incremental advances in MCS functionality.



http://www.draper.com

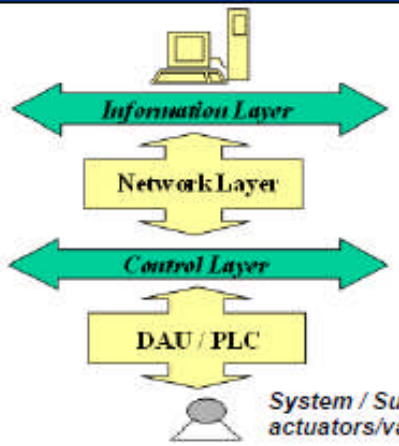


Today's Baseline Architecture

MCS Overview

- The Machinery Control System (MCS) monitors and controls an array of HM&E systems, including:
  - Propulsion Plant
  - Electric Power Plant
  - Auxiliary Systems
  - Damage Control Systems
  - Up to 30+ other systems
- Most existing MCS implementations have distributed control systems to allow controls from various ship console locations
- The three primary layers of the MCS system are: the control layer, the network layer and the information layer

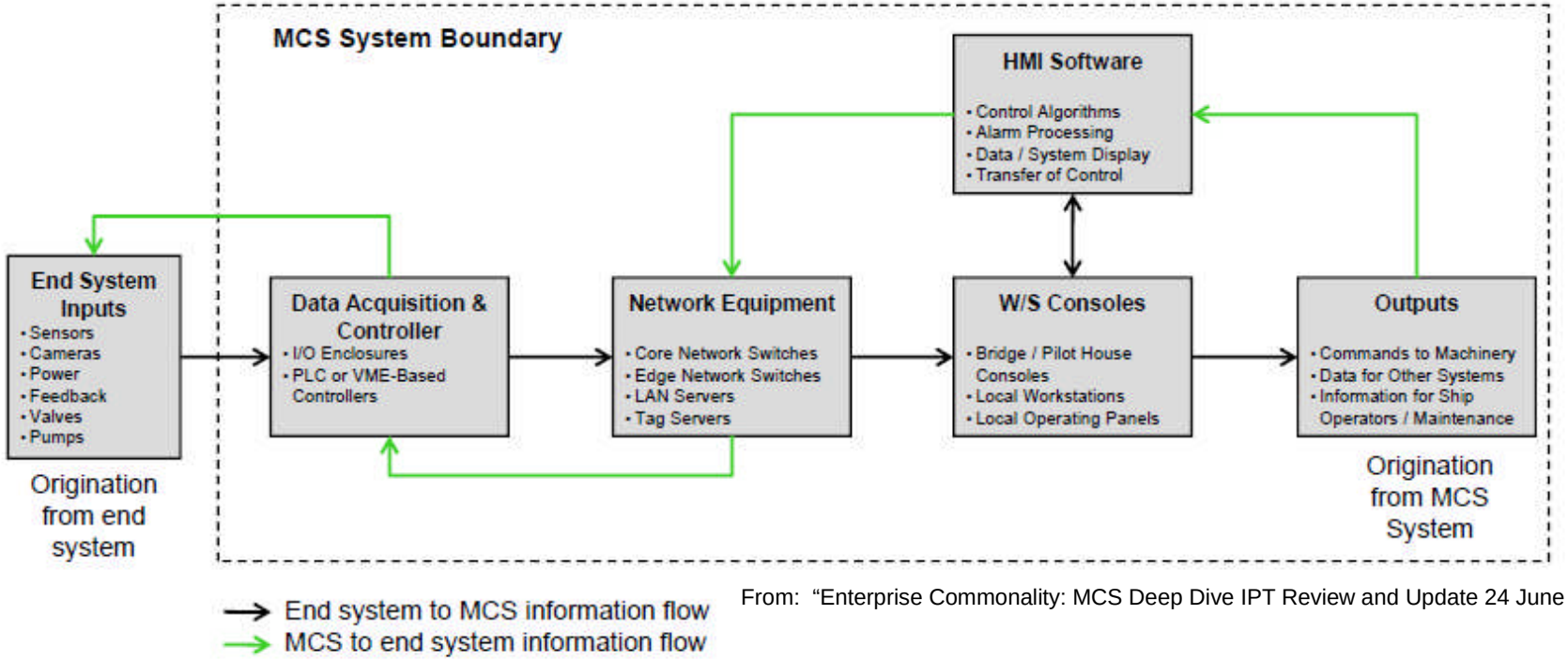
MCS Primary Layers



- Information Layer: User interface; provides a platform for applications that can process data and provide information to the user
- Network Layer: Communication between the control and information layers and between devices within the same layer
- Control Layer: Provides control and monitoring, typically through a VME-based system or PLC (programmable logic controller) to machinery plant

From: "Enterprise Commonality: MCS Deep Dive IPT Review and Update 24 June 2010"

Today's MCS Boundaries



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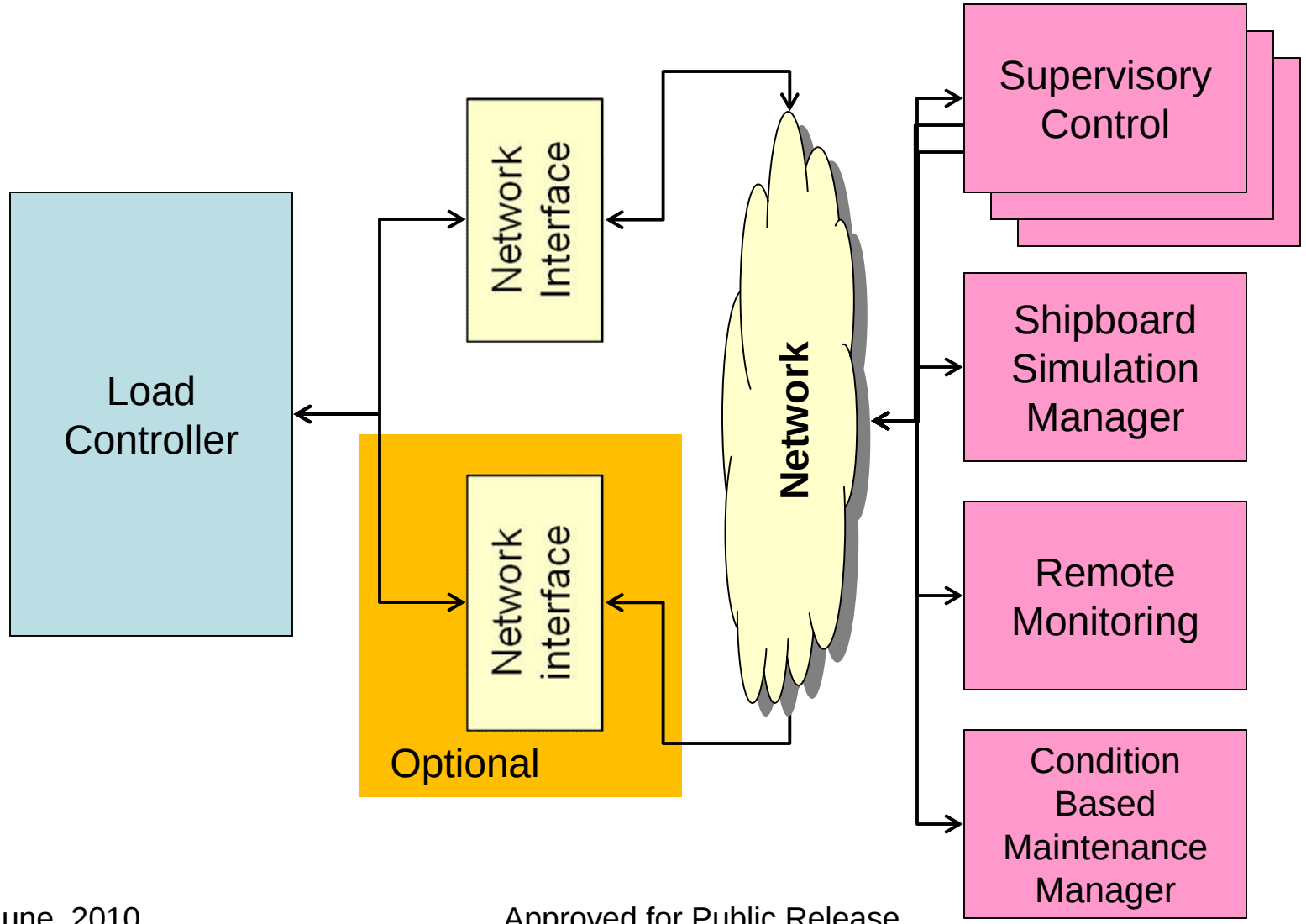
Macro View – Ultimate Vision

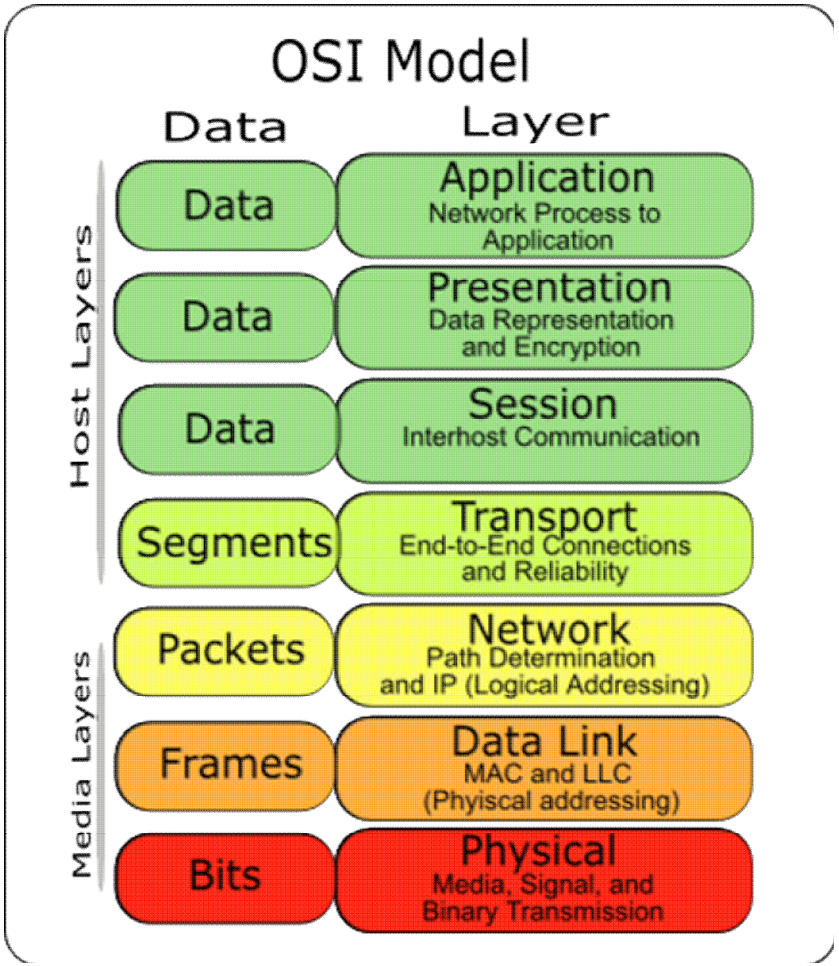


Definitions

- Load Controller
  - Embedded controller within a piece of equipment
- Network Interface
  - Hardware for connecting the Load Controller to the Network
  - May provide redundant connection to the network
- Network
  - Method(s) for routing information, data, and commands
  - Can include a device level network (Fieldbus)
- Supervisory Control
  - For each resource type and mission, a supervisory control provides total ship management
  - Includes the Mission Layer Control / Ship Domain Control
- Shipboard Simulation Manager
  - Provides ship-wide simulation services to the supervisory controllers.
  - Also can be used for onboard training
- Remote Monitoring
  - Provide operator the ability to monitor the condition and information on a given piece of equipment
  - Includes Alarm Management and Logging Managment
- Conditioned Based Maintenance Manager
  - Captures data from multiple equipments to determine the material condition of equipment and to predict future failures.

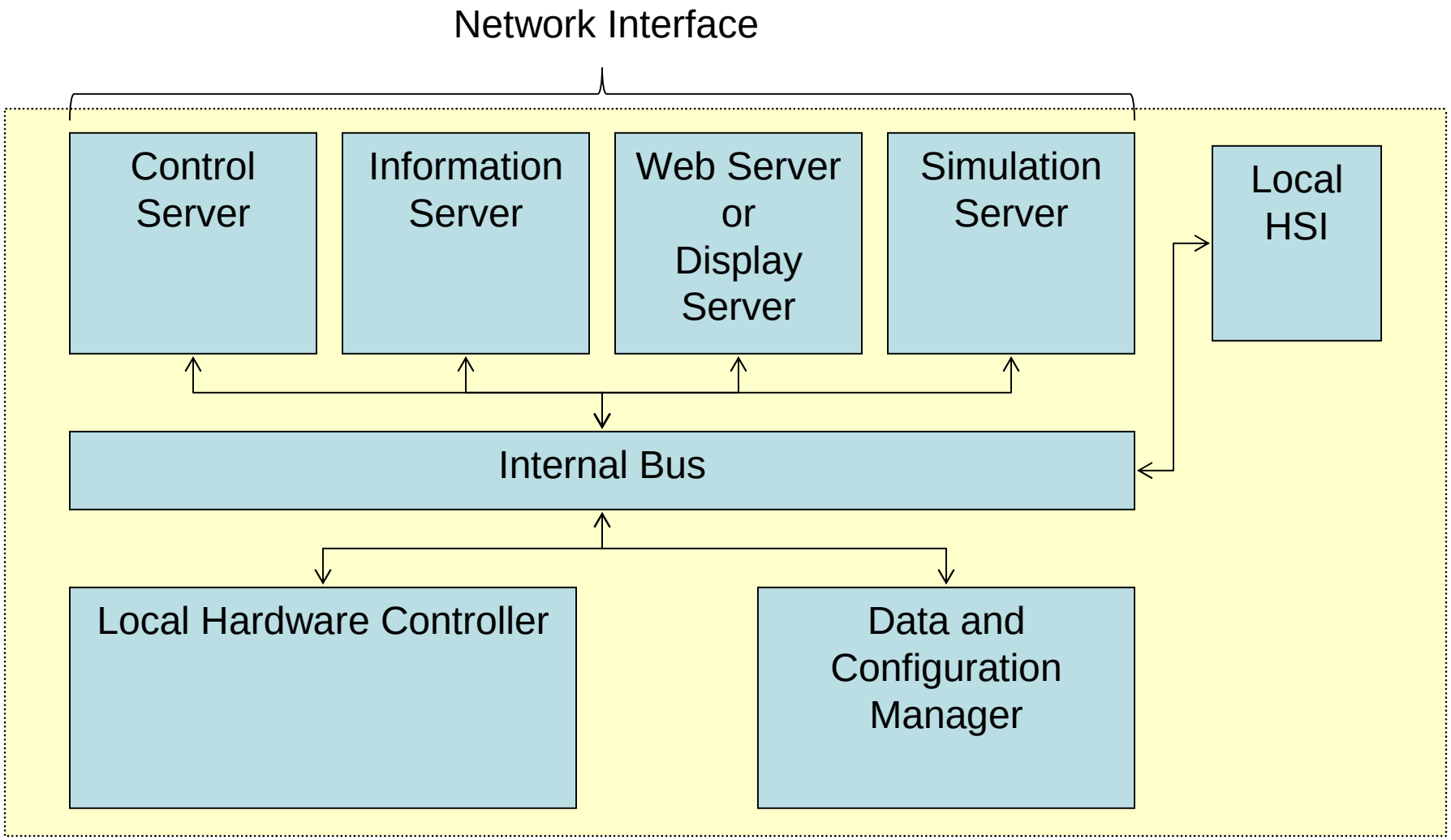
OSI Network Model

- Each Network Interfaces may have a different set of Physical and Data Link layers
  - Copper Signal Cable
  - Fiber Optic Cable
  - Power Cable
  - Wireless
- Load Controller to System Controllers may require different Network and Host Layer protocols.



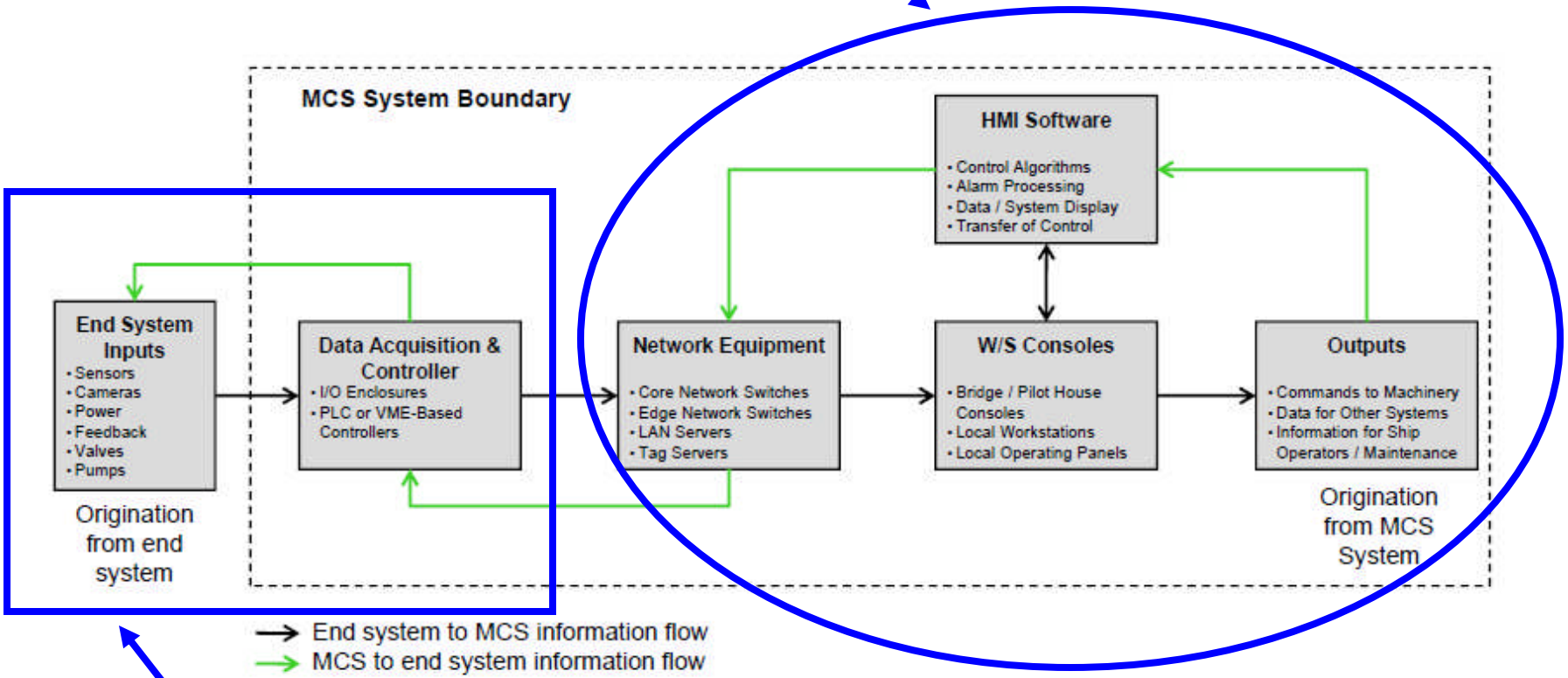
http://www.3mfuture.com/network_security/arp-guard-arp-spoofing.htm

Possible Reference Load Controller Functional Model



Comparison to today's architecture

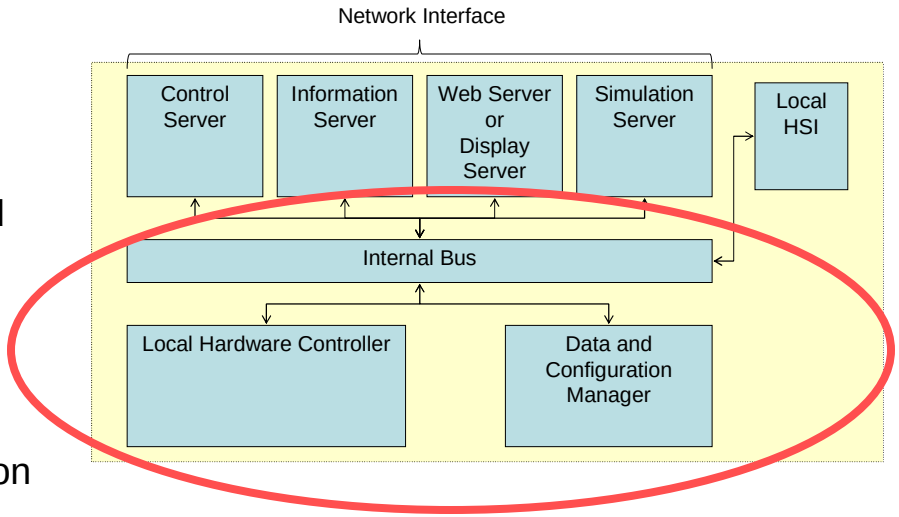
Potential Change in Architecture



"Smart Load" Functional Boundary

Load Controller Elements

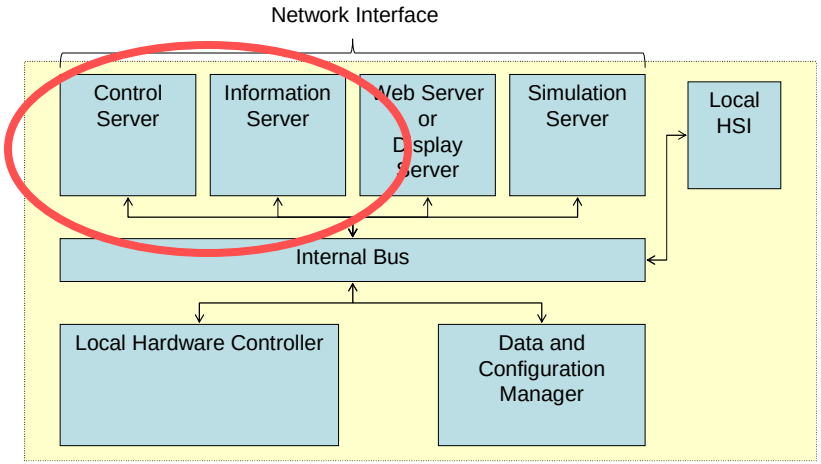
- Load Hardware Controller
  - Executed low level control function for the equipment
  - Gets configuration data and set points from the Data and Configuration Manager
  - Provides operational modes, conditions, and sensor data to the Data and Configuration Manager
  - Gets Commands from the Control Server
  - Provides Commands and information needed for system control to the Control Server
- Data and Configuration Manager
  - Maintains the configuration data for the component
  - Manages all data and configuration information
- Internal Bus
  - Hardware and software for communicating among Load Controller Elements



These internal elements would likely not be specified

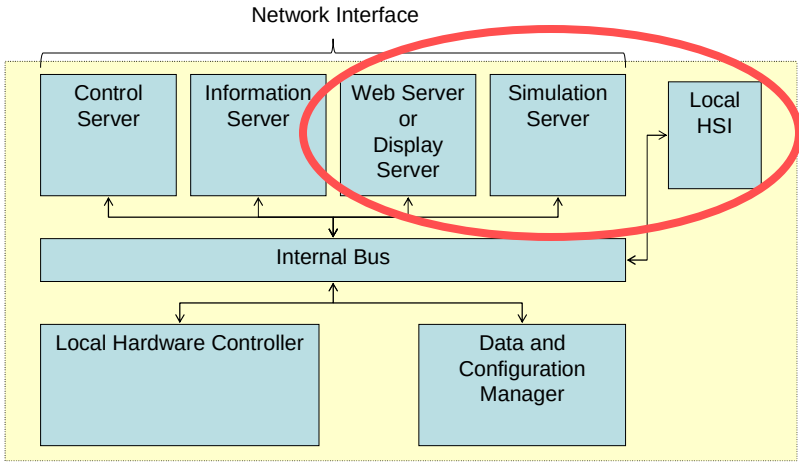
Load Controller Elements (cont)

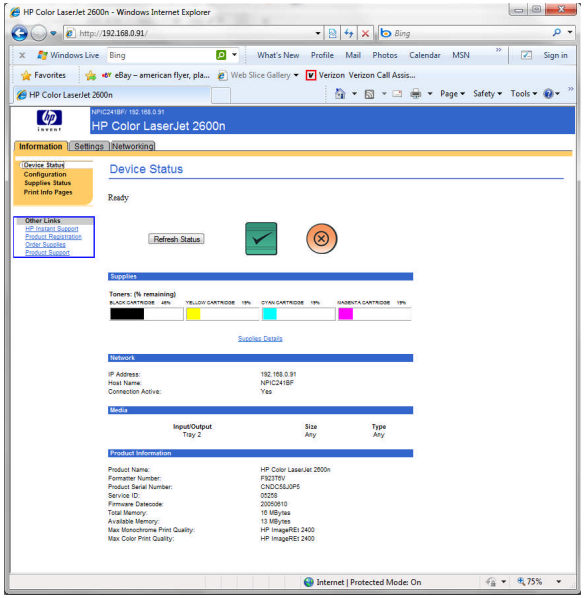
- Control Server
  - Supports a fast, low latency, deterministic communications protocol to support system level control.
  - Communicates commands and information needed for control.
  - Directly communicates with the Local Hardware Controller and the Data and Configuration Manager
- Information Server
  - More generalized protocol for interfacing with Remote Monitoring and Condition Based Maintenance software
  - Can be used to establish configuration set points.



Load Controller Elements (cont)

- Web Server
  - Similar to the Information Server, but uses HTML / HTTPS to communicate with remote HSI's via a standard web browser
  - Types of pages
    - Equipment Status page
    - Equipment Configuration page
    - Parameter trend-line page
    - Diagnostics / Maintenance Page
    - Technical Manual Page
    - Training Manual Page
- Simulation Server
  - Communicates with the Shipboard simulation server
    - Used to support shipboard training environment
    - Also can be used for contingency planning and transition planning by supervisory controllers
  - Able to support multiple simulations simultaneously
- Local HSI
  - Provides local operator access to controller
  - Possibly just a browser for the Web Server?





Protocols

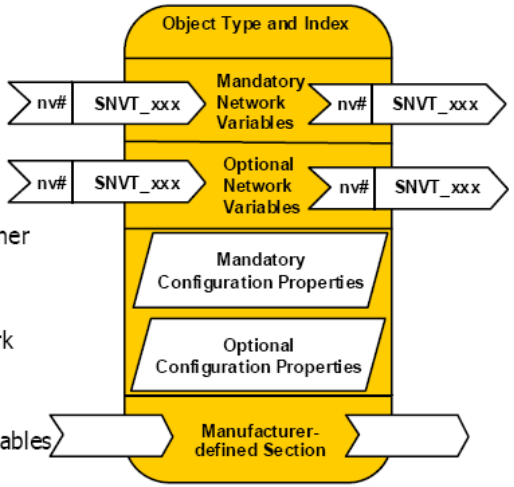
OSI Layer	Control Server	Information Server	Web Server	Simulation Server
Application	Many Available LONWORKS?	XML?	HTTPS/HTML	?
Presentation	ASCII?	ASCII	ASCII	?
Session	UDP/sockets?	TCP/sockets? UDP/sockets?	TCP/sockets	UDP/sockets?
Transport	UDP?	TCP	TCP	UDP?
Network	IP?	IP	IP	IP?

Standards Considerations

- Many standards exist for the Application Layer of the Control Server.
  - LONWORKS could be a model for the control server Application Layer.
- Using wireless or power cables for the Media Layers can reduce costs by eliminated dedicated signal cables.
  - ANSI/EIA 709.2-A-2000 Control Network Powerline (PL) Channel Specification
  - IEEE P1901 Draft Standard for Broadband over Power Line Networks: Medium Access Control and Physical Layer Specifications

LONWORKS Object Model

- Type of object
- Index on device
- Mandatory Network Variables
  - Minimum implementation
  - Use SNVTs
- Optional Network Variables
  - Implemented in standardized manner
  - Use SNVTs
- Configuration Properties
  - Applies to device, object or network variable
- Manufacturer-defined section
  - Manufacturer-defined network variables and types
  - Proprietary, non-interoperable interface

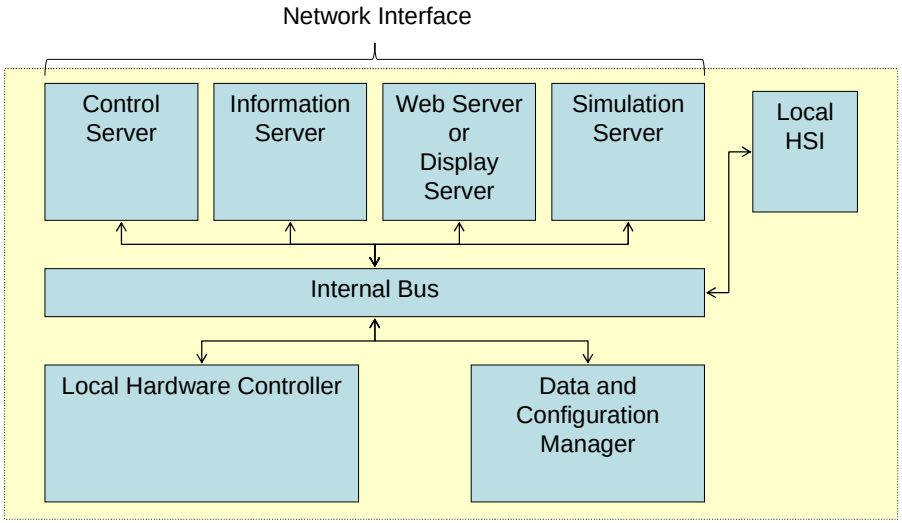


ANSI/EIA 709.1
Control Networking Standard

Echelon 1999

Open Issues

- Protocols for the Control Server
- XML Schema for the Information server (If using XML)
- Style Guide for HTML Server
  - Standardized Pages?
  - Standardized directory structure?
- Protocols for the Simulation Server
  - Should be aligned with High Level Architecture
- Style Guide for HSI
- Information Assurance
- Staying Aligned with Commonality Efforts
- How to Transition from today's system to the vision system?



Potential Next Steps …

- Develop a roadmap to describe the vision for future Machinery Control Systems and the steps to get there.
- Identify the needed specifications, standards, and handbooks needed to support the roadmap.
- Start working on the specifications, standards, and handbooks.
- Prototype implementations.