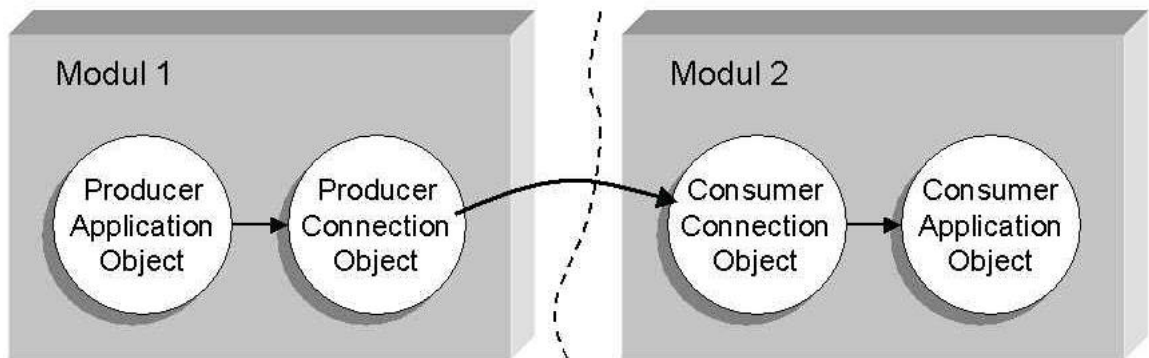


The CIP Object Model of EtherNet/IP

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What makes EtherNet/IP a proven Industrial Ethernet solution? It is the Control and Information Protocol (called "CIP") which is used in EtherNet/IP as a Producer/Consumer-based application layer on top of TCP and UDP. The Control & Information Protocol has been initially introduced in 1998 for industrial networks like ControlNet and DeviceNet. This article shall outline the key features of this well accepted application protocol.

CIP is strongly object-oriented. There are implicit and explicit message connections. Implicit connections are mainly used for time-critical cyclic I/O connections with minimum overhead. Explicit messages are used for a-cyclic information transfer between nodes using the object orientated addressing method of Service, ObjectClass, Instance, Attribute.

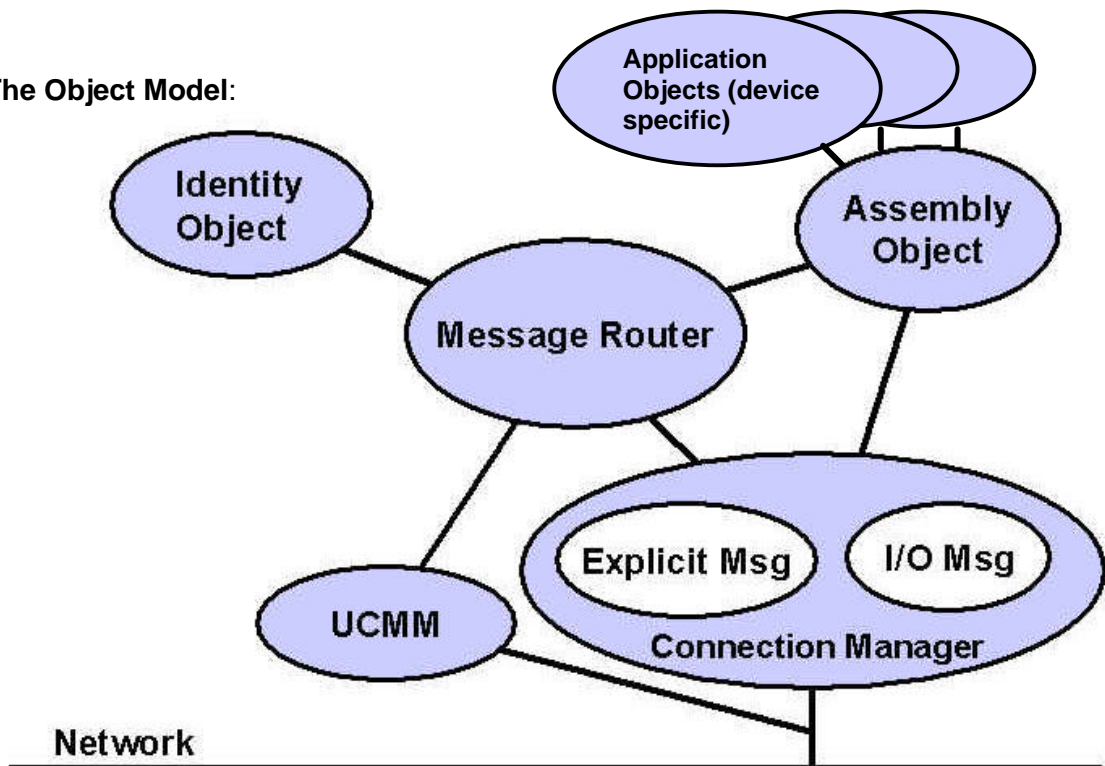


Example of an Implicit I/O Connection

I/O connection:

- Contains only IO data, run/idle state of producer and connectionID (identifies the data) Supports various data production triggers, such as Change_of_state (with heartbeat), Cyclic, Polling and Application Triggered.
- Connection establishment is a single service which includes items such as target device verification(key), device configuration data, expected data exchange rate, what data to exchange, data production trigger, timeouts, connectionIDs,etc.

The Object Model:



This model is interesting for developers only, a user would not have to care about object model relations. For a user, it is much more interesting to refer to Device Profiles. A motor drive device for instance with a certain device profile has required objects with real-time attributes like current, torque and configuration attributes like “accel”, “decel”, overload settings and others which exactly describe the device features and I/O data exchange. This provides a mechanism for multi-vendor interchangeability with simple devices. Devices for which there is no profile already defined, can be built as a Generic Device, which would contain all the EtherNet/IP minimum requirements, as well as any additional public objects (from the spec’s object library) and vendor specific objects.

While it is quite easy and flexible to adopt end devices to this model and also to generate a conformance qualification, it is more complicated to do this for a scanner class device (requires EML master library). There are electronic data files (EDS) which describe the device behavior and features. This allows configuration tools to easily adapt to new devices and provides for both online and offline configuration.

Simple devices can live with quite compact memory requirements (in DeviceNet’s CIP implementation small nodes could run with a few KBytes of memory in a limited model but that is not supported in EtherNet/IP). Even if the application is not master/slave related and the producer/model would not really require a scanner (master), there is a practical need for more memory in at least one of the nodes to hold basic information about the overall Ethernet connections etc. In practice, this is normally covered in a scanner class device. In the future, as the cost of CPU power and memory decreases more peer to peer (distributed) control is expected to occur.

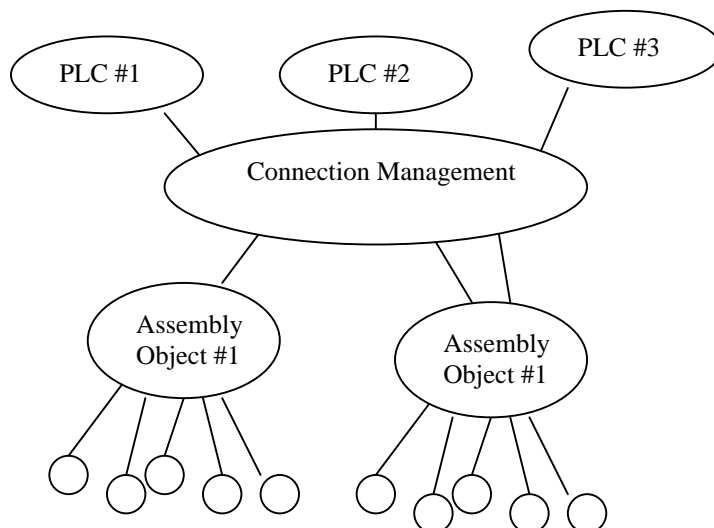
Application Objects are device specific. They include all code and information related to individual device functions and provide a good base for distributed automation

applications. Assembly objects may be fixed or variable. A fixed assembly object for instance is an I/O block with predefined functionality (its member list consisting of attributes from various objects within the device is fixed). Devices can optionally support dynamic assembly objects and can be set up individually.

Other applications based on the TCP/IP protocol suite may run in parallel with CIP (such as FTP, SNMP, HTTP, ...). For file transfer it is possible to use standard FTP client/server connections besides CIP, or as an option use the File Object which is planned as a future part of CIP.

Name spaces in the application object: CIP allows user assigned symbolic names and/or vendor assigned symbolic names to logical addresses (object class/instance/attribute) . Even though symbolic names may be the same in more than one device (for example, as named by the user, or the SPEED setting attribute in two different drives,), they are guaranteed to be uniquely addressable from the protocol level, as node number/name and device identity are checked as part of establishing a connection.

Example



Quality of Service: CIP has several priority levels as part of its connection establishment but there is need for additional prioritization on Ethernet - however this is beyond the scope of CIP. CIP priority levels are planned to be mapped in the future to the emerging IEEE802.1p Frame Prioritization standard (8 levels). It is just now being supported by switches, but also needs to be supported by TCP/IP stacks and by an IETF (or similar) standard that defines how these are to be applied to applications (email, ftp, video conferencing, control, Voice Over IP, etc. Then the mapping of CIP priority levels can be directly mapped to the 801.2p levels. Quality of Service to prioritize between CIP I/O messages and other UDP and TCP messages is therefore not covered yet in EtherNet/IP (a so called "white spot").

IP Configuration: Assignment of IP addresses is not part of the CIP layers, today this is covered by a DHCP or BootP server installed in the network. For automation

applications there is a need for user-friendly assignment of IP addresses when devices are replaced on the factory floor. Special configuration tools will care for this.

Regarding "Multicast over Ethernet" there is discussion about how multicast should be applied. With CIP multicast is primarily related to I/O messages (over UDP/IP). Until routers become faster with less jitter, ODVA and CI feel it is important to recommend to users that multicast connections should not cross routers into other subnets.

Within CIP there will also be safety related objects (as announced by ODVA for DeviceNet Safety, a CIP based safety concept has been approved by TÜV and BIA), these safety services and objects are media independent and will also be applicable on EtherNet/IP in future.

Source: ODVA