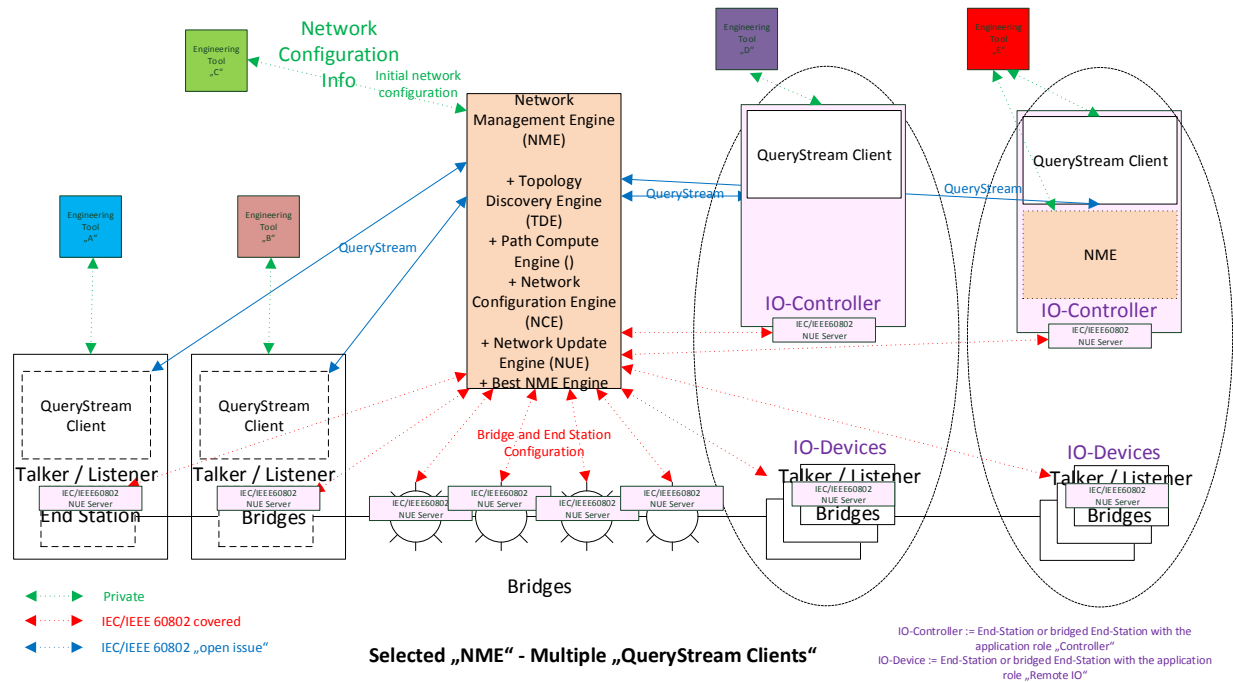


Management selection

Engineering management model

To understand the requirements for network configuration, deployment and management, an engineering model covering industrial use cases is required. A representative model is shown in figure X.



This diagram maintains the traditional role of the I-Controller and the IO-Device. It also recognizes the existence of an “engineering tool” which provides end station capabilities and user requirements, and configures TSN features in end stations. The protocols that the engineering tool uses for communication with end stations are specific to the user application.

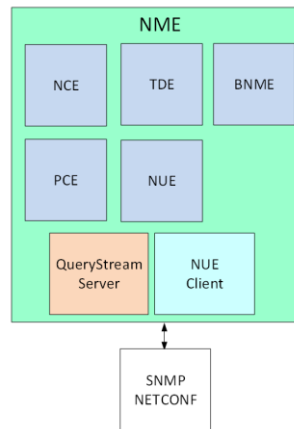
The diagram also introduces three new management entities:

- The Network Management Engine (NME)
- The Network Update Engine (NUE)
- The Query Stream Entity

The network management engine is responsible for the policy-based network configuration using Network Configuration Engine (NCE) and stream data obtained from Network Update Engine (NUE). It also contains entities to calculate the topology based path computing using Path Compute Engine (PCE) and Network Update Engine (NUE); perform topology discovery using the Topology Discovery Engine (TDE) and negotiate with other NME negotiation in case of multiple NMEs in one TSN domain using the Best NME Engine (BNME) based on IEC/IEEE 60802 defined/selected interfaces and protocols.

The NME provides an interface (defined/selected by IEC/IEEE 60802) to request a Stream for any device of the TSN domain and for cross domain streams. It can also allow query multiple Query Stream Client simultaneously in order to optimize the PLC / Controller / Remote Io use case. The NME may be located

in a dedicated device or integrated into any PLC or IO-controller. Thus, its configuration interface is vendor-specific and may only work with the NME vendors engineering tool. A conceptual block diagram of the NME is shown below.



Network Configuration Engine

The NME consists of several sub-entities:

- **NCE (Network Configuration Engine)** - The network configuration engine is responsible for the policy based network configuration using the Network Update Engine (NUE) based on a policy-based network configuration provided by an engineering tool and the discovered topology provided by the Topology discovery engine. The policy-based network configuration is loaded by the vendor specific engineering tool using vendor-specific mechanisms. The network configuration is loaded into any device in the TSN domain using IEC/IEEE 60802 defined/selected interfaces and protocols. TSN-IA profile based devices need to be fully configurable using only the IEC/IEEE 60802 defined/selected interfaces, protocols and managed objects.
- **TDE (Topology Discovery Engine)** - The topology discovery engine is responsible for the topology discovery and device identification. The TDE also performs a topology validation in cases where a fixed topology is provided by the engineering tool. The internal provided topology database is used by the NCE, NUE and PCE. The TDE detects added or remove devices and alerts the NCE, NUE or PCE if needed.
- **PCE (Path Compute Engine)** - The path compute engine is responsible for the management of the stream MAC addresses, the calculation of paths through the TSN domain based on the topology database, and the expected maximum latency calculation for each stream. The PCE also performs a check of the bridge resources for each stream and associated path against the defined limits. The NUE is used to update the devices on the path using IEC/IEEE 60802 defined/selected interfaces and protocols. All calculated paths may be stored persistently and reestablished during startup for performance reasons.
- **BNME (Best NME Engine)** - The best NME engine is responsible for the management of the active NME. If multiple NME are detected, one is selected. This process shall be reproducible to make sure that unnecessary switches between NMEs are avoided. A device with a deselected NME is handled like a device without an NME.

Network Update Engine Server

The network update engine server (NUE) is responsible for the update of the managed objects in the devices when requested by the NCE or PCE.

Query Path Entity

The Query Path Entity provides an interface to request a path for a stream or multiple streams. There are two functions associated with the Query Path Entity:

- The Query Path Client provides any end station in the TSN domain an interface to request streams from the NME.
- The Query Path Server is a network management engine server responsible for:
 - the handling of Query Path requests
 - the forwarding of Query Path requests to its PCE
 - the establishment of the path
 - providing the feedback from the PCE

Operation

The Query Path Entity recognizes that industrial automation communications are typically connection-based. So, while an I/O device understands what information it is capable of producing and the maximum rate at which that information can be provided, it typically does not know where that information needs to go and what update rate is required to close the control loop. There is a communications master, typically in a PLC, which is responsible for establishing those connections, determining what I/O data is of interest and providing the required update rate. The PLC gets this information from an engineering tool. There may be multiple PLC in a given TSN domain.

For a centralized approach with a fixed topology and fixed paths, an engineering tool provides traffic requirements, path information and topology information to the NME. The NME then performs the calculations necessary to meet the specified traffic requirements and Query Path delivers the result of the calculation via remote management.

For a centralized approach with a dynamic topology and dynamic paths, an engineering tool provides traffic requirements and path information to the Query Stream Clients. The Query Stream Server, in turn provides those requests to the NME. The Topology Discovery Engine provides topology information to the NME. The NME then performs the calculations necessary to meet the specified traffic requirements and Query Path delivers the result of the calculation via remote management.