4.3 Traffic Type Descriptions

Isochronous

The applications in each device are synchronized to a common time, which is strictly monotonic and steadily increasing, without jumps or leaps. Devices synchronously sample inputs and apply outputs by exchanging data at a defined periodic rate or cycle. When applied to motion applications, this rate can be fast, in some cases, under 100µs. For tight control loops, transmission jitter must be minimal, with no interference from other traffic. Messages needs to be delivered before a certain point in time. If they arrive later than this deadline, they are ignored for that cycle or discarded, thus potentially affecting the control loop. Message sizes are fixed at design time and remain constant for each cycle. Payload sizes are typically under 100 bytes per device. This type can be used for controller-to-controller and controller-to-I/O-communication in synchronous exchanges.

Examples include

- *time-synchronized applications* where data must be produced and delivered consistently and where packets are delivered with a bounded latency, in other words before or by the deadline and
- *applications with implicit synchronization* where devices act on reception of a frame and therefore lack tolerance to interference and require very low jitter to produce an *on-time* delivery (at a specific point in time).

Characteristics		**Notes**
Periodicity	Cyclic/periodic	
Period	100µs ~ 2ms	
Data transmission time is synchronized to network cycle	Yes	
Data delivery requirements	Deadline	Usually within one data transmission period
Tolerance to interference	0	
Tolerance to loss	No (0 frames)	Seamless redundancy is required
Application Data size	Fixed (30 ~ 100 bytes)	
Criticality	High	

Cyclic

This type involves cyclic/periodic communication between devices. The applications in each device are not synchronized to a common time. Devices sample inputs and apply outputs cyclically, which may or may not be the same as the data transmission period. When applied to a client-server protocol (e.g. Profinet IO), messages can be clustered while in a publish/subscribe environment (e.g. EtherNet/IP) messages can be distributed over the cycle time. For best control, the time between a device sending a message and its reception should be minimized, with predictable interruptions from other traffic. Messages need a defined maximum latency time. Data message sizes are fixed at design time and remain constant for each cycle. This type can be used for controller to controller and controller to I/O communication.

Examples include:

- *input/output* updates sent to/from actuators and sensors and a programmable logic controller in a discrete manufacturing facility with request packet interval (RPI) times usually measured in milliseconds and cycle times usually 3 to 4 times the RPI,
- *process graphic updates* that need to be updated on a cyclic polling basis, with up to 1 second cycle times; the process controllers send this information to the servers of the plant; maximum frame size varies following each vendor but may reach 1500 bytes and
- fast *diagnostic data* for drives that produce 1500 bytes samples at a rate up to every 4 ms that is used to verify drive functionality,
- *historian information* where process controllers create data traffic which is cyclic, but with an update rate or cycle time of around one second. Maximum frame size varies following each vendor but may reach 1500 bytes;

Characteristics		**Notes**
Periodicity	Cyclic/periodic	
Period	2 ~ 20ms	
Data transmission time is synchronized to network cycle	No	
Data delivery requirements	Latency	Typically 50% of the period is worst case and lower network latency improves control.
Tolerance to interference	Yes, <= latency requirement	The jitter is constrained by the latency requirement.
Tolerance to loss	1 ~ 4 frames	Applications are designed to tolerate the loss of one to 4 successive frames (1 ~ 4 periods).
Application Data size	Fixed (50 ~ 1000 bytes)	
Criticality	High	

Alarms and Events

In a system when an input or output variable change occurs that requires attention, Alarm and Event messages are generated. Depending upon the change, this might be a single message, or a flurry of messages (domino effect). While the messages may be directed to different end devices, typically, they are directed at a single device, like an HMI or SCADA system. The network must be able to handle a burst of messages without loss, up to a certain number of messages or data size over a defined period.

After this period, messages can be lost until the allowed bandwidth quantity has been restored.

Examples include

- *process alarms and events* that create traffic that may require 1 to 2 seconds latencies and is acyclic but prone to flooding when issues arise in the process being controlled. Maximum frame size varies by vendor and application but may reach 1500 bytes and
- *operator commands* create another type of alarm and event traffic that is acyclic and has a latency up to 1 second. Maximum frame sizes vary following each vendor but are usually smaller than the previous ones, reaching 500 ~ 600 bytes.

Characteristics		**Notes**
Periodicity	Acyclic/sporadic	
Period	n.a.	
Data transmission time is synchronized to network cycle	No	
Data delivery requirements	Latency (100ms ~ 1s)	A bandwidth requirement is also implied as stated above.
Tolerance to interference	n.a.	To be defined by the application.
Tolerance to loss	Yes	For example, alarm showers of up to 2000 alarms per second must be delievered, after which some packet loss is acceptable. The number is application dependent.
Application data size	Variable (50 ~1500 bytes)	
Criticality	High	

Configuration & Diagnostics

This type is used for the transport of configuration data, such as device configuration and firmware downloads. This data is traditionally sent using TCP/IP-based protocols that contain lost message recovery capabilities. This data is not time critical, but it must eventually be delivered.

IACS configuration, maintenance and operator triggered diagnostics use this traffic type. Network and system management and configuration (e.g. SNMP, RESTCONF/NETCONF, firmware updates) protocol traffic also belongs to this traffic type.

Examples include:

- configuration activities create traffic with maximum frame sizes (1500 bytes) in an acyclic manner. This traffic type may occasionally create peaks of bandwidth utilization with a latency of up to 1 second,
- diagnostic activities to monitor equipment health that creates acyclic traffic type, and
- process information from the application, such as order scheduling and production.

Characteristics		**Notes**
Periodicity	Acyclic/sporadic	Some process supervision/diagnostic data may be sent periodically with higher periods (500ms ~ 2s).
Period	n.a.	
Data transmission time is synchronized to network cycle	No	
Data delivery requirements	Bandwidth	
Tolerance to interference	n.a.	
Tolerance to loss	Yes	No seamless redundancy is required.
Application Data size	Variable	Can be large packets of 500 ~ 1500 bytes
Criticality	Medium	

Network Control

This type contains network control messages, like those for synchronizing time (IEEE 802.1AS a.k.a. Precision Time Protocol or PTP), for network redundancy (e.g. MSTP, RSTP), topology detection (e.g. LLDP). These messages are low in volume but have critical delivery requirements. Many of the messages are cyclic, but not relative to any TSN network cycle times. PTP traffic due to its small size and the nature of the time-stamping shall not be preempted.

Characteristics		**Notes**
Periodicity	Cyclic/periodic	
Period	50ms ~ 1s	
Data transmission time is synchronized to network cycle	No	
Data delivery requirements	Bandwidth	Typically 1 ~ 2 Mbps per port
Tolerance to interference	Yes	Transmission of PTP frames should not be interrupted. Transmission jitter should not exceed the period.
Tolerance to loss	Yes	Excessive loss of network control frames can lead to loss of network functions (e.g. link-down state or grand master fail-over).
Application data size	Variable (50 ~ 500 bytes)	
Criticality	High	

Best Effort

Best effort traffic follows one of two rules: either it suffers from data loss when higher priority traffic may use all of the available bandwidth, or some bandwidth reservations can be made. Best effort messages may be lost in the former case, and by reserving the bandwidth, the best-effort messages (within the bandwidth reservations) are delivered to the receivers.

Characteristics		**Notes**
Periodicity	Acyclic/sporadic	
Period	n.a.	
Data transmission time is synchronized to network cycle	No	
Data delivery requirements	None	Typically networks are configured to provide some bandwidth to best effort.
Tolerance to interference	n.a.	
Tolerance to loss	Yes	
Application data size	Variable (30 ~1500 bytes)	
Criticality	Low	

Video

Video traffic is the streaming of video data between end-points. IACS often include video systems, but this traffic will be mapped to previous types such as *Cyclic* or potentially *Isochronou*s data depending on the criticality of the application. The characteristics below describe video for human consumption. Video streaming for human consumption tends to have lower performance requirements and is reflected in the IEEE 802.1Q, where video "traffic is characterized by less than 10ms delay and, hence, maximum jitter (one way transmission through the LAN infrastructure of a single campus)."

Characteristics		**Notes**
Periodicity	Acyclic/sporadic	
Period	n.a.	
Data transmission time is synchronized to network cycle	No	
Data delivery requirements	Latency	Less than 10ms
Tolerance to interference	n.a.	
Tolerance to loss	Yes	Loss of packets may lead to decreased quality, but not necessarily application failure
Application Data size	Variable	Large packets (1000 - 1500 bytes)
Criticality	Low	

Audio/Voice

Audio traffic is the streaming of audio or voice traffic between end-points. As with video traffic, IACS systems often include sound sensors and actuators, but such end devices treat the streaming data as *Cyclic* or potentially *Isochronous* data depending on the criticality of the application. Audio streaming for human consumption tends to have lower performance requirements and is reflected in the IEEE 802.1Q where audio traffic is "characterized by less than 100ms delay, or other applications with low latency as the primary QoS requirement".

Characteristics		**Notes**
Periodicity	Acyclic/sporadic	
Period	n.a.	
Data transmission time is synchronized to network cycle	No	
Data delivery requirements	Latency	Less than 100ms
Tolerance to interference	n.a.	
Tolerance to loss	Yes	Loss of packets may lead to decreased quality, but not necessarily application failure.
Application Data size	Variable	Large packets (1000 - 1500 bytes)
Criticality	Low	