

Industrial Automation Traffic Types and their Mapping to QoS/TSN Mechanisms

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Traffic Type Characteristics

Application-derived communication requirements

Traffic Type	Description
Data transmission periodicity	<ul style="list-style-type: none"> • Cyclic/periodic • Acyclic/sporadic - also periodic frames with large periods (1-2 seconds)
Typical period	Planned data transmission interval ("cycle"), range in orders of magnitude of time
Synchronized to network	Indication whether application is synchronized to network time (yes or no)
Data delivery guarantee	<ul style="list-style-type: none"> • <u>Deadline</u>: data delivery of each packet in a stream is guaranteed to occur at all registered receivers at or before a specified time (within a communication cycle) • <u>Latency</u>: data delivery of each packet in a stream is guaranteed to occur at all registered receivers within a predictable timespan starting when the packet is transmitted by the sender and ending when the packet is received • <u>Bandwidth</u>: data delivery of each packet in a stream is guaranteed to occur at all registered receivers if the bandwidth utilization is within the resources reserved by the sender
Tolerance to interference	Application's tolerance of a certain amount of latency variation of the packet's transmission (i.e. jitter)
Tolerance to loss	Application's tolerance to a certain amount of consecutive packet loss in network transmission
Typical application data size	Application payload size to be transmitted (fixed or variable)
Criticality	<ul style="list-style-type: none"> • Criticality of the application data for the operation of the critical parts of the system (high, medium, low) • Application criticality is used as a criteria for bandwidth reservations in case of conflicting requirements.

Traffic Types for Industrial Automation and Control Systems

Types	Periodicity	Typical period	Synchronized to network	Data delivery guarantee	Tolerance to interference	Tolerance to loss	Typical application data size	Criticality
Isochronous	Periodic	< 2ms	Yes	Deadline	0	None	Fixed: 30 - 100 Bytes	High
Cyclic	Periodic	2 - 20ms	No	Latency	<= latency	1 - 4 Frames	Fixed: 50 - 1000 Bytes	High
Events	Sporadic	n.a.	No	Latency	n.a.	Yes	Variable: 100 - 1500 Bytes	High
Network Control	Periodic	50ms - 1s	No	Bandwidth	Yes	Yes	Variable: 50 - 500 Bytes	High
Config & Diagnostics	Sporadic	n.a.	No	Bandwidth	n.a.	Yes	Variable: 500 - 1500 bytes	Medium
Best Effort	Sporadic	n.a.	No	None	n.a.	Yes	Variable: 30 - 1500 Bytes	Low
Video	Periodic	Frame Rate	No	Latency	n.a.	Yes	Variable: 1000 - 1500 Bytes	Low
Audio/Voice	Periodic	Sampling Rate	No	Latency	n.a.	Yes	Variable: 1000 - 1500 Bytes	Low

Complete description: https://www.iconsortium.org/pdf/IIC_TSN_Testbed_Traffic_Whitepaper_20180418.pdf

Traffic Type: Isochronous

Example: Printing machine with synchronized drives

- Devices synchronously sample inputs and apply outputs by exchanging data at a defined periodic rate
- Applications in each device are synchronized to a common (network) time
- For tight control loops, transmission jitter must be minimal with no loss and interference from other traffic

Isochronous		
Characteristics		Notes
Periodicity	Cyclic/periodic	
Typical period	< 2ms	
Synchronized to network	Yes	
Data delivery guarantee	Deadline	Usually within one data transmission period
Tolerance to interference	0	Least possible jitter is required
Tolerance to loss	None	Seamless redundancy is required
Typical application data size	Fixed (30 - 100 bytes)	
Criticality	High	

Traffic Type: Cyclic

Example: Pick & Place, Sorting

- Devices sample inputs and apply outputs cyclically (cycle may differ from data transmission period)
- Applications in each device may not be synchronized to a common (network) time
- Time between sending and receiving application data should be minimized, with predictable interruptions

Cyclic		
Characteristics		Notes
Periodicity	Cyclic/periodic	
Typical period	2 - 20ms	
Synchronized to network	No	
Data delivery guarantee	Latency	Typically less than 50% of the period; lower network latency improves control
Tolerance to interference	\leq latency	The jitter is constrained by the latency requirement
Tolerance to loss	1 - 4 frames	Applications may tolerate frame loss for 1 - 4 periods
Typical application data size	Fixed (50 - 1000 bytes)	
Criticality	High	

Traffic Type: Events

Examples: a) Event-based control, b) alarms/warnings and operator commands

- Devices generate messages when an input or output variable change occurs that requires attention
- May lead to single message or a flurry of messages (domino effect) depending on the type of change
- Network must be able to handle messages burst without loss (up to a certain no. of messages or bandwidth)

Events		
Characteristics		Notes
Periodicity	Acyclic/sporadic	
Typical period	n.a.	
Synchronized to network	No	
Data delivery guarantee	Latency (10ms - 2s)	<ul style="list-style-type: none">• <i>Alarms and operator commands</i> have relaxed latency• <i>Control events</i> have much shorter latency requirements
Tolerance to interference	n.a.	
Tolerance to loss	No	Unless application exceeds configured bandwidth limits
Typical application data size	Variable (100 - 1500 bytes)	
Criticality	High	

Traffic Type: Configuration & Diagnostics

Examples: Network and System management and configuration (e.g. SNMP, RESTCONF/NETCONF, firmware updates)

- This traffic type may occasionally create peaks of bandwidth utilization and has a latency of up till 1 second
- Diagnostic activities to monitor equipment health typically creates acyclic traffic type

Events		
Characteristics		Notes
Periodicity	Acyclic/sporadic	
Typical period	n.a.	
Synchronized to network	No	
Data delivery guarantee	Bandwidth	
Tolerance to interference	Yes	Additionally, the latency is in the range of 100ms
Tolerance to loss	Yes	No seamless redundancy required
Typical application data size	Variable (500 - 1500 bytes)	
Criticality	Medium	

Traffic Type: Network Control

Examples: Clock synchronization (e.g. PTP), Network redundancy (e.g. RSTP), Topology detection (e.g. LLDP)

- The network control traffic type contains network control messages. 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.

Events		
Characteristics		Notes
Periodicity	Cyclic/periodic	
Typical period	50ms ~ 1s	
Synchronized to network	No	
Data delivery guarantee	Bandwidth	Typically 1 ~ 2 Mbits
Tolerance to interference	Yes	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).
Typical application data size	Variable (50 ~ 500 bytes)	
Criticality	High	

Traffic Type: Best Effort

Best effort traffic can follow two rules:

- Either it suffers from data loss when higher priority traffic uses all the bandwidth allocated (default)
- Or it can utilize a guaranteed bandwidth allocation

Best effort provides no delivery guarantees in the former case, and bandwidth guarantees in the latter

Events		
Characteristics		Notes
Periodicity	Acyclic/Sporadic	
Typical period	n.a	
Synchronized to network	No	
Data delivery guarantee	None	Typically networks are configured to provide some bandwidth to Best Effort
Tolerance to interference	Yes	
Tolerance to loss	Yes	
Typical application data size	Variable (30 ~ 1500 bytes)	
Criticality	Low	

Traffic Type: Video

Examples: Video Surveillance traffic used to visually monitor production conditions but are not part of any control process

- Video for human consumption – no vision based control application traffic

Events		
Characteristics		Notes
Periodicity	Frame Rate	
Typical period	n.a	
Synchronized to network	No	
Data delivery guarantee	Bandwidth	Latency greater than 10ms may impact application performance
Tolerance to interference	n.A	
Tolerance to loss	Yes	Loss of packets may lead to decreased quality, but not necessarily application failure
Typical application data size	Variable (1000 ~ 1500 bytes)	
Criticality	Low	

Traffic Type: Audio

- Audio traffic is the streaming of audio or voice traffic between end-points.
- 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 100 ms delay, or other applications with low latency as the primary QoS requirement”.

Events		
Characteristics		Notes
Periodicity	Sampling Rate	
Typical period	n.a	
Synchronized to network	No	
Data delivery guarantee	Bandwidth	Latency greater than 10ms may impact application performance
Tolerance to interference	n.A	
Tolerance to loss	Yes	Loss of packets may lead to decreased quality, but not necessarily application failure
Typical application data size	Variable (1000 ~ 1500 bytes)	
Criticality	Low	

Thank you!