

Finding your GOOSE in the Substation

Rodney Hughes

A quick 10 minutes

- Identify the difference between 'general' Industrial Ethernet and Substation Automation System application of Industrial Ethernet
- What is a GOOSE message (and what it is not)
- How a switch manages the messages on Ingress and Egress
- Correct configuration of switch ports, VLANs, Priority and Multicast Filtering

Then on the fifth day

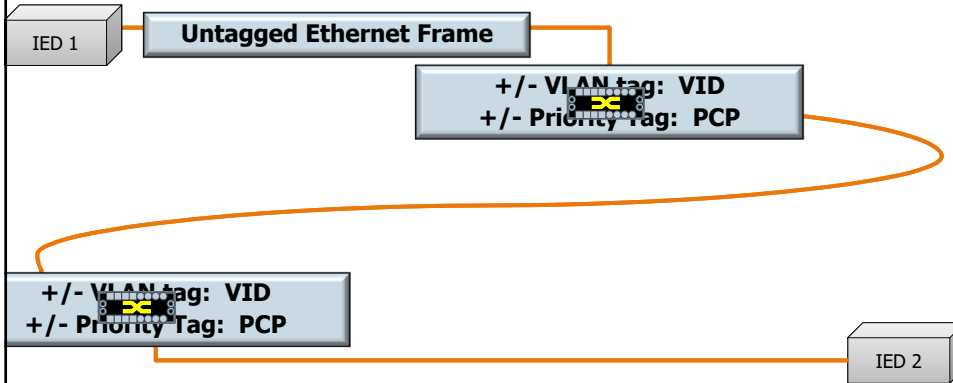
Industrial Ethernet vs Substation Automation System Application

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Industrial Ethernet

Generally devices send **Untagged** messages

Tags are added/removed by the switches to manage network passage



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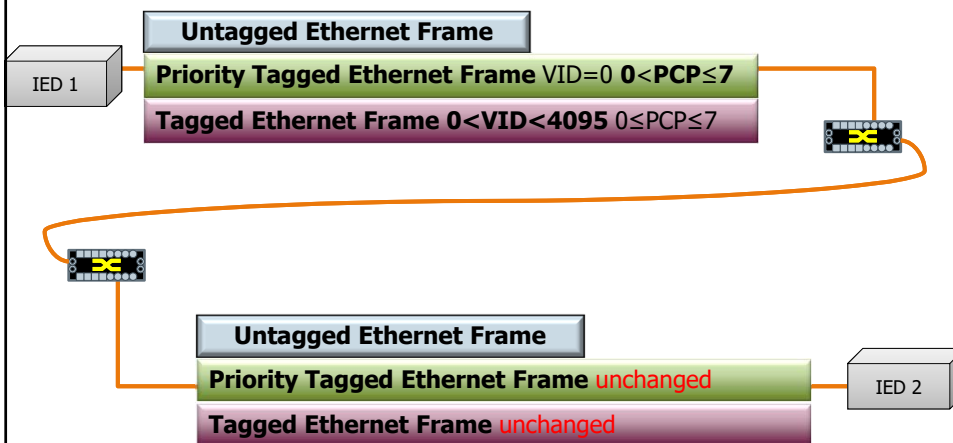
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Industrial Ethernet vs Substation Automation System Application

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Substation Automation System

Need to ensure real time end-to-end performance



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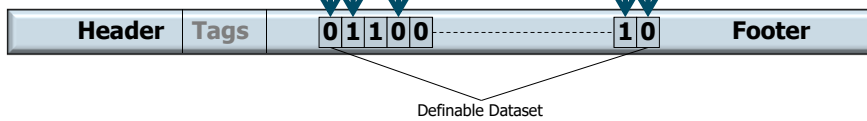
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Generic Object Oriented System Event

GOOSE message contains the definable Dataset
 Dataset contains the present STATUS (value) of a function as "0" or "1"


- Protection function: Not Operated/Operated
- Current magnitude: Below Setting/Above Setting
- Button Pressed: No/Yes
- Circuit Breaker: Open/Closed
- Fan or Pump: Off/On



It is not a command as such
 ... The receiving device will interpret the "0" or "1" and act according to its own functionality

GOOSE does not flood the network

1 Gb/s handles at least 81,063 Ethernet messages per second

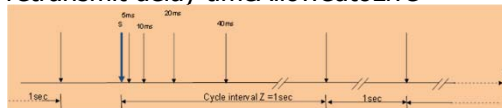
"heartbeat" repetition of function status 
 gives certainty that end-to-end network is healthy

Status change creates Fast Repetition cycle

Selectable first Repetition rate: examples

- 1 ms, then 2 ms (total 3 ms), then 4 ms (total 7 ms)
- 50 ms, then 100 ms (total 150 ms), then 200 ms (total 350 ms)

Upto the setting of the maximum retransmit delay timeAllowedtoLive



Example for 1 ms first retransmit

- timeAllowedtoLive = 1,000 ms 40 messages will take 30 seconds
- timeAllowedtoLive = 4,294,967,295 ms 40 messages will take 447 days

What happens on Ingress – EDGE port

Port TRUNK or EDGE setting	Ingress Frame format	Admit Rule Setting	EDGE: PVID Match	Ingress Action	"Internal" Frame refer IEC 61850-90-4 cl 6.4.8.2.1, Note 2. 1<=VID<=4094 0<=PCP<=7	
EDGE	Untagged no VID field no PCP field	Admit All (switch is in VLAN Unaware mode for all ports)	Irrelevant (no PVID values for any port when switch is in VLAN-unaware mode)	no action	Untagged no VID field no PCP field	
		This Port only admits Untagged or Priority Tagged messages	Irrelevant: PVID matching not applicable to Untagged frame	acquires Port PVID acquires Port PCP	Tagged VID = Ingress Port PVID PCP = Ingress Port PCP	
		This Port Admits Only VLAN Tagged messages 1<=VID<=4094	Irrelevant	dropped due to Admit rule for that Port	Dropped	
	Priority Tagged VID=0 0<=PCP<=7	Admit All (switch is in VLAN Unaware mode for all ports)	Irrelevant (no PVID values for any port when switch is in VLAN-unaware mode)	Irrelevant (no PVID values for any port when switch is in VLAN-unaware mode)	retains Ingress Frame VID=0 retains Ingress Frame PCP	Priority Tagged VID = 0 PCP = Ingress Frame PCP
		This Port only admits Untagged or Priority Tagged messages	Irrelevant: PVID matching not applicable to Priority Tagged frame	acquires PVID retains Ingress Frame PCP	Tagged VID = Ingress Port PVID PCP = Ingress Frame PCP	
		This Port Admits Only VLAN Tagged messages 1<=VID<=4094	Irrelevant	dropped due to Admit rule for that Port	Dropped	
	Tagged 1<=VID<=4094 0<=PCP<=7	Admit All (switch is in VLAN Unaware mode for all ports)	Irrelevant (no PVID values for any port when switch is in VLAN-unaware mode)	Irrelevant (no PVID values for any port when switch is in VLAN-unaware mode)	retains Ingress Frame VID retains Ingress Frame PCP	Tagged VID = Ingress Frame VID PCP = Ingress Frame PCP
		This Port only admits Untagged or Priority Tagged messages	Irrelevant	dropped due to Admit rule for that Port	Dropped	
		This Port Admits Only VLAN Tagged messages 1<=VID<=4094	Ingress Frame VID = Ingress Port PVID	retains Ingress Frame VID retains Ingress Frame PCP	Tagged VID = Ingress Frame VID PCP = Ingress Frame PCP	
		This Port Admits Only VLAN Tagged messages 1<=VID<=4094	Ingress Frame VID = Ingress Port PVID	retains Ingress Frame VID retains Ingress Frame PCP	Tagged VID = Ingress Frame VID PCP = Ingress Frame PCP	

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What happens on Ingress – TRUNK port

Port TRUNK or EDGE setting	Ingress Frame format	Admit Rule Setting	TRUNK: PVMS Match	Ingress Action	"Internal" Frame refer IEC 61850-90-4 cl 6.4.8.2.1, Note 2. 1<=VID<=4094 0<=PCP<=7	
TRUNK	Untagged no VID field no PCP field	Admit All (switch is in VLAN Unaware mode for all ports)	Irrelevant (no PVMS values for any port when switch is in VLAN-unaware mode)	no action	Untagged no VID field no PCP field	
		This Port only admits Untagged or Priority Tagged messages	Irrelevant: PVMS matching not applicable to Untagged frames	acquires Port PVID acquires Port PCP	Tagged VID = Ingress Port PVID PCP = Ingress Port PCP	
		This Port Admits Only VLAN Tagged messages 1<=VID<=4094	Irrelevant	dropped due to Admit rule for that Port	Dropped	
	Priority Tagged VID=0 0<=PCP<=7	Admit All (switch is in VLAN Unaware mode for all ports)	Irrelevant (no PVMS values for any port when switch is in VLAN-unaware mode)	Irrelevant (no PVMS values for any port when switch is in VLAN-unaware mode)	retains Ingress Frame PCP	Priority Tagged VID = 0 PCP = Ingress Frame PCP
		This Port only admits Untagged or Priority Tagged messages	Irrelevant: PVMS matching not applicable to Untagged frames	acquires Port PVID retains Ingress Frame PCP	Tagged VID = Ingress Port PVID PCP = Ingress Frame PCP	
		This Port Admits Only VLAN Tagged messages 1<=VID<=4094	Irrelevant	dropped due to Admit rule for that Port	Dropped	
	Tagged 1<=VID<=4094 0<=PCP<=7	Admit All (switch is in VLAN Unaware mode for all ports)	Irrelevant (no PVMS values for any port when switch is in VLAN-unaware mode)	Irrelevant (no PVMS values for any port when switch is in VLAN-unaware mode)	retains Ingress Frame VID retains Ingress Frame PCP	Tagged VID = Ingress Frame VID PCP = Ingress Frame PCP
		This Port only admits Untagged or Priority Tagged messages	Irrelevant	dropped due to Admit rule for that Port	Dropped	
		This Port Admits Only VLAN Tagged messages 1<=VID<=4094	Ingress Frame VID = Member of PVMS	retains Ingress Frame VID retains Ingress Frame PCP	Tagged VID = Ingress Frame VID PCP = Ingress Frame PCP	
		This Port Admits Only VLAN Tagged messages 1<=VID<=4094	Ingress Frame VID ≠ Member of PVMS	retains Ingress Frame VID retains Ingress Frame PCP	Tagged VID = Ingress Frame VID PCP = Ingress Frame PCP	

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What happens on Egress VLAN Unaware, Non-multicast

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VLAN-Aware / Unaware setting	Multicast address	PVMS Match	PVID Match	Message tagging	Port TRUNK or EDGE	Multicast address range	Egress "Forward Tagged/Untagged" Rule	Egress Frame note 2: a switch egress frame is either Tagged or Untagged, and can never be Priority Tagged as VID=0 note 3: Internal Frame VID may be different to Ingress Frame VID note 4: Internal Frame PCP may be different to Ingress Frame PCP
VLAN Un-Aware	Not Multicast destination address	PVMS not Applicable to VLAN-Unaware	Irrelevant to VLAN-Unaware switch	Untagged, or Priority Tagged, or Untagged	EDGE	Multicast filtering not applicable to non-multicast address	Forward Untagged: remove tags	Untagged no VID field no PCP field
					TRUNK		Forward Tagged: retain tags	Tagged VID = Internal Frame VID PCP = Internal Frame PCP
							Forward Untagged: remove tags	Untagged no VID field no PCP field
							Forward Tagged: retain tags	Tagged VID = Internal Frame VID PCP = Internal Frame PCP

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What happens on Egress VLAN Unaware, Multicast (GOOSE, SV)

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VLAN-Aware / Unaware setting	Multicast address	PVMS Match	PVID Match	"Internal" Frame note 1: all internal frames are effectively tagged 1<=VID<=4094 0<=PCP<=7 Refer Ingress Rules	Port TRUNK or EDGE	Multicast address range	Egress "Forward Tagged/Untagged" Rule	Egress Frame note 2: a switch egress frame is either Tagged or Untagged, and can never be Priority Tagged as VID=0 note 3: Internal Frame VID may be different to Ingress Frame VID note 4: Internal Frame PCP may be different to Ingress Frame PCP
VLAN Un-Aware	Multicast destination address	PVMS not Applicable to VLAN-Unaware	Irrelevant to VLAN-Unaware switch	Tagged 1<=VID<=4094 0<=PCP<=12	EDGE	Multicast address within Filter range	Forward Untagged: remove tags	Untagged no VID field no PCP field
					TRUNK	Multicast address NOT within Filter range	Irrelevant: dropped due to Multicast filter	Dropped
						Multicast address within Filter range	Forward Untagged: remove tags	Untagged no VID field no PCP field
						Multicast address NOT within Filter range	Irrelevant: dropped due to Multicast filter	Dropped
				Untagged or Priority Tagged VID=0 0<=PCP<=12	EDGE	Multicast address within Filter range	Forward Tagged: retain tags	Tagged VID = Internal Frame VID PCP = Internal Frame PCP
					TRUNK	Multicast address NOT within Filter range	Irrelevant: dropped due to Multicast filter	Dropped
						Multicast address within Filter range	Forward Untagged: remove tags	Untagged no VID field no PCP field
						Multicast address NOT within Filter range	Irrelevant: dropped due to Multicast filter	Dropped

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What happens on Egress VLAN Aware, Non-multicast

VLAN-Aware / Unaware setting	"Internal" Frame note 1: all internal frames are effectively tagged 1<=VID<=4094 0<=PCP<=7 Refer Ingress Rules	Multicast address	Port TRUNK or EDGE	PVMS Match	PVID Match	Multicast address range	Egress "Forward Tagged/Untagged" Rule	Egress Frame note 2: a switch egress frame is either Tagged or Untagged, and can never be Priority Tagged as VID=0 note 3: Internal Frame VID may be different to Ingress Frame VID note 4: Internal Frame PCP may be different to Ingress Frame PCP
VLAN Aware	Tagged 1<=VID<=4094 0<=PCP<=7	Net Multicast destination address	EDGE	PVMS not Applicable to EDGE ports	Internal Frame VID ≠ Egress Port PVID	Multicast filtering not applicable for non-multicast address	Irrelevant: dropped due to VID-PVID mismatch	Dropped
					Internal Frame VID = Egress Port PVID		Forward Untagged: remove tags	Untagged no VID field no PCP field
			TRUNK	Internal Frame VID = Member of PVMS	Internal Frame VID ≠ Egress Port PVID		Forward Tagged: retain tags	Tagged VID = Internal Frame VID PCP = Internal Frame PCP
					Internal Frame VID = Egress Port PVID		retain tags	Tagged VID = Internal Frame VID PCP = Internal Frame PCP
					Internal Frame VID = Egress Port PVID		Forward Untagged: remove tags	Untagged no VID field no PCP field
					Internal Frame VID = Egress Port PVID		Forward Tagged: retain tags	Tagged VID = Internal Frame VID PCP = Internal Frame PCP
Internal Frame VID ≠ Member of PVMS	Irrelevant	Irrelevant: Irrelevant: dropped due to VID-PVMS mismatch	Dropped					

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What happens on Egress VLAN Aware, Multicast (GOOSE, SV)

VLAN-Aware / Unaware setting	"Internal" Frame note 1: all internal frames are effectively tagged 1<=VID<=4094 0<=PCP<=7 Refer Ingress Rules	Multicast address	Port TRUNK or EDGE	PVMS Match	PVID Match	Multicast address range	Egress "Forward Tagged/Untagged" Rule	Egress Frame note 2: a switch egress frame is either Tagged or Untagged, and can never be Priority Tagged as VID=0 note 3: Internal Frame VID may be different to Ingress Frame VID note 4: Internal Frame PCP may be different to Ingress Frame PCP
VLAN Aware	Tagged 1<=VID<=4094 0<=PCP<=14	Multicast destination address	EDGE	PVMS not Applicable to EDGE ports	Internal Frame VID ≠ Egress Port PVID	Irrelevant	Irrelevant: dropped due to VID-PVID mismatch	Dropped
					Internal Frame VID = Egress Port PVID	Multicast address within Filter range	Forward Untagged: remove tags	Untagged no VID field no PCP field
			TRUNK	Internal Frame VID = Member of PVMS	Internal Frame VID ≠ Egress Port PVID	Multicast address NOT within Filter range	Irrelevant	Dropped
					Internal Frame VID = Egress Port PVID	Multicast address within Filter range	retain tags	Tagged VID = Internal Frame VID PCP = Internal Frame PCP
					Internal Frame VID = Egress Port PVID	Multicast address NOT within Filter range	Forward Untagged: remove tags	Untagged no VID field no PCP field
					Internal Frame VID = Egress Port PVID	Multicast address within Filter range	Forward Tagged: retain tags	Tagged VID = Internal Frame VID PCP = Internal Frame PCP
Internal Frame VID ≠ Member of PVMS	Irrelevant	Irrelevant: Irrelevant: dropped due to VID-PVMS mismatch	Dropped					

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Recommendations for Substation LAN Switches

Compliance to IEC 61850 -3 Environment and EMC requirements

Correct use of VLAN, Priority by IED

Correct switch configuration for ingress and egress

- edge/trunk
- admit rule
- PVID/PVMS matching
- Multicast filtering

Compliance to IEC 61850-90-4 LAN configurations and switch data models

Ruggedcom – for substation networks

- Layer 3 Routers for the Substation WAN
- Layer 2 Switches for the Substation LAN
- Layer 1 Media Converters
- Wimax for the field communication
- Remote IED Access Management
- Integrated PC "APE" module for local applications



Further Information



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