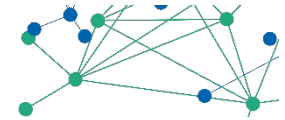


TSN, OPC UA e PROFINET: una combinazione vincente per l'automazione di domani

Micaela Caserza Magro – Genoa Fieldbus Competence Centre srl
micaela.caserzamagro@gfcc.it





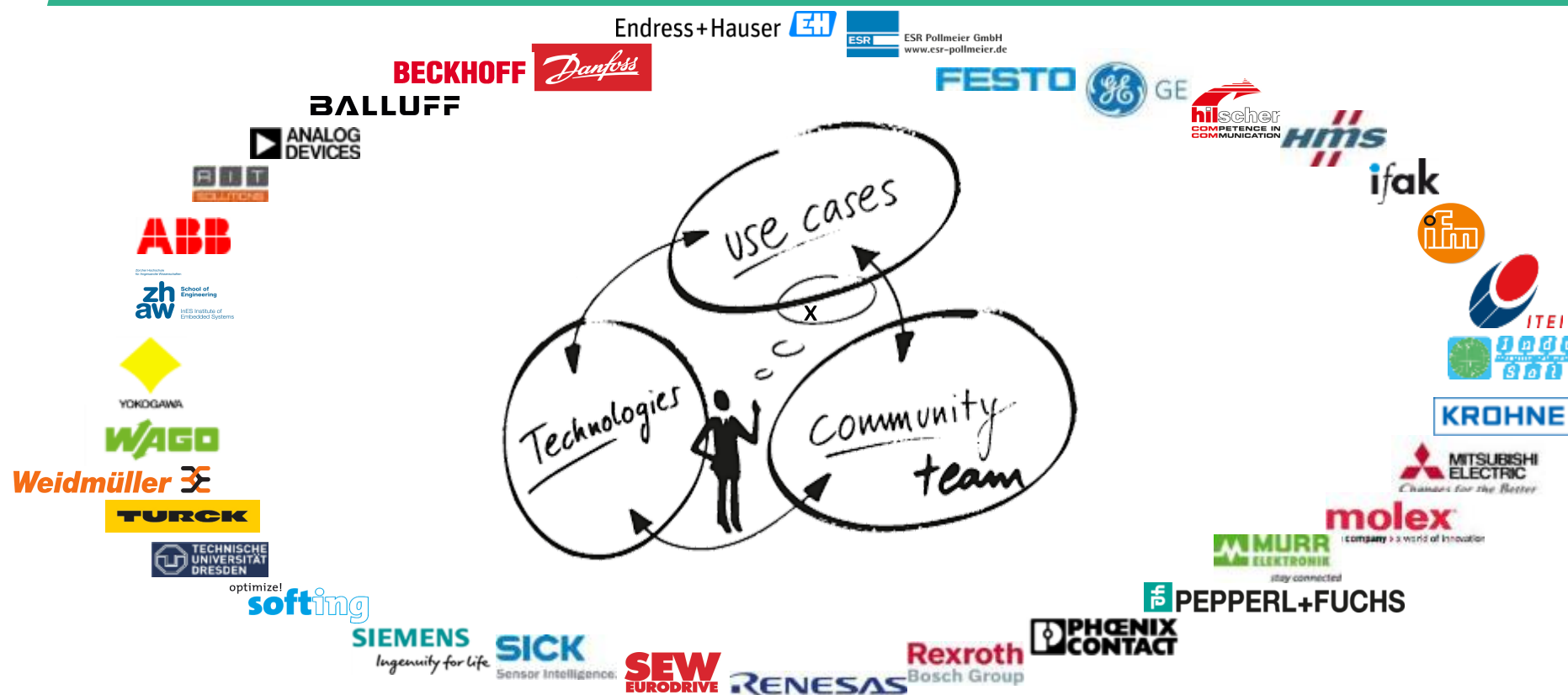
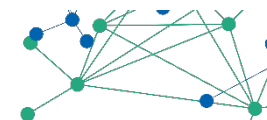
1 Introduzione

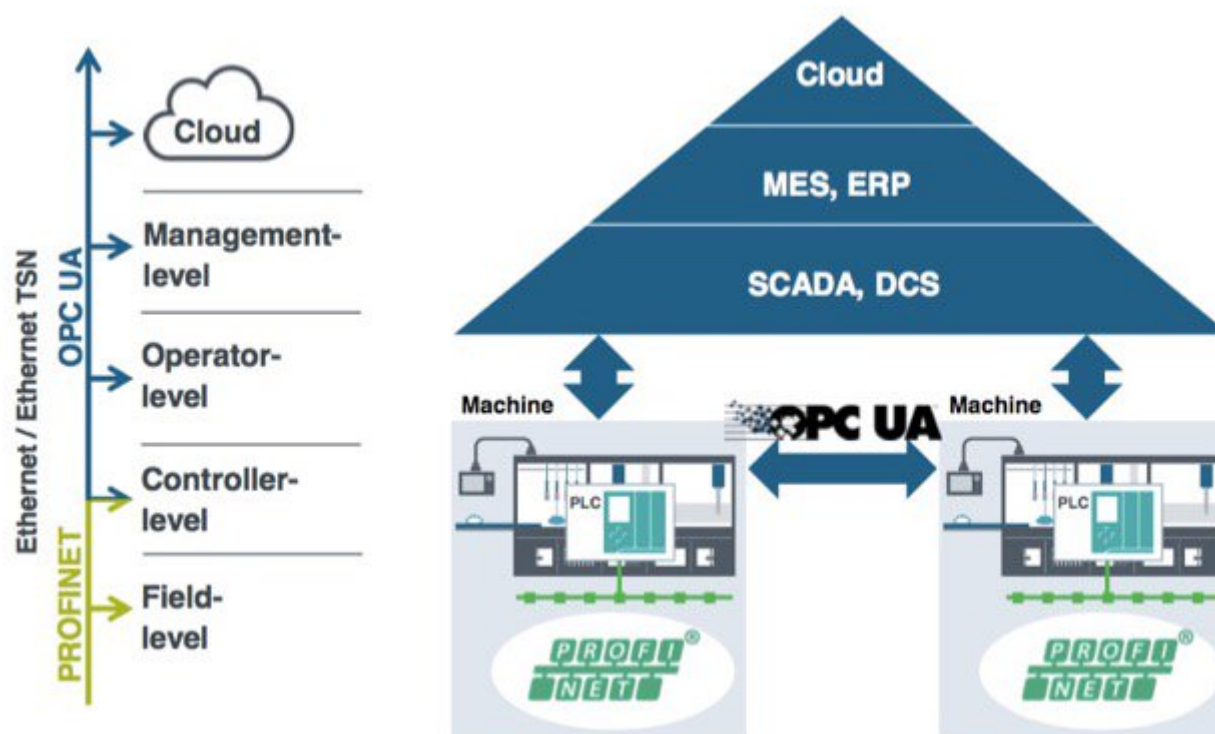
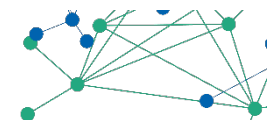
2 TSN

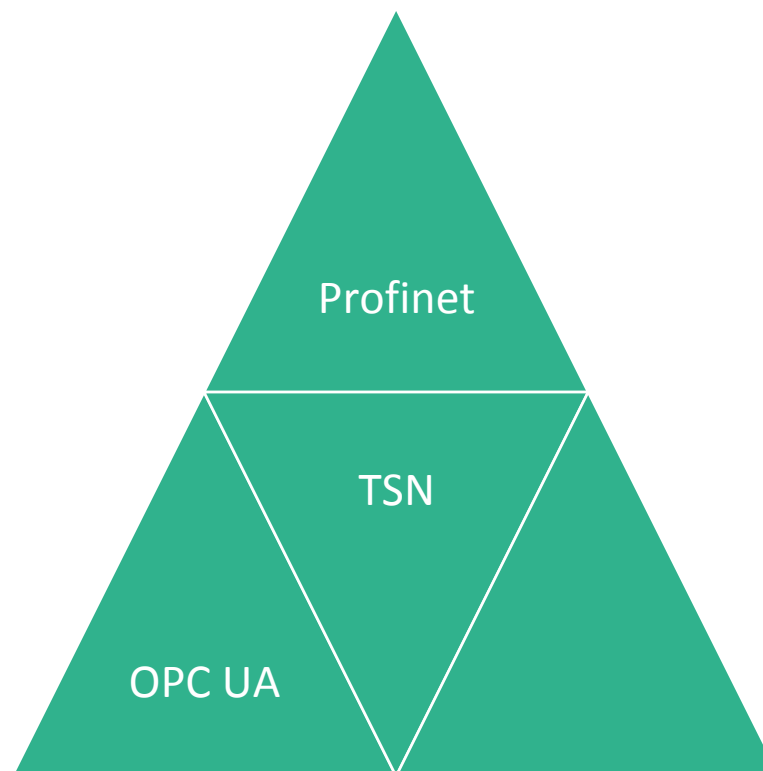
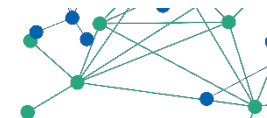
3 OPC UA

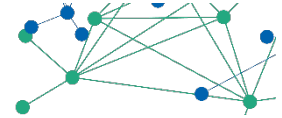
4 Riepilogo

Una comunità forte guida lo standard

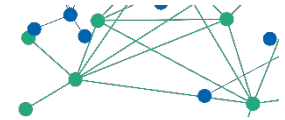








- OPC si focalizza sulla comunicazione vertical di dati aciclici e per le comunicazioni controller to controller;
- PROFINET è usato per lo scambio dati ciclico real-time di I/O a livello di campo;
- TSN + PROFINET garantisce la larghezza di banda e la prestazioni real-time usando chip standard
- TSN + OPC UA permette di avere integrazione tra machine garantendo comunque prestazioni real-time
- Siccome OPC UA e PROFINET possono divider la stessa rete, il loro utilizzo combinato permette ai dati di campo di essere trasferiti ai sistemi SCADA, MES, ERP e volendo anche in cloud.



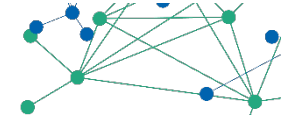
1 Introduzione

2 TSN

3 OPC UA

4 Riepilogo

Che cosa è il TSN (Time Sensitive Network)?



■ Significato di TSN

- TSN è composto da **diversi standard IEEE** che estendono le funzionalità di **Ethernet standard**.

Funzioni

Sincronizzazione

Bassa latenza

Progettazione robusta

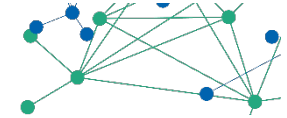
Seamless redundancy

Obiettivi del TSN

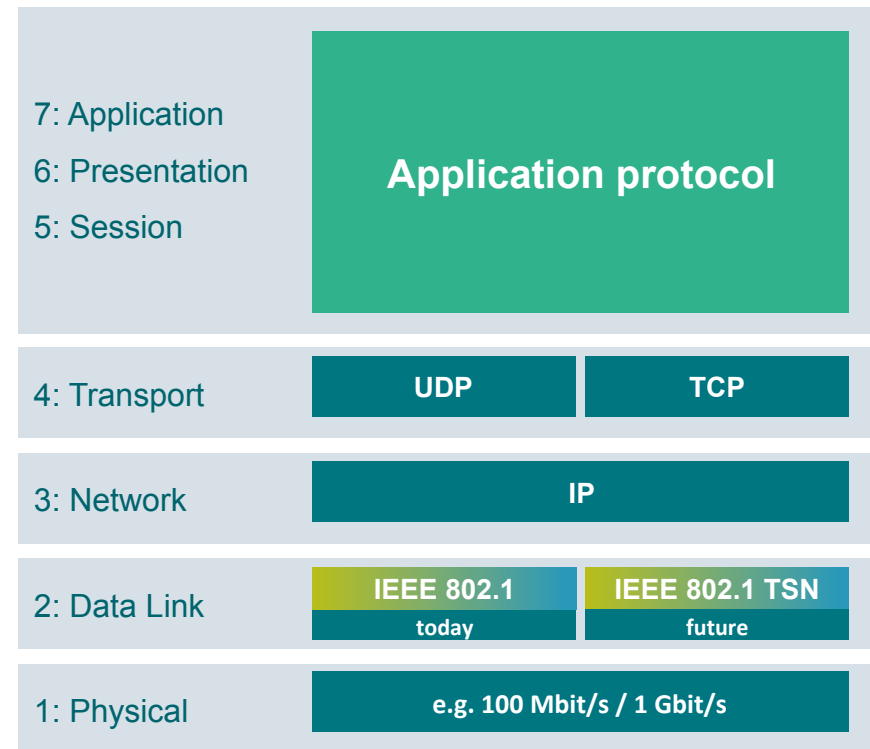
- Interfacce standardizzate nella rete per garantire il Quality of Service (QoS)
- Trasmissioni con una bassa latenza
- Comunicazioni real-time di alta qualità
- Convergenza: diverse applicazioni condividono la rete e ciascuna garantisce il proprio QoS necessario



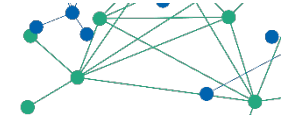
Il TSN rispetto al modello di riferimento OSI



- TSN = insieme di protocolli IEEE di Livello 2
- Per una comunicazione end-to-end complete è necessario utilizzare tutti e 7 i livelli definiti nel modello



Quali sono le caratteristiche del TSN?



Effetti del TSN

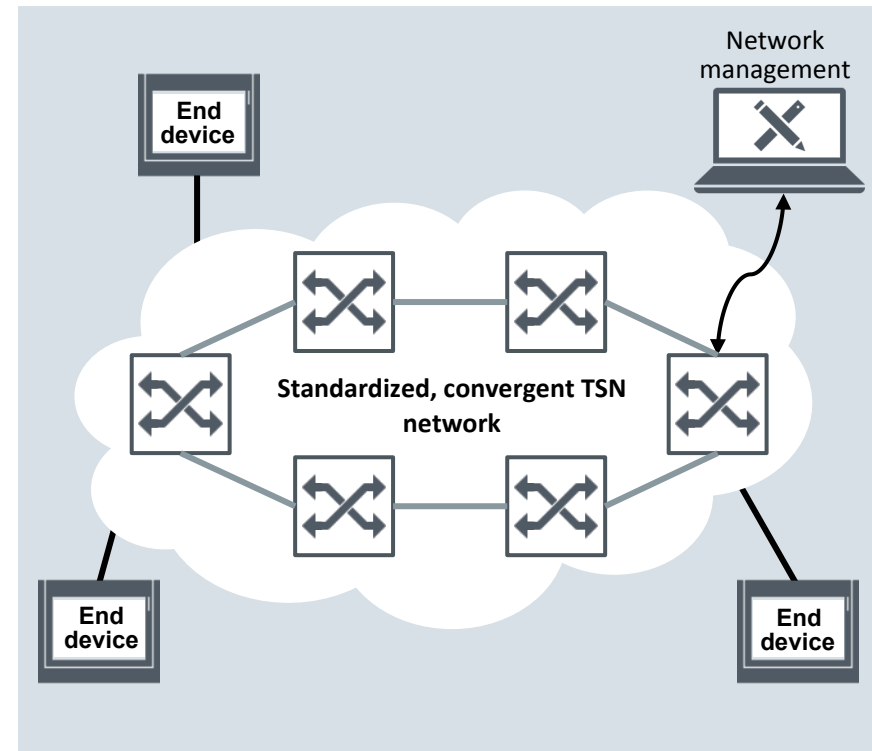
- L'Ethernet standard diventa capace di gestire comunicazioni real-time
- "Ciascuna" comunicazione Ethernet-based potrebbe offrire/garantire prestazioni real-time sia ora che in futuro
 - PROFINET, OPC UA, ...
- TSN permette di avere un miglioramento della tecnologia basandosi su component Ethernet standard

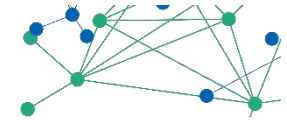
Aree applicative

- Audio/Video, In-Car, Industry

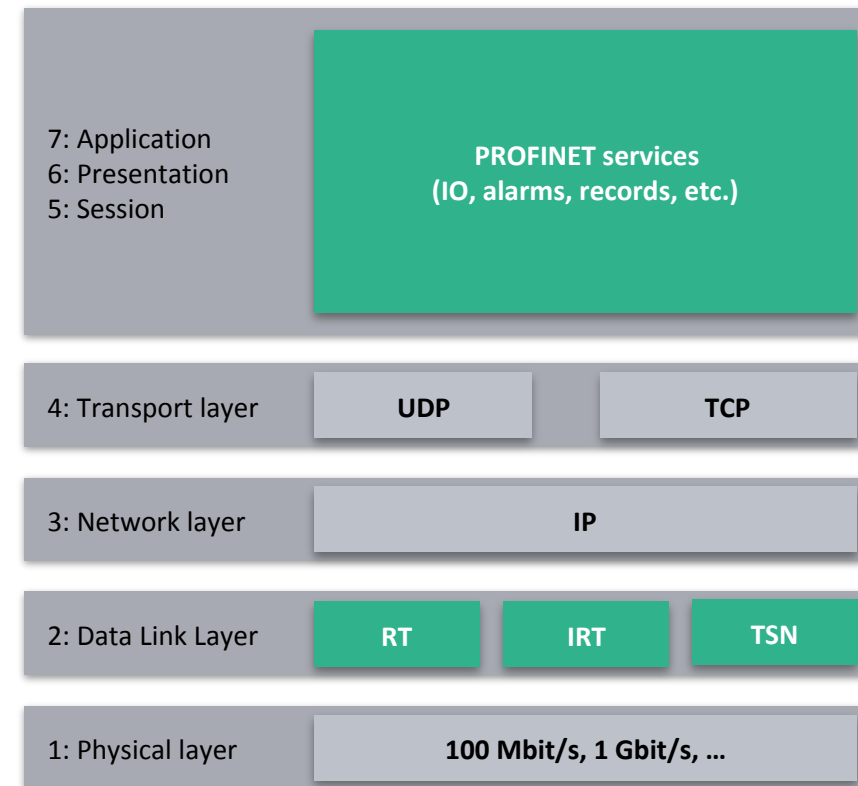
Requisiti

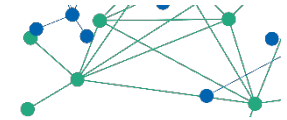
- Hardware con TSN capability





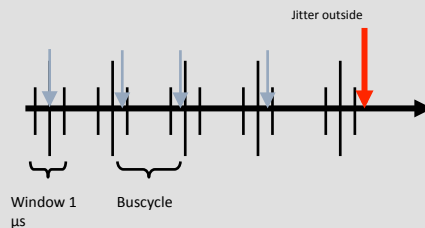
- Servizi PROFINET disponibili
 - Configurazione, parametrizzazione, diagnostica
 - Profili: PROFIsafe, PROFIdrive, PROFIenergy, etc.
- Semplice configurazione della rete TSN
 - Supportato dai meccanismi runtime
 - Configurazione della topologia opzionale
- Meccanismo uniforme
 - Per applicazioni isocrone e non isocrone
 - Topologie flessibili





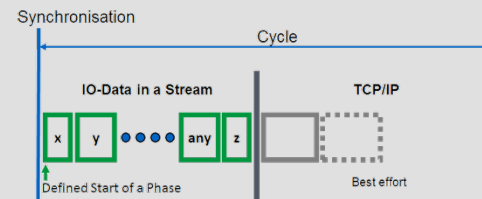
- 802.1ASrev:
Time Synchronization
 - <1μs Jitter
 - Error Correction, Redundancy, Multiple Time Scale

➔ Manda list control ed applicazioni sincrone



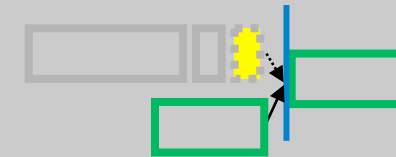
- IEEE 802.1Qbv:
Scheduled Traffic
TAS
(Time Aware Shaper):
 - Invia ad intervalli definiti

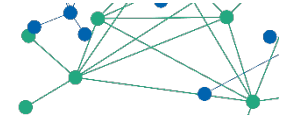
➔ Low Latency, performance



- IEEE 802.1Qbu:
Frame Preemption

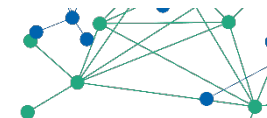
■ Priorità
➔ Low Latency, performance





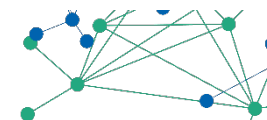
- **Ethernet TSN Domain**: un insieme di component, incluse le loro porte, che trasmettono utilizzando time sensitive streams utilizzando standard TSN e che condividono un meccanismo comune di gestione
- **Time-Sensitive Stream**: uno stream di frame aventi una QoS nota per una consegna definita nel tempo da una singola sorgente che raggiunge uno o più destinatari seguendo percorsi dedicati e predefiniti all'interno di una rete.

Le diverse tipologie di traffico su una rete PN



PROFINET over TSN Traffic Types	Cyclic / Acyclic	Latency Requirement Deadline / Bounded Latency	Data Size	Redundancy
Pass-Through Traffic	Acyclic	No	N/A	Up to regular ²
Connection establishment, records / control	Acyclic			
Non-TSN cyclic and acyclic frames	Cyclic			
Alarms / Events	Acyclic			
Real Time	Cyclic	Yes (see Table 4)	Bounded	Up to seamless ¹
Isochronous Real-Time	Cyclic	Yes (see Table 3)	Bounded	Up to seamless ¹
Synchronization and other non-interruptible protocols	Acyclic	N/A	N/A	Up to seamless ¹
¹ Almost zero failover time		² Larger failover time because of network re-convergence		

Requisiti prestazionali per IRT e RT



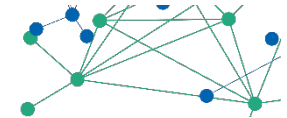
IRT

Characteristic	10 Mbit/s	100 MBit/s	1 Gbit/s and more
Max. End-to-End Latency	50% of the network cycle (15.63 μs – 4 ms)	50% of the network cycle (15.63 μs – 2 ms)	20% of the network cycle (6.25 μs – 0.2 ms)
Network Cycle Times	31.25 μs – 8 ms ¹	31.25 μs – 4 ms ¹	31.25 μs – 1 ms
Application synchronized to working clock	Yes		
¹ Cycle times > 1 ms do not increase the amount of real time frames per cycle due to hardware constraints.			

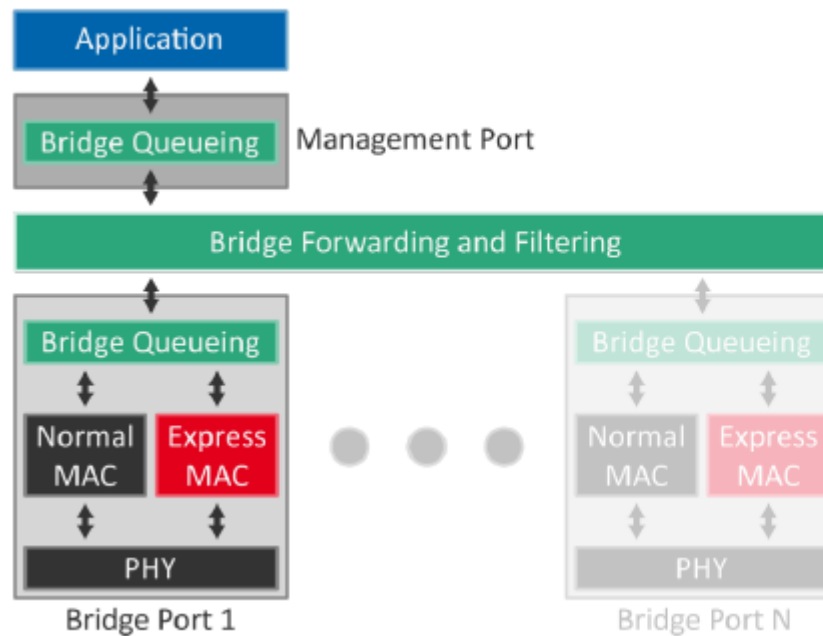
RT

Characteristic	All link speeds
Max. End-to-End Latency	max. N x network cycle time
Network Cycle Times	min. 31.25 μ s
Application synchronized to working clock	Optional

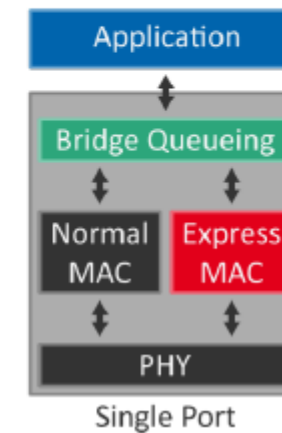
Tipologie di device su una rete PROFINET TSN

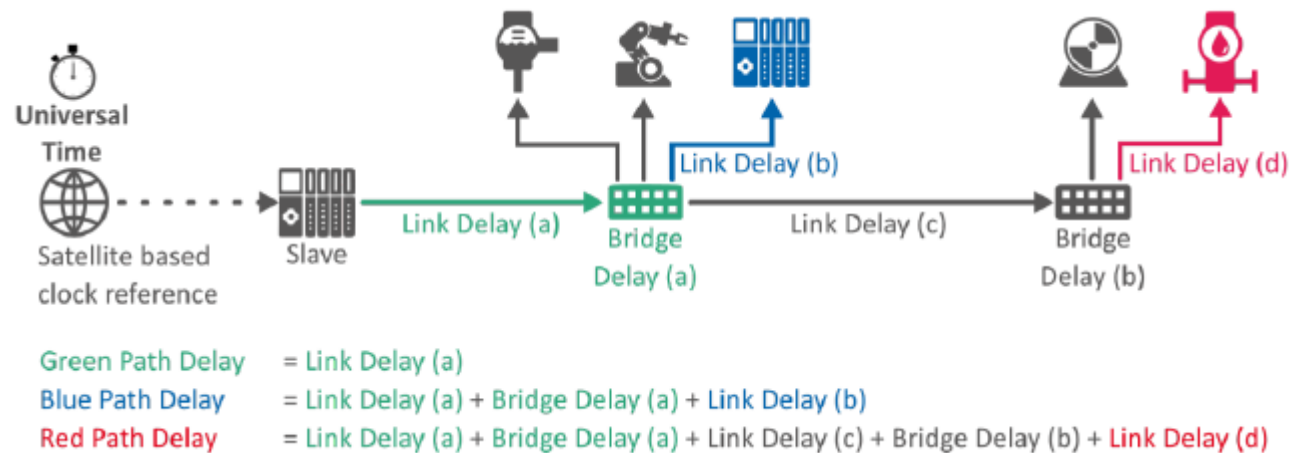
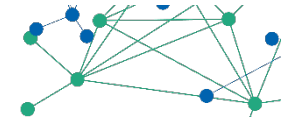


a) Bridge or Bridged End-Station

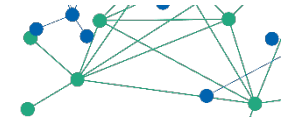


b) End-Station with Single Port

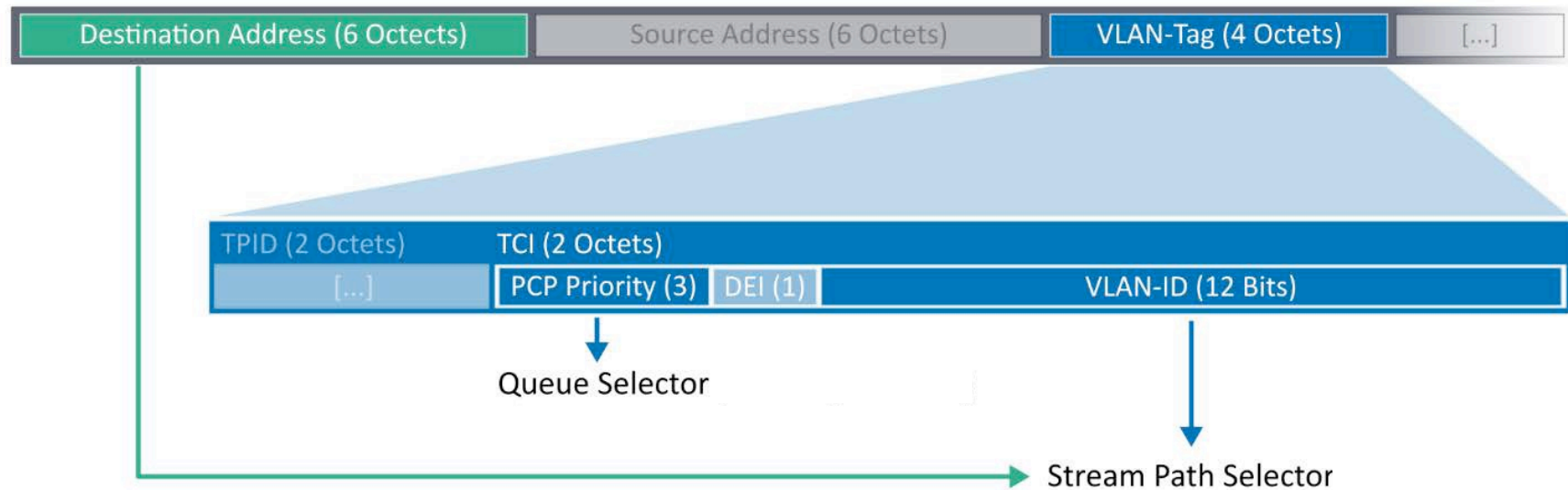




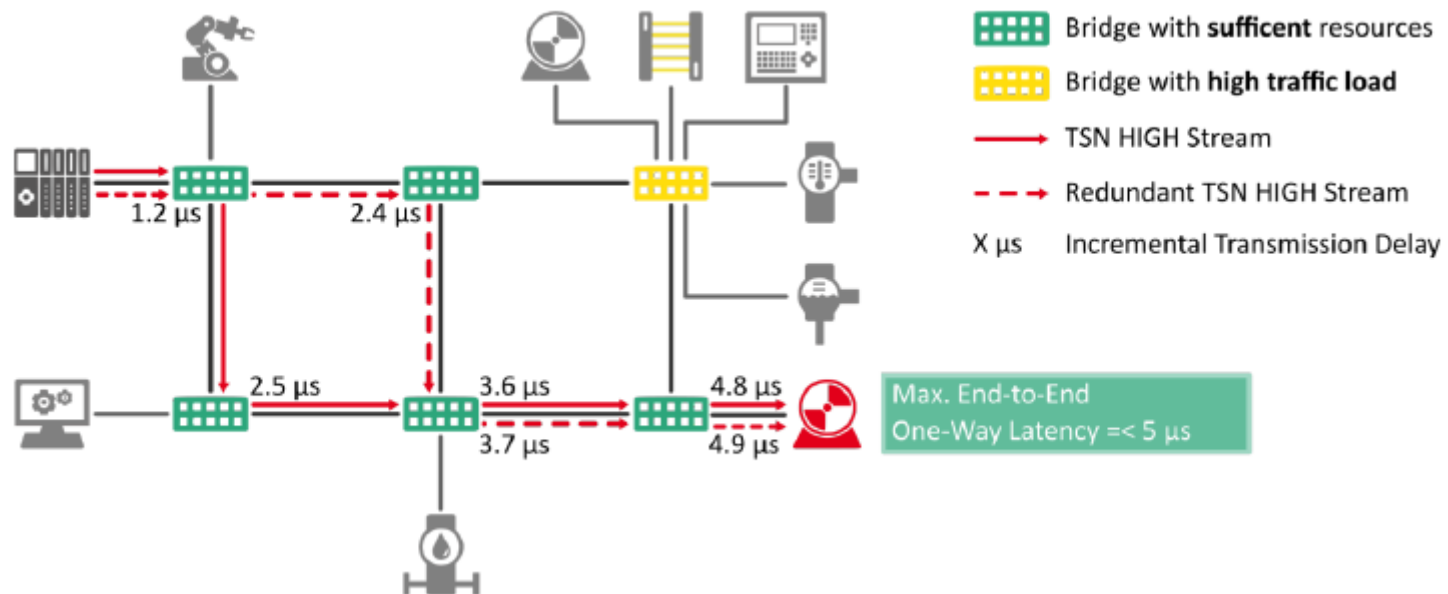
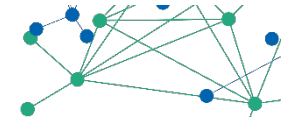
- **Tempo universale:** sincronizzato su una referenza globale
- **Tempo di lavoro:** usato per la comunicazione schedulata e per la comunicazione isocrona

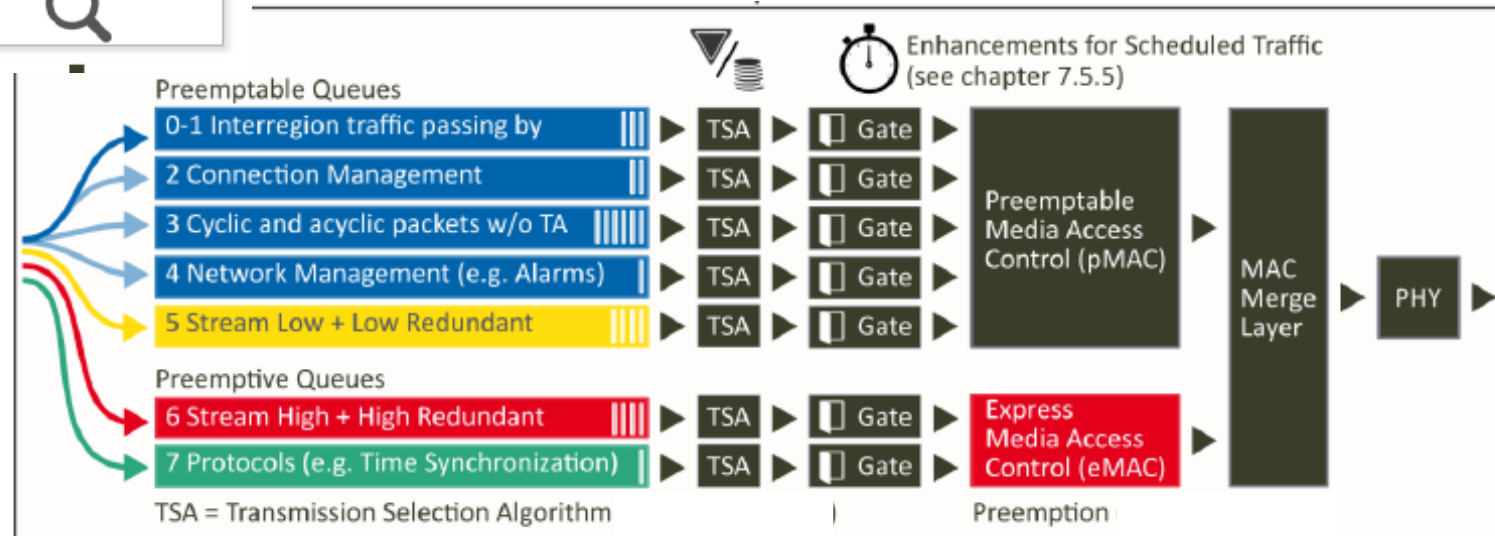
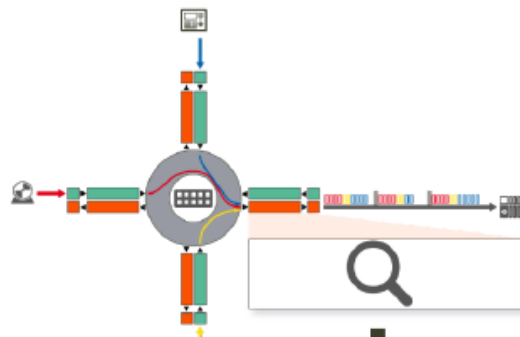
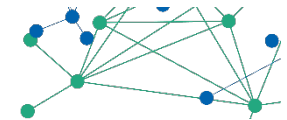


PROFINET over TSN Ethernet Frame

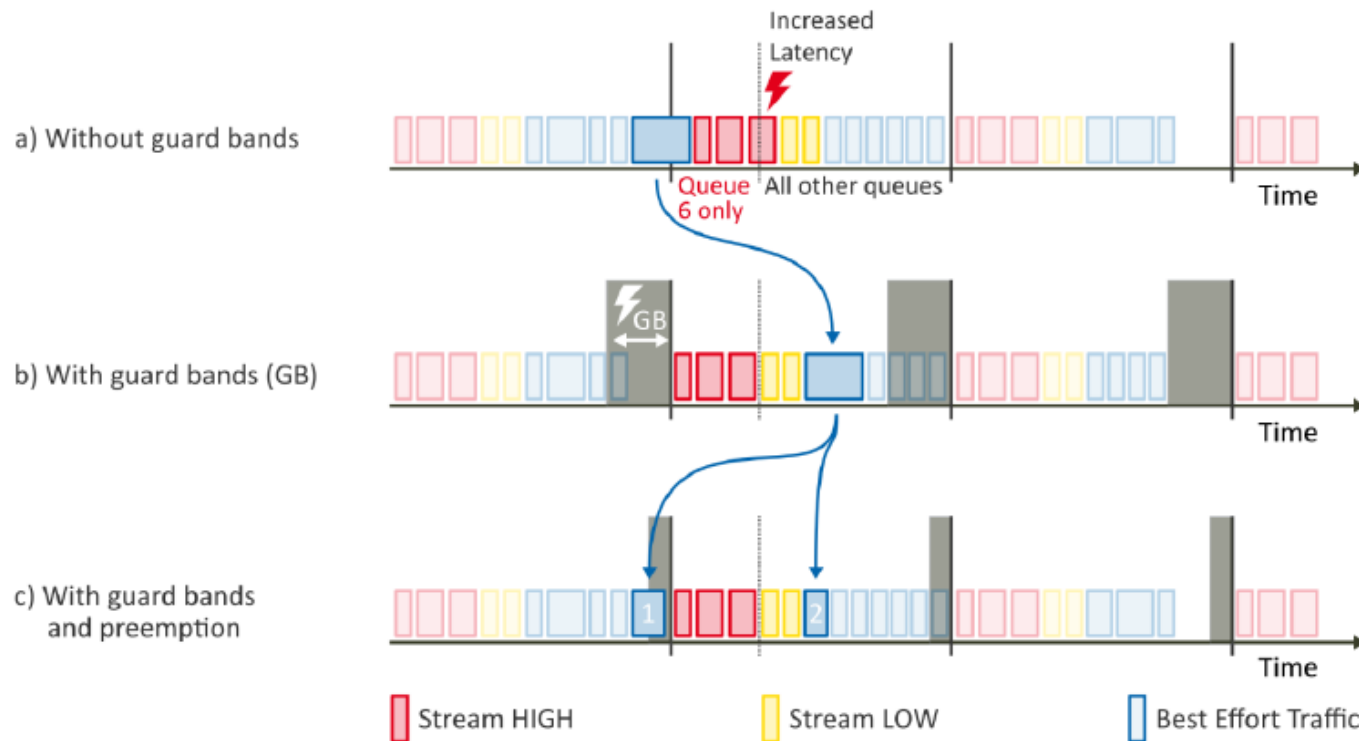
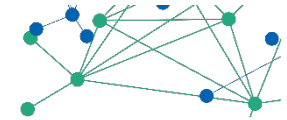


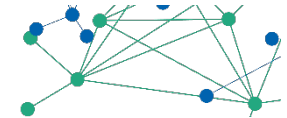
Definizione di uno stream TSN





Meccanismo di Preeemption

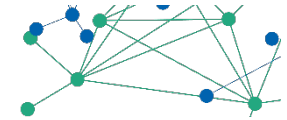




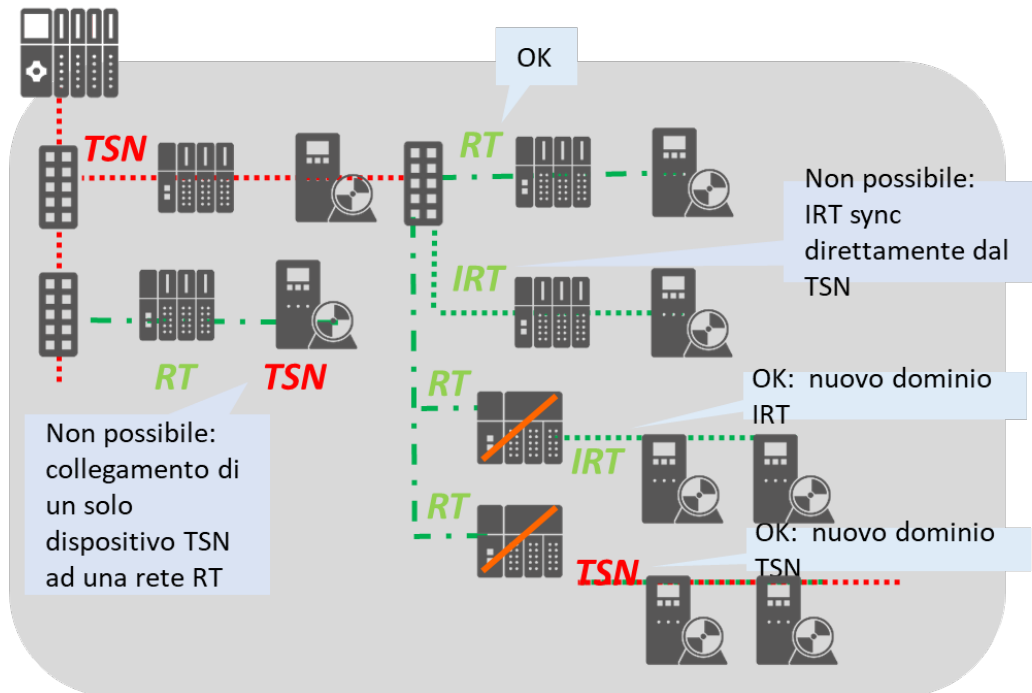
Goals

- Plug&Work: cambi nella rete senza una nuova configurazione
- Convergence: Diversi TSN-Streams (PN, OPC UA) nella rete
- Device Interface: Stessa device interface (UNI) per il dispositivo





■ RT, IRT, TSN

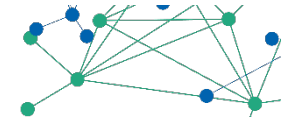


■ Possibile

- Alla fine di un dominio TSN-Synch i dispositivi RT possono essere collegati
- Via interfacce separate è possibile derivare reti IRT o TSN
- I dispositivi che supportano sia il TSN sia il RT/IRT possono essere usati ovunque

■ Non ammesso

- Un mix tra dispositivi TSN e dispositivi IRT
- Usare dispositivi RT in un dominio TSN

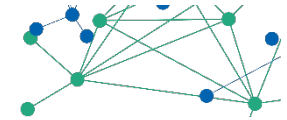


1 Introduzione

2 TSN

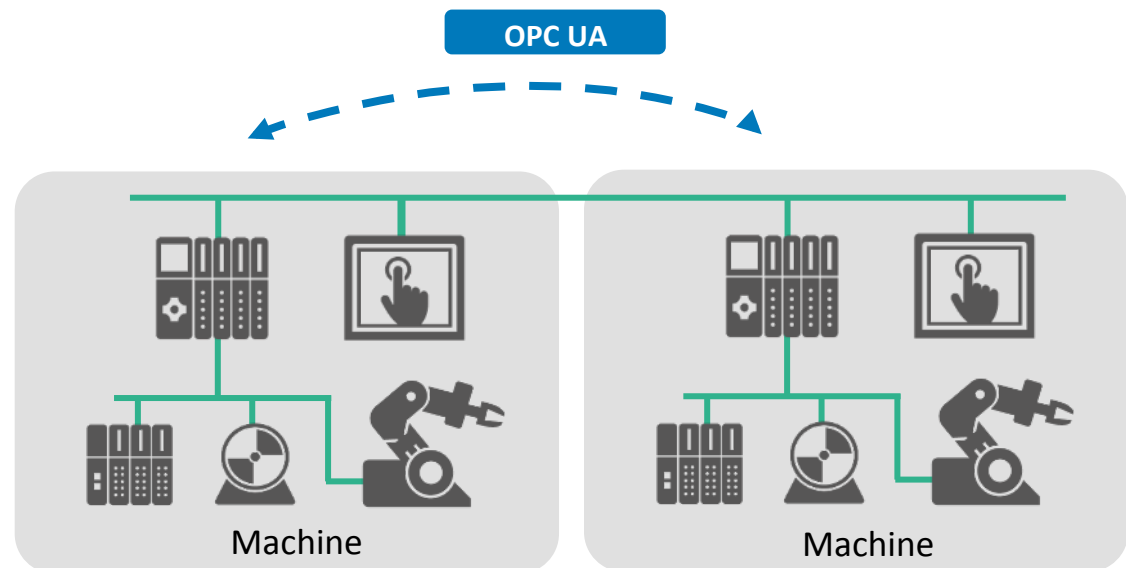
3 OPC UA

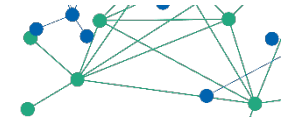
4 Riepilogo



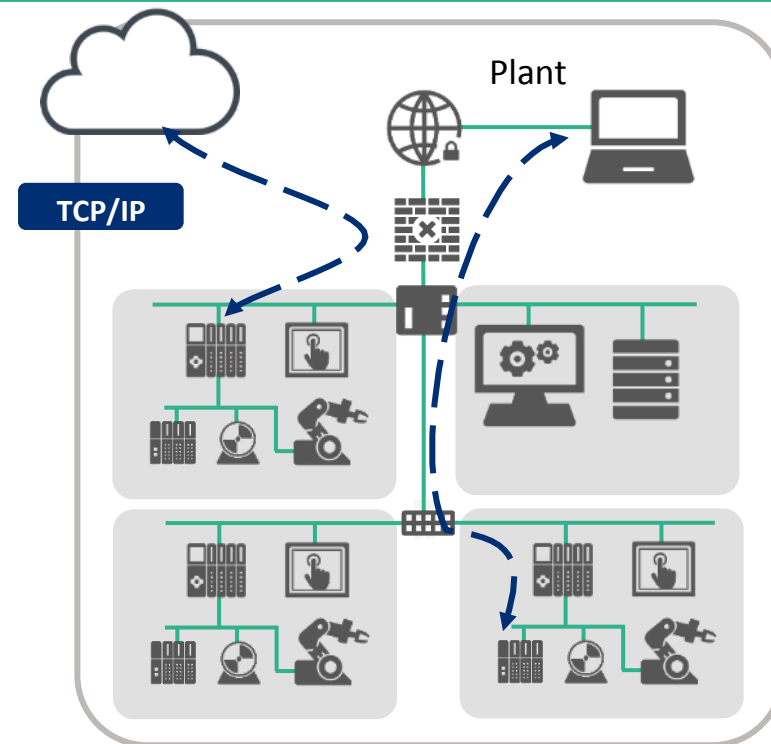
OPC UA

- Per comunicazione orizzontale controller to controller
- Interoperabilit  cross vendor
- Metodologie
 1. Client/Server (TCP/IP)
 2. Pub/Sub (UDP)
 3. Pub/Sub on Streams (TSN)

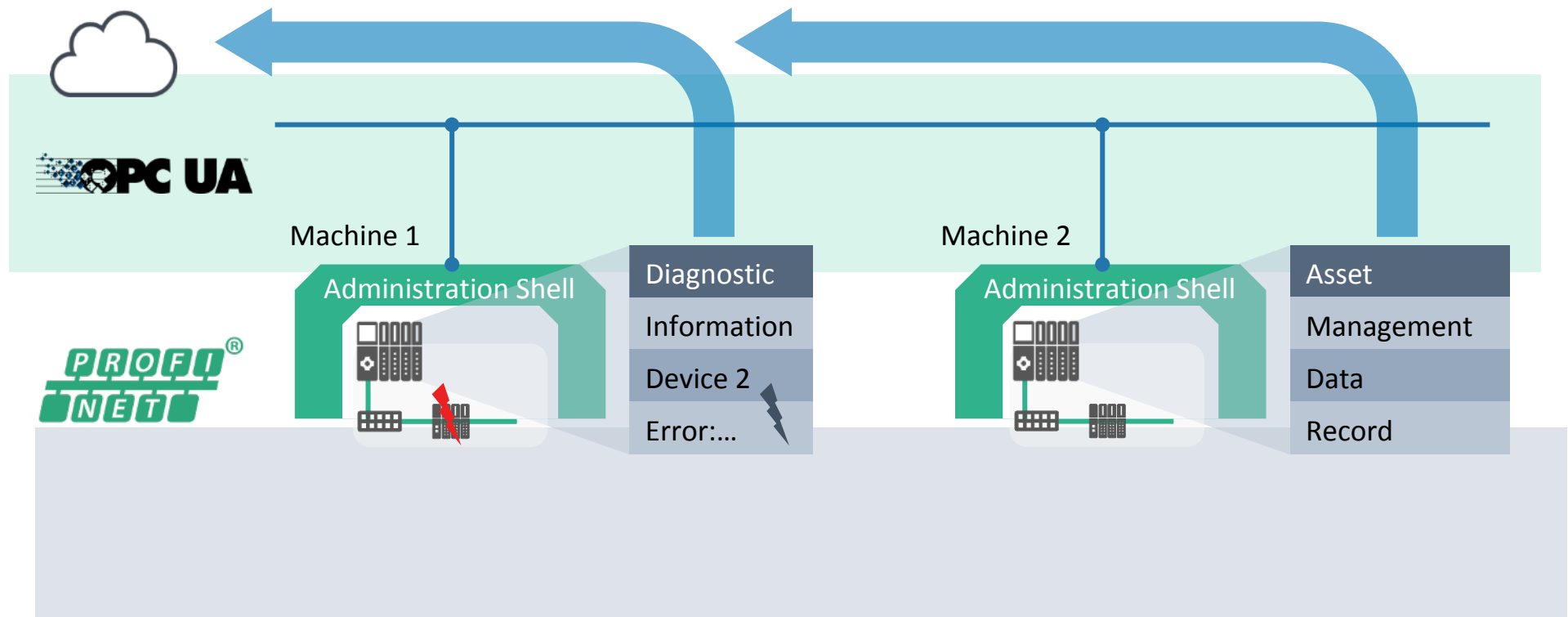
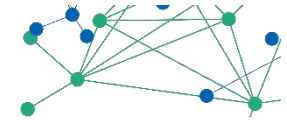


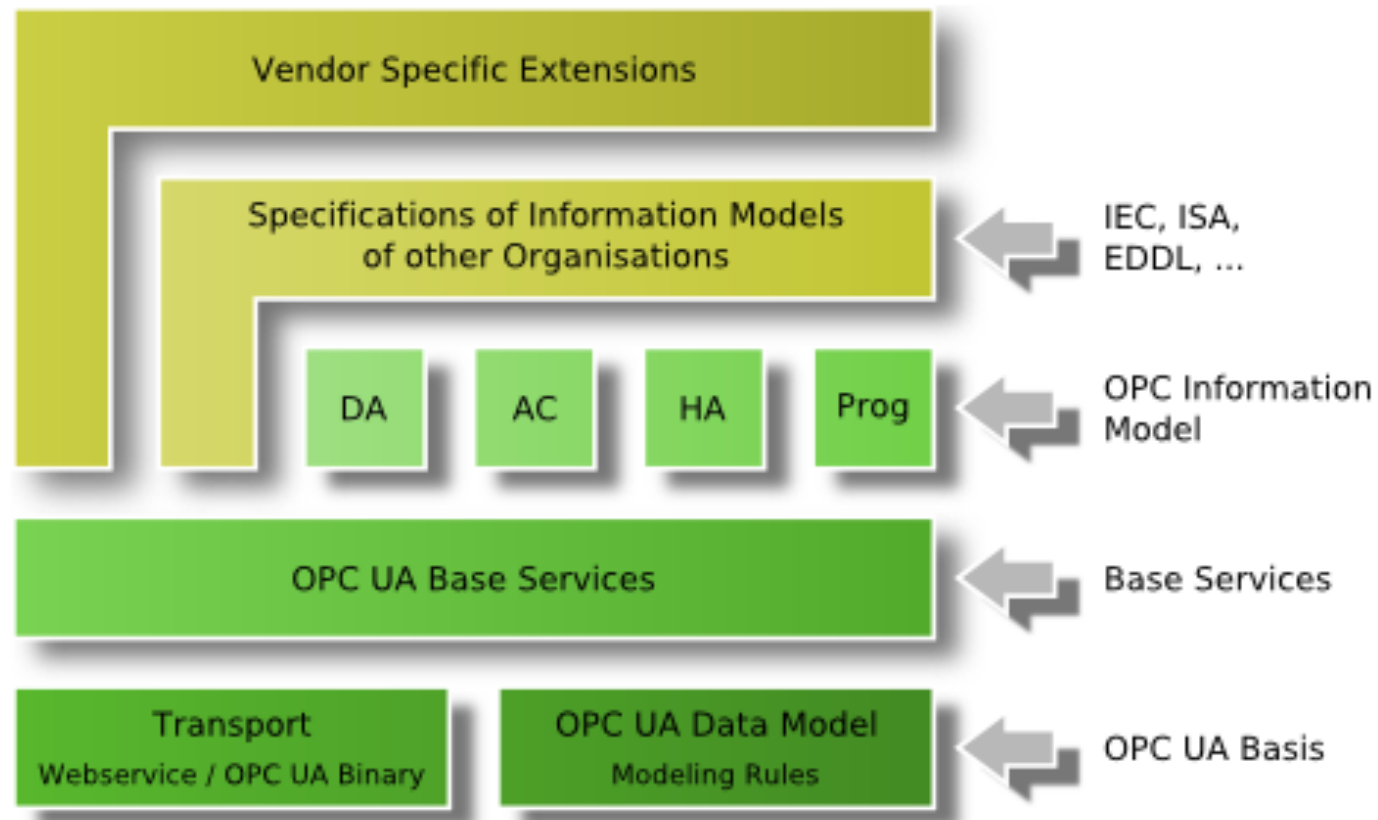
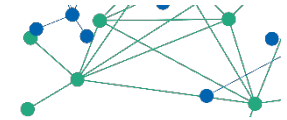


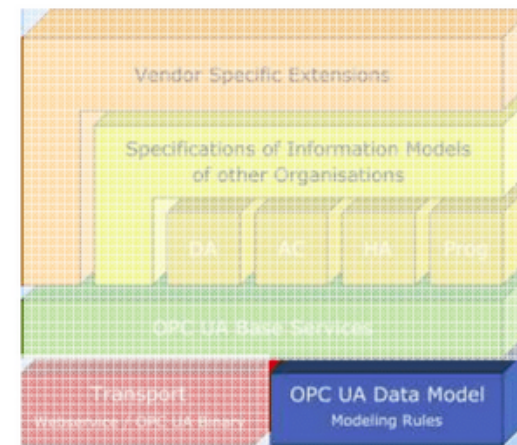
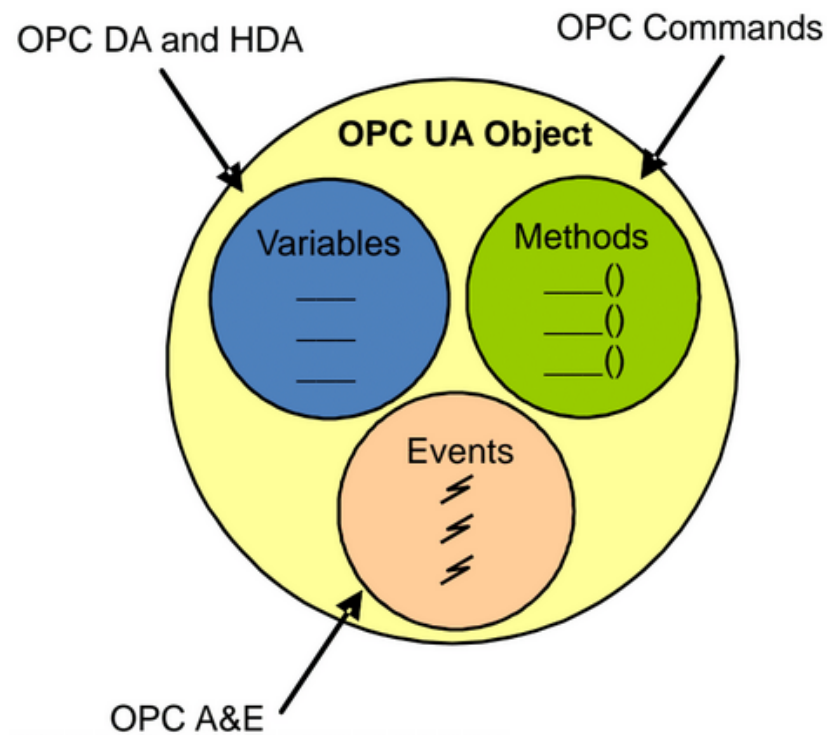
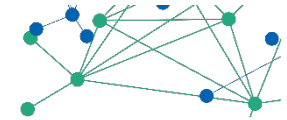
- **Industry 4.0** causa un aumento della comunicazione TCP/IP
- Esempi
 - Dal disposition al clous
 - SCADA, MES
 - Data di qualità, manutenzione predittiva
 - Asset management, etc.
- **Convergence** con TCP/IP è e rimane una parte importante nell'architettura PROFINET
- Maggiore grandezza di banda e resilienza grazie al meccanismo del TSN



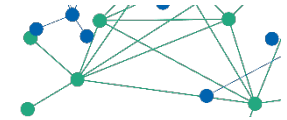
Mappatura degli oggetti PROFINET in OPC UA







OPA UA Trasporto

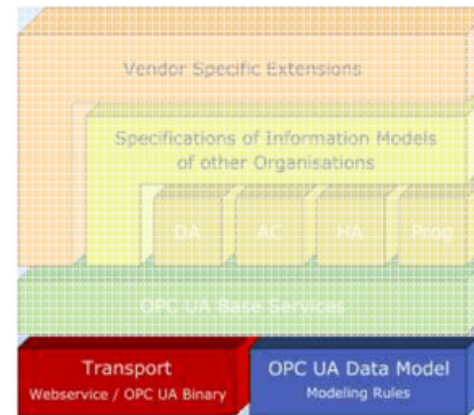


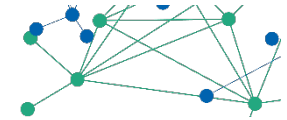
XML Web Services Optimized OPC UA Binary



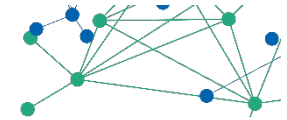
UA XML	UA Binary
WS Secure Conversation	UA Secure Conversation
SOAP 1.2	UA TCP
HTTP	TCP/IP

Message Based Security





- I dati possono essere strutturati (gerarchicamente)
- Le relazioni tra i dati possono essere stabilite secondo referenze
- Modelli differenti possono coesistere
- Possono essere definite relazioni tra diversi sotto-modelli

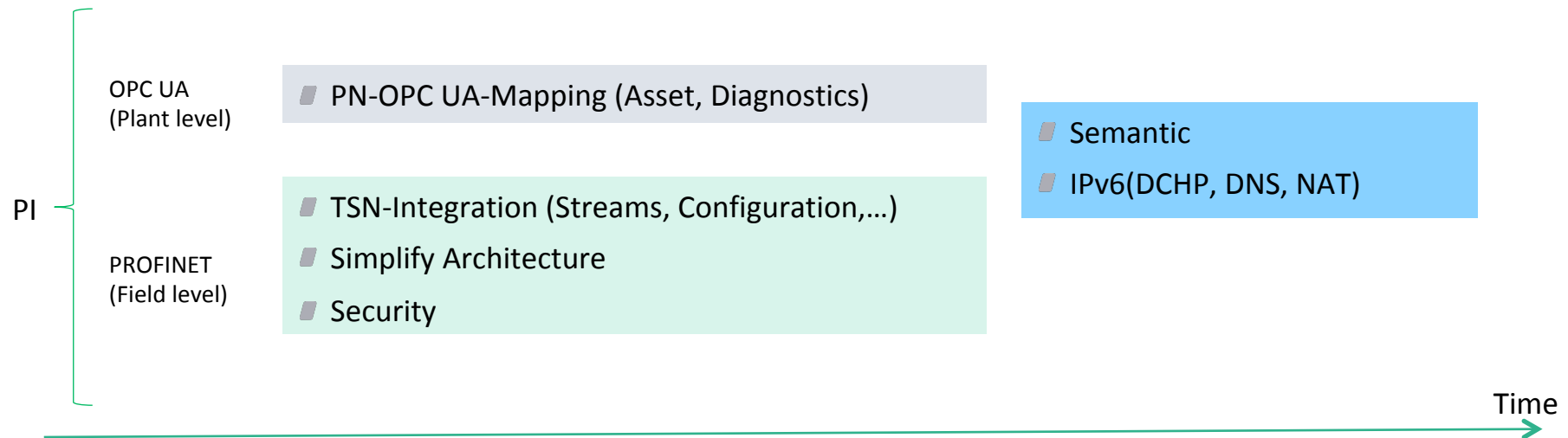
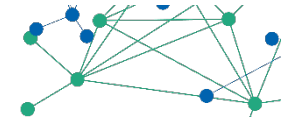


1 Introduzione

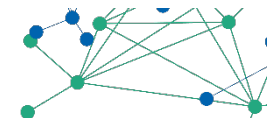
2 TSN

3 OPC UA

4 Riepilogo



- ➔ Necessità di avere una soluzione complete
- ➔ PI non è si limita alla comuniazione verso IO, ma si occupa dell'intera applicazione

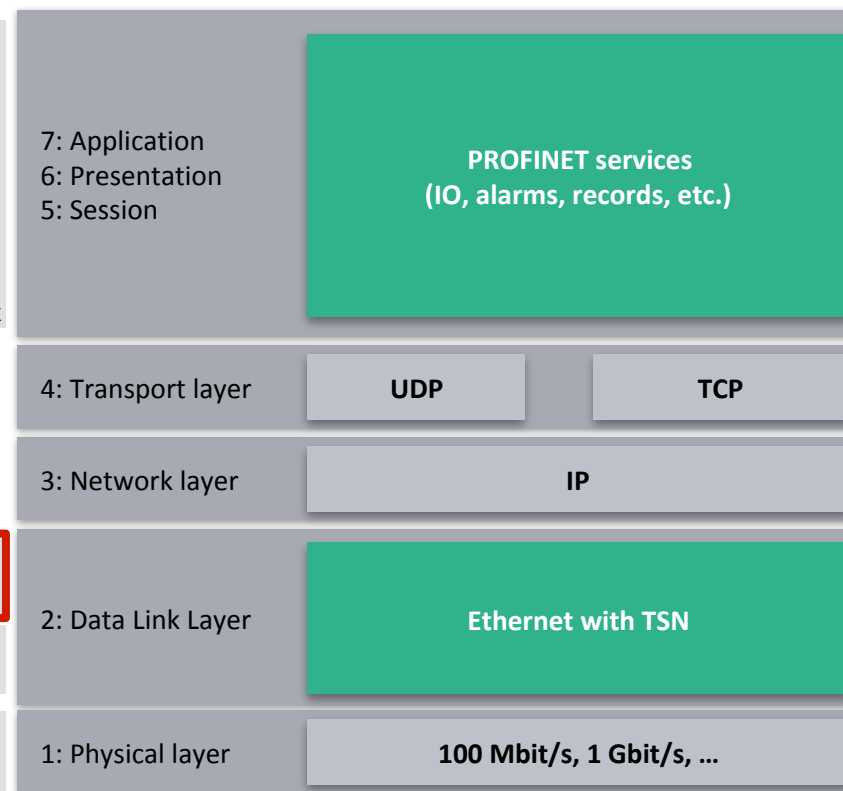


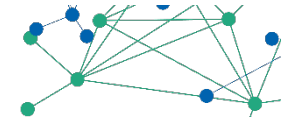

PROFI
NET
PI (PROFIBUS & PROFINET International)
 IEC 61158-5/6, IEC 61784-2

Companion Specs

OPC UA
 OPC Foundation
 IEC 62541-x

IEC/IEEE 60802 TSN Industry Automation Profile
 (a profile selecting features from various IEEE802 and IEC standards)
 IEEE 802.1 / IEC
 IEEE 802.3





- PROFINET e OPC UA formano la base per la comunicazione industriale su tutti i livelli
 - PROFINET = Fieldbus
 - OPC UA = M2M, M2Cloud, Device2Cloud
- Convergence con TCP/IP è importante su tutti i livelli
- PROFINET, OPC UA ed altre applicazioni useranno la stessa infrastruttura TSN
- TSN offer una maggiore
 - Larghezza di banda
 - Determinismo, robustezza
 - Reti Plug&Work
 - Standard chips

