Insights and observations on TSN applied across ecosystems

A look back and forward

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ANALOG DEVICES

Insights on trends of TSN applied to the ecosystem

Over the past 5+ years TSN has expanded to multiple markets, and multiple applications within each of those markets.

This presentation presents trends and insights on the TSN adoption across the ecosystem and actual market value chain

Intent is to promote discussion on how TSN standards might be further optimized in the future for market acceptance

A brief history of Time (sensitive networking)

			PRO AV
USING TSN	APPLICATION PROTOCOLS		AVDECC 1722
	INTEROP PROFILE		Avnu ProAV
	TECH PROFILE		802.1BA
TSN PROTOCOLS AND CAPABILITES	MANAGEMENT	802.1Qat	
	TIME SYNC	802.1AS	
	TRAFFIC SHAPING	802.1Qav	
	ETHERNET		

A brief history of Time

			PRO AV	AUTO
USING TSN	APPLICATION PROTOCOLS		AVDECC 1722	1722
	INTEROP PROFILE		MILAN	Avnu Auto
	TECH PROFILE		802.1BA	
TSN PROTOCOLS AND CAPABILITES	MANAGEMENT	802.1Qat		
	TIME SYNC	802.1AS		
	TRAFFIC SHAPING	802.1Qav		
		802.1Qbv		
		802.1Qbu		
	ROBUSTNESS			
	ETHERNET			

A brief history of Time

			PRO AV	AUTO	INDUSTRIAL
USING TSN	APPLICATION PROTOCOLS		AVDECC 1722	1722	MULTIPLE
	INTEROP PROFILE		MILAN	Avnu Auto	…
	TECH PROFILE		802.1BA	802.1DG	60802
TSN PROTOCOLS AND CAPABILITES	RESOURCE MANAGEMENT	802.1Qat 802.1Qcc 802.1Qdd			
	TIME SYNC	802.1AS			
	TRAFFIC SHAPING	802.1Qav			
		802.1Qbv			
		802.1Qbu			
	ROBUSTNESS	802.1Qci			
		802.1CB			
	ETHERNET				

A brief history of Time

			PRO AV	AUTO	INDUSTRIAL	AEROSPACE
USING TSN	APPLICATION PROTOCOLS		AVDECC 1722	1722 RTP	MULTIPLE	
	INTEROP PROFILE		MILAN	Avnu Auto	TBD	
	TECH PROFILE		802.1BA	802.1DG	60802	
TSN PROTOCOLS AND CAPABILITES	MANAGEMENT	802.1Qat 802.1Qcc 802.1Qdd				
	TIME SYNC	802.1AS				
	TRAFFIC SHAPING	802.1Qav			Future?	
		802.1Qbv		?		
		802.1Qbu	Future?	?		
	ROBUSTNESS	802.1Qci				
		802.1CB	Future?			
	ETHERNET		WIFI		5G	

Applications span market segments

		MARKET SEGMENTS		
		PRO AV	**AUTO**	**INDUSTRIAL**
APPLICATION AREAS	**NETWORKED TIME SENSITIVE AV**	PROFESSIONAL LIVE AND INSTALLED AV	IN VEHICLE INFOTAINMENT	COMPUTER VISION BUILDING AV
	NETWORKED TIME SENSITIVE TRANSPORTATION	THEME PARKS, LIVE SHOWS, SPORTING MOBILE ELEMENTS	AUTONOMOUS VEHICLES	AUTONOMOUS MOBILE ROBOTS
	NETWORKED TIME SENSITIVE CONTROL	LIGHTING, MECHANICAL, LIVE SHOWS	VEHICLE CONTROL SYSTEMS	PROCESS AND MACHINE CONTROL
USING TSN	**APPLICATION PROTOCOLS**	AVDECC 1722	1722 *+ Other?*	MULTIPLE
	INTEROP PROFILE	MILAN	Avnu Auto	TBD
	TECH PROFILE	802.1BA	802.1DG	60802

Insights from latest ProAV requirements

&

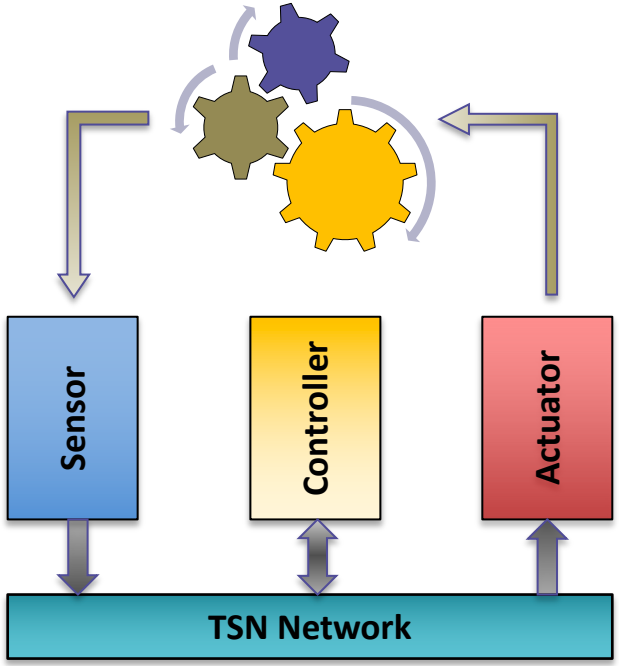
Credit: Jens Koch

TSN For Pro AV –

So ProAV applications are very different from industrial applications

… right?

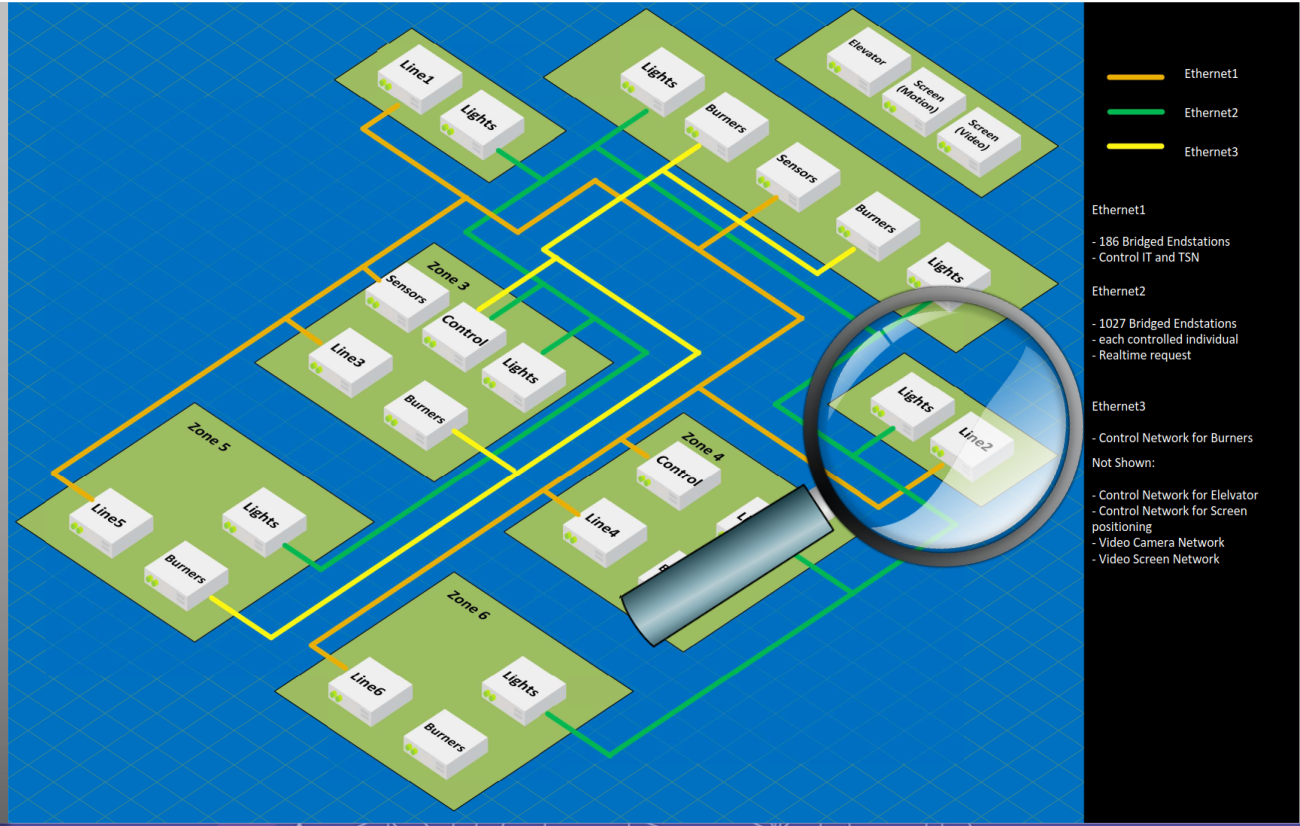
Well …….



TSN For Pro AV –

Let’s take a look …

On a first view ProAV may appear quite simple and straight, but at a closer look ….



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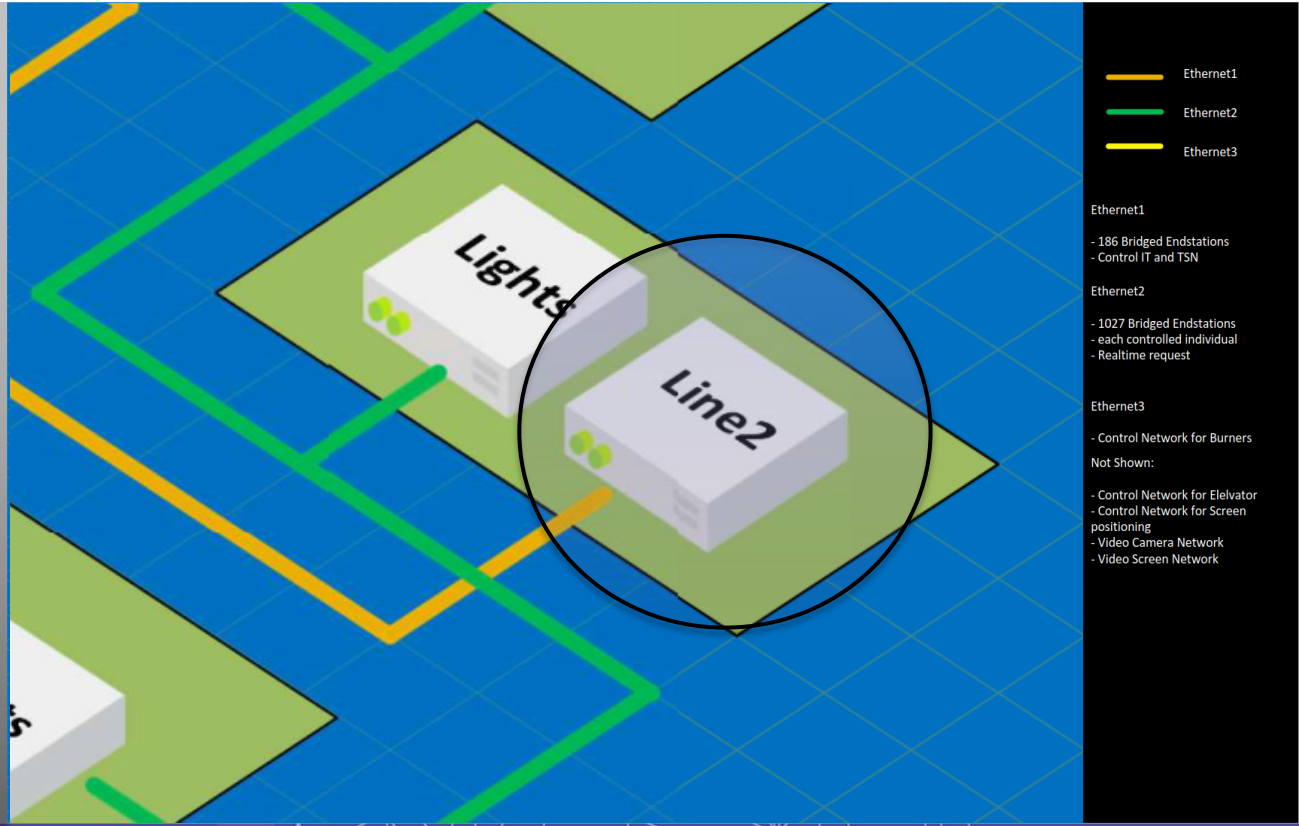


TSN For Pro AV – Milan™

Let's take a look …

On a first view it may appear quite simple and straight, but at a closer look ….

… we can sense the complexity …

TSN For Pro AV – MOAN™

3 Ethernet Networks

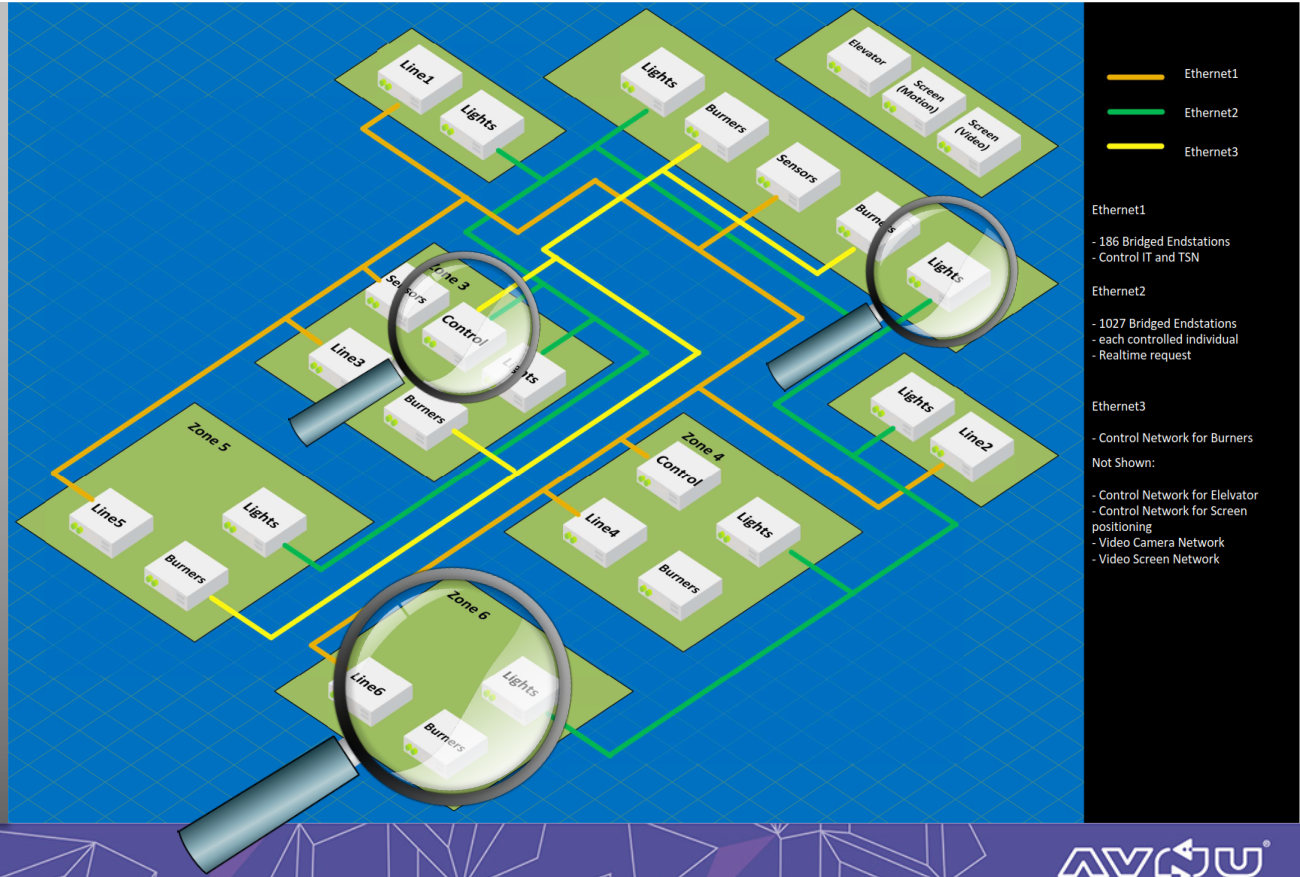
Network #1: (Audio)
- 186 Bridged Endstations

Network #2: (Lights)
- 1027 Bridged Endstations
- Each indiv. controlled

Network #3: (Pyro)
- Control Network for Pyrotechnic

Not shown:
- NW for Cameras and Screens

Some more details ……



TSN For Pro AV –

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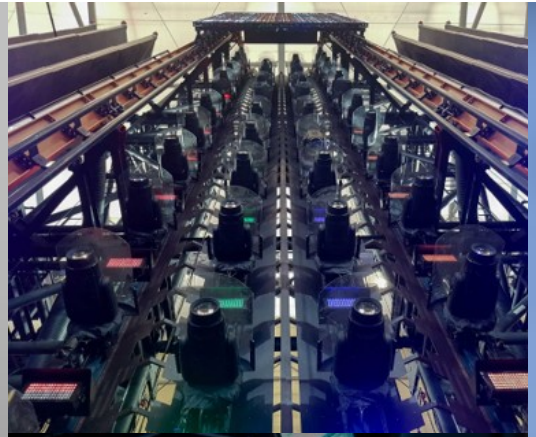
What is this ?
Have a guess !



TSN For Pro AV –

Rammstein at the Olympic Stadium Munich 2019

- 186 TSN Amplifiers / 744 channels
- > 190 networked processing units
- > 360 Loudspeakers

- > 30 rigging motors
- > 1000 networked lights
- >100 networked pyro burners/effects

- 17 TSN switches

- Setup time: One work day
- Criticality: Very high

(just one of many thousands concerts happening every day - usually)

ProAV requirements

Network size:

- ~ 8-10k End-stations
- 4-5000 Audio Streams
- 100 Video Streams (compressed and partly uncompressed)
- Add. 8-10k Control Streams
- Often beneficial to structure systems in sub-nets

- **Audio networks of larger scale mostly on 10Gb (1Gb for general use)**
- **Video networks min. 10Gb, often 40Gb or even larger**

- **TSN could uniquely help to provide these scales of systems**

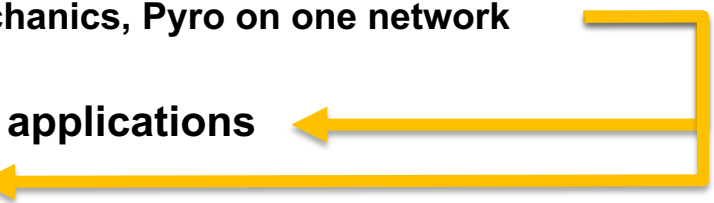
ProAV requirements

Control:

Key point: **ProAV has nearly the control requirements of Industrial but must additionally deal with the real time audio and video streams.**

- Huge benefits expected from real-time device control:
  Distributed DSP
  Safety relevant use-cases
  Full integration of AV, Lights, Stage mechanics, Pyro on one network

- **Use standard industrial TSN devices in ProAV applications**
- **It can be and should be one infrastructure**

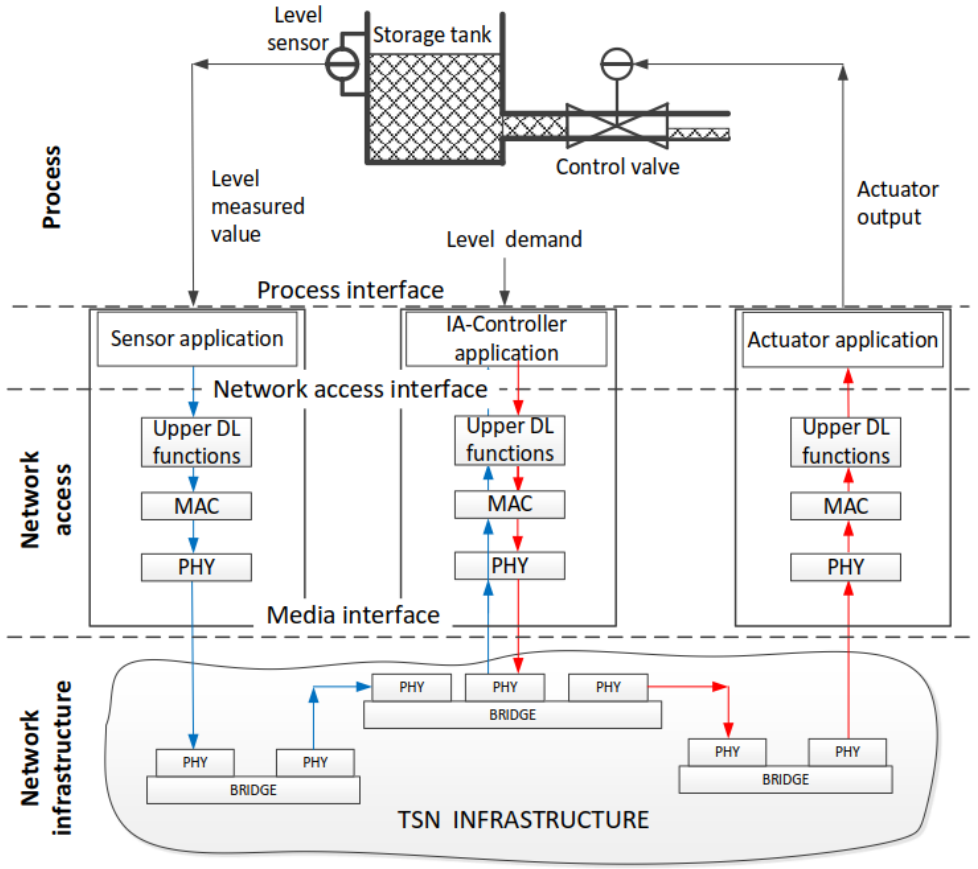


ProAV requirements

Latency and Criticality:

We took a close look at 60802 trying to find fundamental differences.

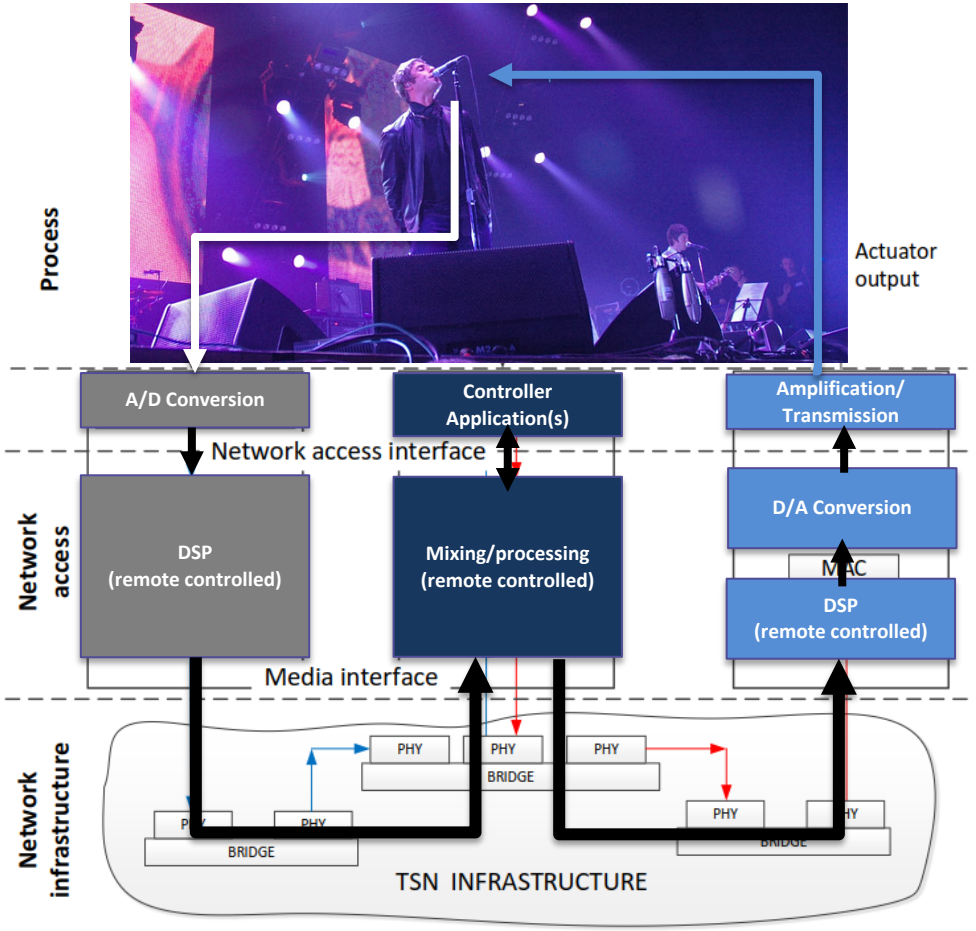
… not so easy …..



ProAV requirements

Latency and Criticality:

- In live-events the ‘Process’ is +- equiv. to a stage
- ‘Sensors’ are microphones (or other signal receivers)
- Signals are processed in mixing consoles and other processors
- ‘Actuators’ are amplifiers, transmitters etc.
- **This is only the audio path !**
  (very much simplified)



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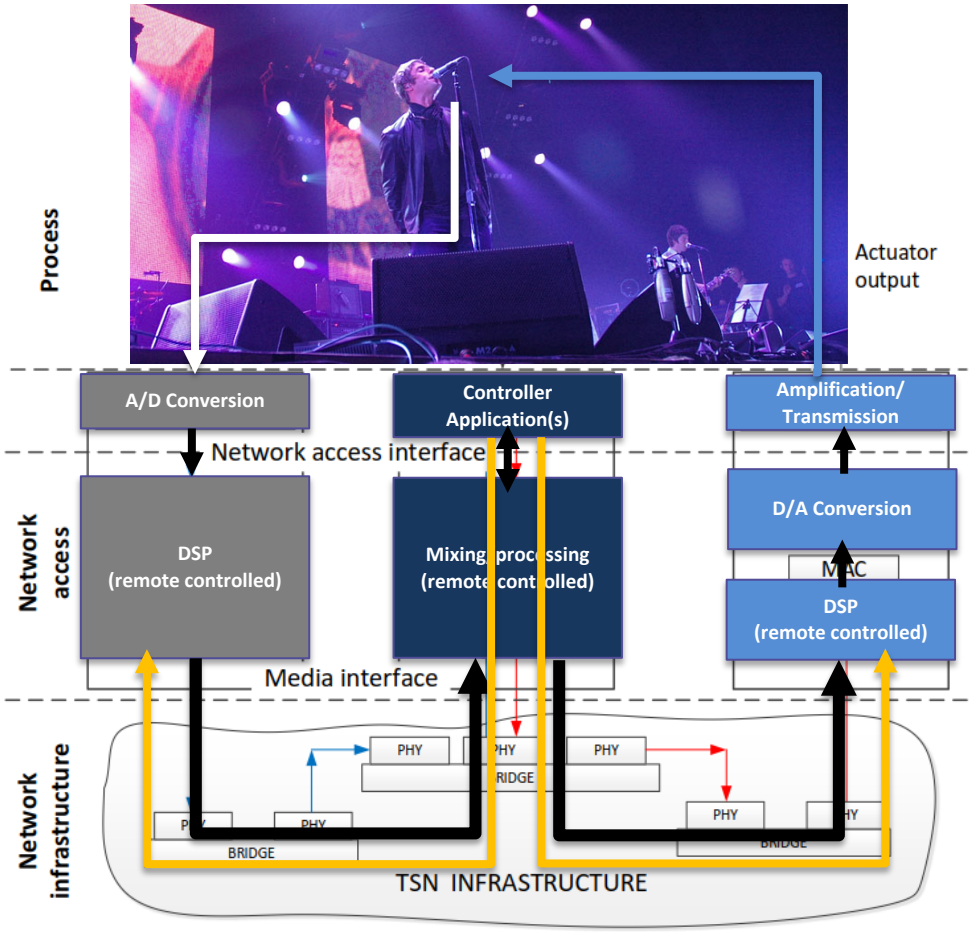
- **This is only the audio path !**
  (very much simplified)
- **All networked end-stations and processors need control, some in real time.**



ProAV requirements

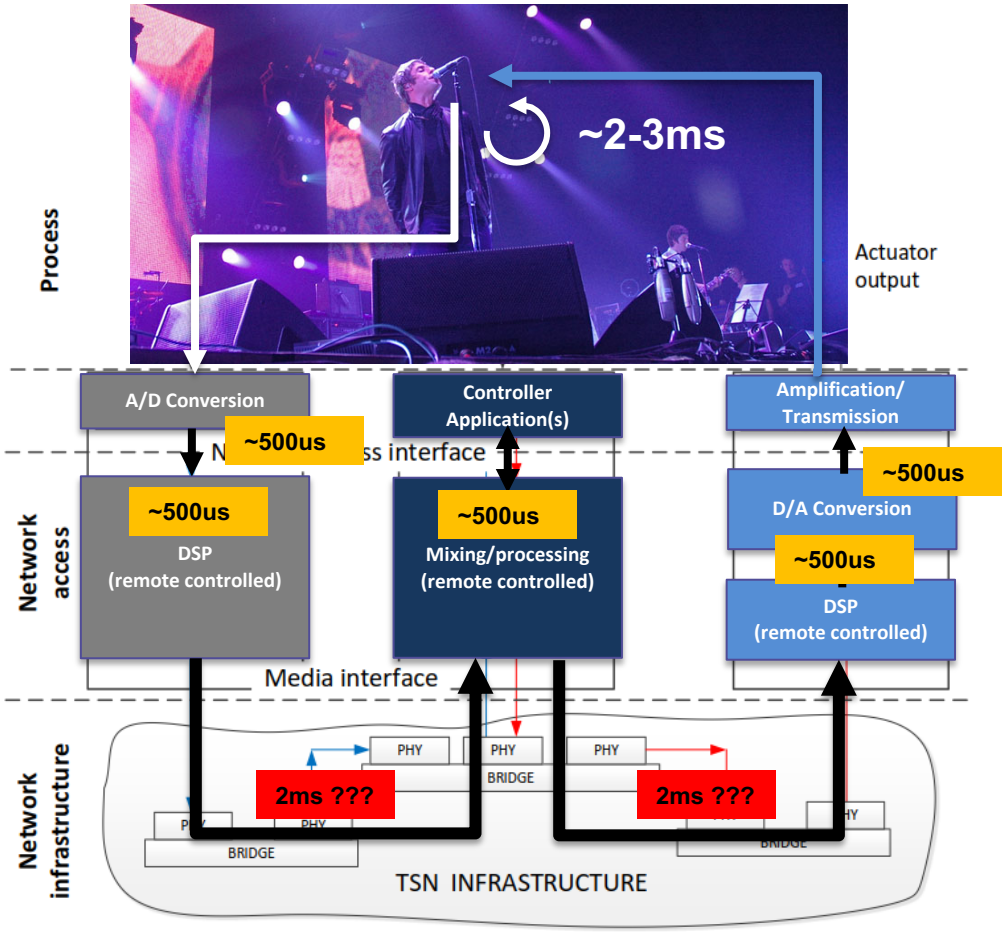
Latency and Criticality:

- The total latency through such a path is never allowed to exceed ~2-3ms
- **Problem: A/D D/A conversions and DSP processing take time**
- **Often 2-5ms of latency is already given by the various applications**

Conclusion:

- **A ProAV network cannot be fast enough !**
- **We would very much benefit from 100us !**

Requirement for synchronicity <= 1us **Ok!**



ProAV requirements

Other ProAV requirements:

- Daisy-chaining end-stations (50-100) Latency guaranteed across those lines
- Single-pair PoE Ethernet
- Encryption of stream content
- Standardized network management handling for
  - Detailed network monitoring
  - Redundancy
  - Temporary devices
  - Device replacements
  - …..

- **Currently most of the described requirements are not captured in 802.1BA !**

ProAV requirements

Other ProAV requirements:

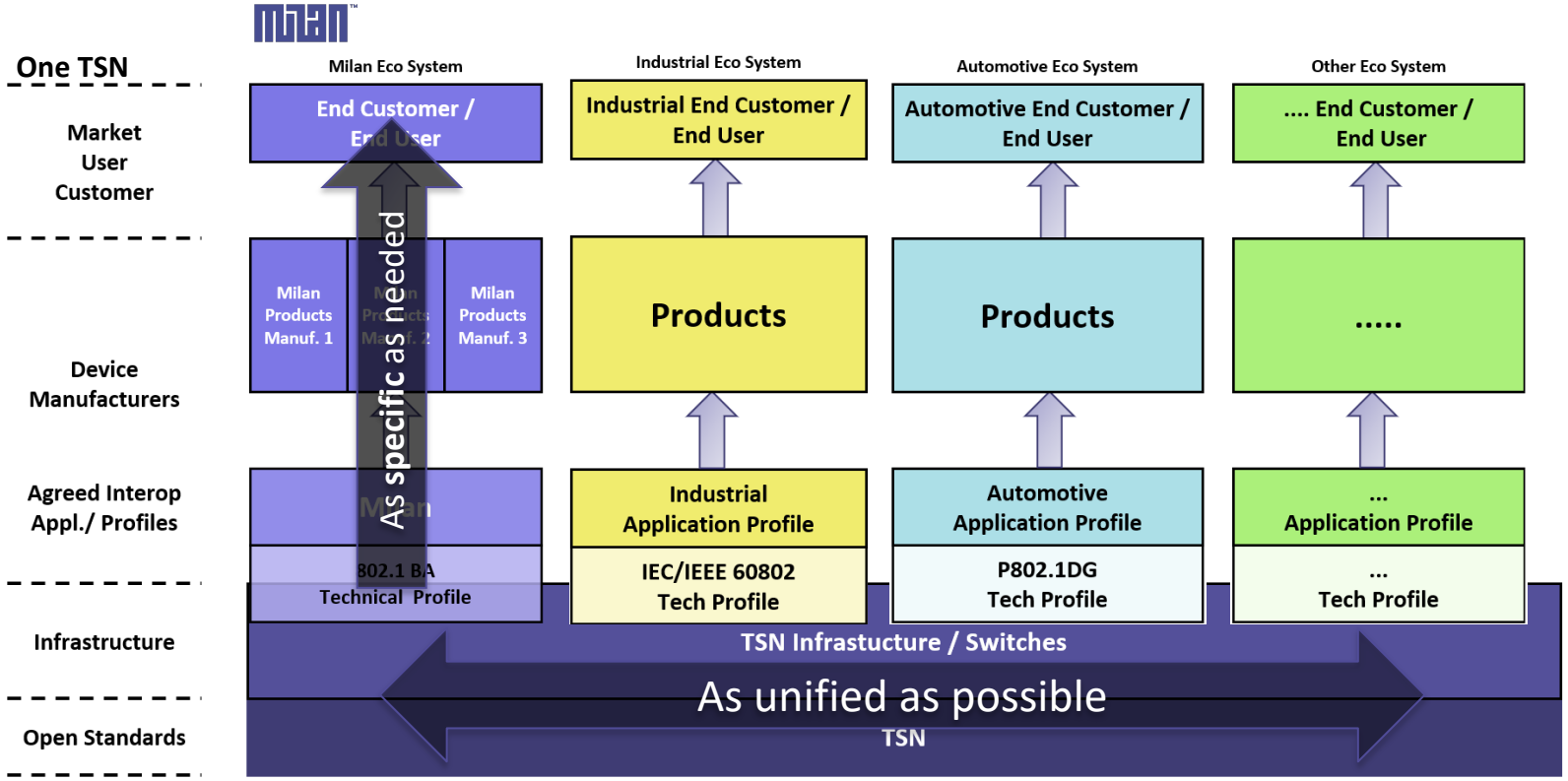
Ultimately critically important:

- Build on a unified TSN infrastructure for **all** production components (Network, Switching)
- Ability to use standardized industrial TSN components in ProAV applications

Manufacturing / R&D:

- Availability of economic standard designs for bridging and endpoint products
- Industrial scales of silicon available

Learnings


One TSN
Market
User
Customer
Device
Manufacturers
Agreed Interop
Appl./ Profiles
Infrastructure
Open Standards
Milan Eco System
Industrial Eco System
Automotive Eco System
Other Eco System
End Customer /
End User
Industrial End Customer /
End User
Automotive End Customer /
End User
.... End Customer /
End User
Milan
Products
Manuf. 1
Milan
Products
Manuf. 3
Products
Products
.....
As specific as needed
Industrial
Application Profile
Automotive
Application Profile
...
Application Profile
802.1 BA
Technical Profile
IEC/IEEE 60802
Tech Profile
P802.1DG
Tech Profile
...
Tech Profile
TSN Infrastucture / Switches
As unified as possible
TSN

Perspectives from component (silicon) suppliers

Silicon Providers Perspective

- Flexible selection of software and silicon
- New software
- New silicon
  - Superset vs. Purpose-built
  - Today's requirements vs. Tomorrow's use cases

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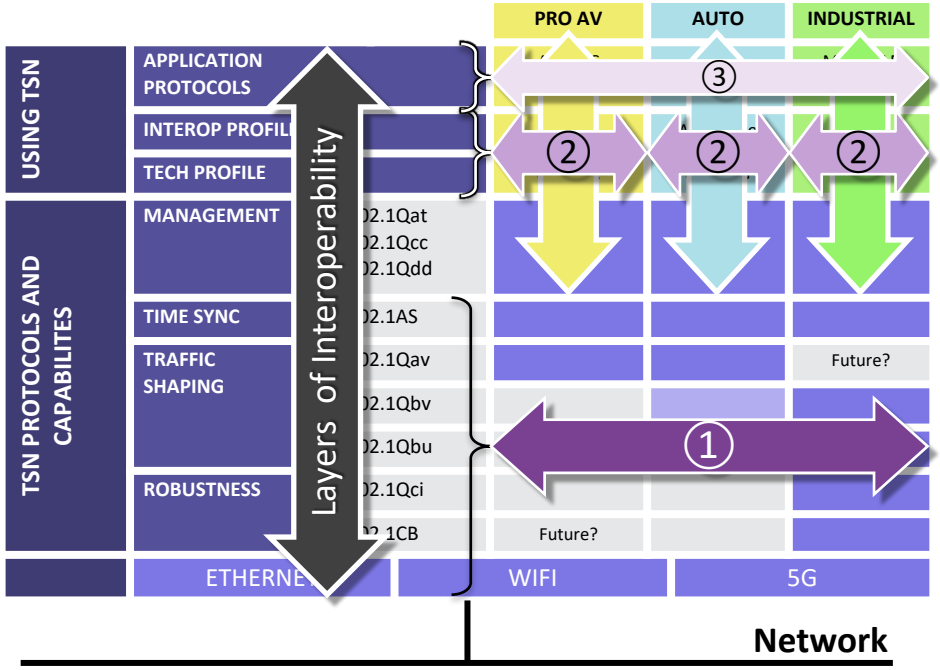
Silicon Providers Perspective

One TSN does NOT mean
One Layer of Interoperability



① Silicon layer:
- Interoperability starts here
- ASSPs, ASICs, FPGAs must interoperate

② Profile layer:
- Devices interoperate within a profile
- Devices reconfigured for use across profiles

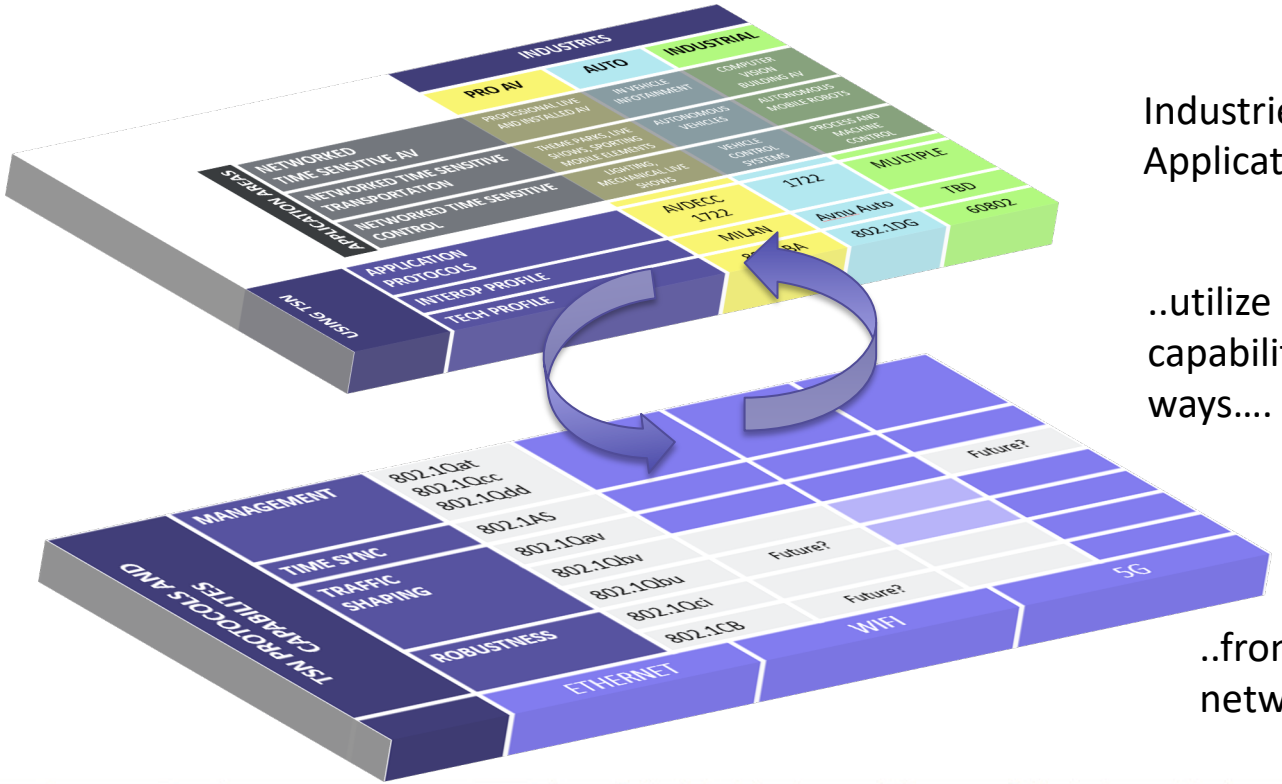
③ Application protocol layer:
- Devices with common application protocols interoperate
- Devices with different application protocols co-exist (share the wire)

Innovation cycle

Diverse Industries and Applications

..drive new capabilities and tools..

..into network “toolbox”



Industries and Applications

..utilize increasing capabilities in new ways….

..from diverse network toolbox

Approach going forward

- TSN serves *multiple, interdependent ecosystems that overlap*

- *Understand unique requirements for different applications while striving for commonality in network requirements (these are not mutually exclusive)*

Focusing on commonality (at network level) to serve diverse market requirements (at application level) will accelerate building a broad, diverse TSN ecosystem more quickly

- How do we facilitate this discussion in IEEE 802? (and elsewhere)

Note: Avnu Alliance is creating a common / base workgroup, including discussion of common bridge requirements

Questions + Discussion