



# HIRSCHMANN

A **BELDEN** BRAND

## AVB and Fault Tolerant Networking



**IEEE 802.1 AVB Real Time Communication Symposium**

Munich, January 17, 2012

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# BELDEN - Signal Transmission Solutions

- 1.62 billion US\$ revenues (2010), 6600 employees
- Company HQ: St Louis, MO, USA
- Hirschmann HQ: Neckartenzlingen, Germany



- Industrial Cables
- Networking Cables
- CATV Cables
- Broadcast Cables
- Optical Fiber Cables



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- Industrial Ethernet Switches
- WLAN & Security
- Network Management



**lumberg automation**

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- Industrial Connectors
- Distribution boxes





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# Hirschmann Target Markets

## Industrial Communication Infrastructure for



**Public Transport**



**Traffic Control**



**Power Generation**



**Power Transmission  
& Distribution**



**Oil & Gas**



**Chemical /  
Petrochemical**



**Factory Automation**

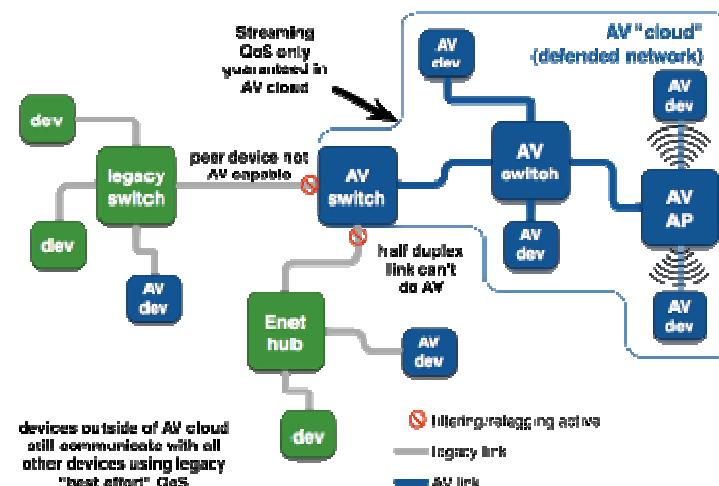


**Machine Building**



## Hirschmann – an AVB technology pioneer

- Involved in AVB technology since 2007
- Active work in IEEE 802.1 AVB standardization group
- Contributions to working group with
  - Industrial application requirements
  - Low-Latency concepts
  - Fault tolerance concepts



(Source: IEEE802.1 AVB task group)

## ETHERNET

moves from an IT technology



to a communication protocol used in many different applications!



# Ethernet Applications

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moves from an IT technology



to a communication protocol used in many different applications!

## INDUSTRIAL AUTOMATION

- Machinery
- Robot Control
- Oil, Gas, Chemical, Pharmaceutical
- Food & Beverage
- Automobile Production
- ...



**Control and Supervision**

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## PROFESSIONAL BROADCAST

- TV Studios
- Theaters, Event and Sport Locations
- ...

Audio,  
High resolution Video,  
Control





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## SMART GRID

- Power Plants
- Alternative Power Generation
- Electrical Power Transmission & Distribution
- ...

Measurement, Monitoring  
Control and Protection  
Metering, Billing, Pricing  
Energy Management, Outage Management,  
Demand Response





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to a communication protocol used in many different applications!

## AVIONICS

- Infotainment
- Control
- Fly-by-Wire
- ...

Audio, Video  
Safety Critical Control



## ETHERNET

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## AUTOMOTIVE

- Infotainment
- Diagnostics
- Control
- Drive-by-Wire
- ...

**Audio, Video**  
**Safety Critical Control**





# Ethernet Applications

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## RAILWAY SYSTEMS

- Passenger Information Systems
- Train Control Systems
- Railway Traffic Management Systems
- ...

**Audio, Video**  
**Safety Critical Control**





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# Ethernet Applications

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### Future Applications:



How will they look like and what will be  
their specific requirements?

→ A future proof AVB needs meet the highest  
possible performance requirements and  
needs to be highly adaptable to topology /  
fault tolerance requirements...

**Because we don't know what the future has  
in store for us!**

# Communication Requirements



REQUIREMENT	APPLICATION EXAMPLE	IMPACT OF SYSTEM FAILURE
<ul style="list-style-type: none"> <li>▪ Realtime</li> <li>▪ Deterministic behaviour</li> <li>▪ High availability</li> </ul>	<ul style="list-style-type: none"> <li>▪ High Speed Machinery</li> <li>▪ Robot Control</li> <li>▪ Train Control System</li> <li>▪ Electrical Power Protection System</li> <li>▪ Drive-by-wire, Fly-by-wire</li> <li>▪ Emergency shut-down</li> <li>▪ Broadcasting System</li> </ul>	<ul style="list-style-type: none"> <li>▪ High financial losses</li> <li>▪ Damage of assets</li> <li>▪ Danger for human lives</li> <li>▪ Impacts on the environment</li> </ul>

**Additional Requirement:**  
Flexibility, adaptation to various application scenarios

**If possible:**

Use standard Ethernet

**For more demanding applications:**

Proprietary (beyond IEEE802 specifications) extensions

- AFDX (avionics)
- Profinet IRT (motion control)
- EtherCAT (industrial automation)
- Powerlink (industrial automation)
- Varan (industrial automation)
- Sercos-III (motion control)
- TTEthernet (avionics)
- and many others...

**ARINC** AFDX

**EtherCAT**  
Technology Group

**PROFI**  
**net**  
**PROFINET IRT**

**ETHERNET**  
**POWERLINK**

**SERCOS**  
**interface**  
**SERCOS-III**



**TTEthernet**

**All those protocols and technologies use Ethernet as a base technology,  
but do make some special modification to improve realtime behaviour!**



## IEEE 802.1

## *Audio/Video Bridging Task Group*



### **AVB – Audio/Video Bridging**

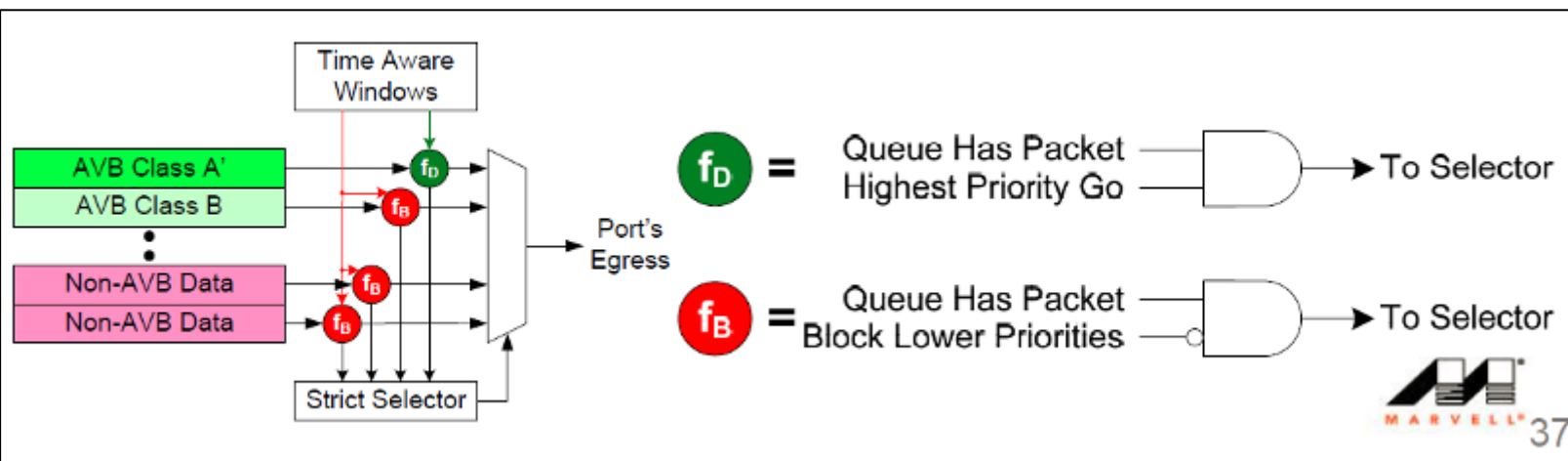
- Defines an enabling technology for deterministic real time applications
- Open and flexible, applicable to different applications
- Works in combination with existing and future Ethernet based systems
- Nevertheless cost effective

## Important Requirement: Low Latency

- Create an Ethernet based networking technology providing lowest possible latency and latency variation
- Meet Quality of Service requirements



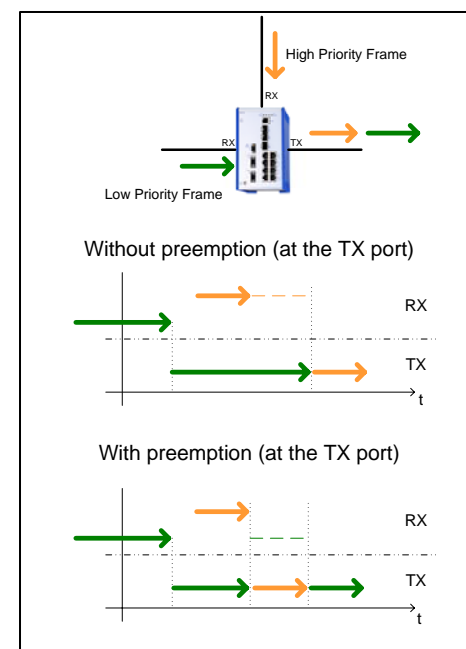
# Low Latency: Preemption and Time-Aware Scheduling



<http://www.ieee802.org/1/files/public/docs2011/new-avb-pannell-latency-options-1111-v2.pdf>

- Time-Aware scheduling and Preemption in combination is a feasible approach to provide low latency
- The two technologies complement each other
- With 100 MBit/s Ethernet, Preemption has large impact on max latency, augmented by the Time-Aware Shaper
- With 1000 MBit/s Ethernet and above, Preemption remains useful but in relation to preemption, the overall importance of the Time-Aware Shaper increases

Preemption and Time-Aware Scheduling provide the necessary performance for today's and future application fields!





## Important Requirement: Highest possible Reliability

- Create an Ethernet based networking technology that guarantees highest availability
- Can use existing and future redundancy mechanisms and protection switching schemes
- Works in „zero packet loss“ applications
- Independence from specific protocols

## Example of redundancy control protocols

<b>IEEE 802.1</b>	<b>IEEE Standard for Local and metropolitan area networks</b> Rapid Spanning Tree Protocol Multiple Spanning Tree Protocol Shortest Path Bridging
<b>IEC 62439</b>	<b>INDUSTRIAL COMMUNICATION NETWORKS – HIGH AVAILABILITY</b> Parallel Redundancy Protocol (PRP) High-availability Seamless Redundancy (HSR) Media Redundancy Protocol (MRP)
<b>ITU-T G.8032</b>	<b>Packet over Transport aspects – Ethernet over Transport aspects</b> Ethernet ring protection switching

## Example of Redundancy Protocols

- Parallel Redundancy Protocol (PRP) and High-availability Seamless Redundancy (HSR)
- Defined in IEC 62439-3 (High availability automation networks, Part 3)
- Unlike other protocols there is no re-configuration in case of a failure. Instead data is transmitted on 2 independent paths simultaneously. Protocol has to do the frame duplication at transmit side and has to discard the duplicates at receive side.

AVB has to work with those concepts

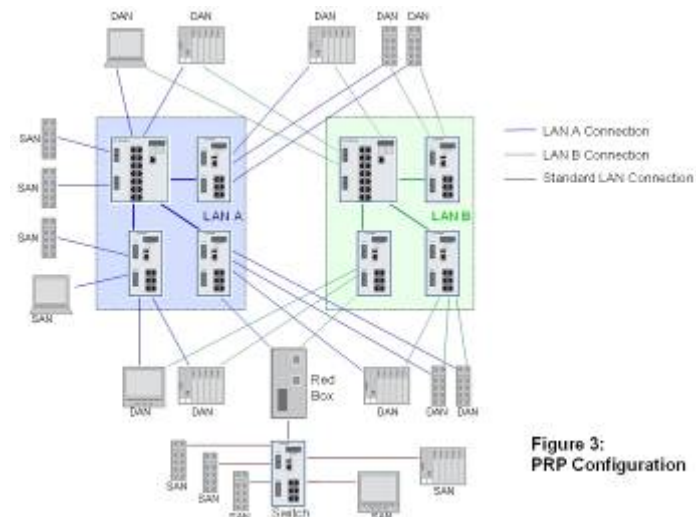


Figure 3:  
PRP Configuration

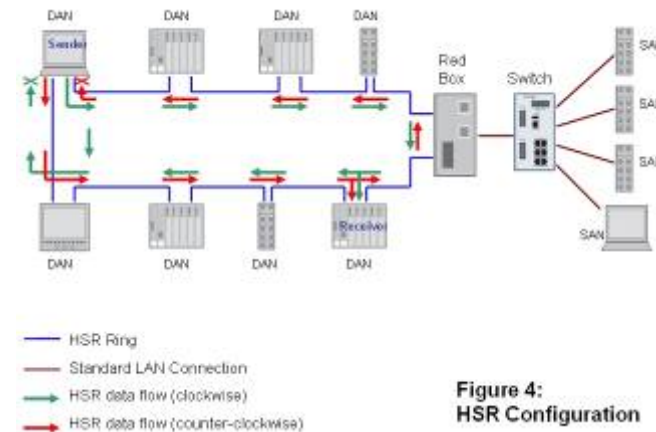
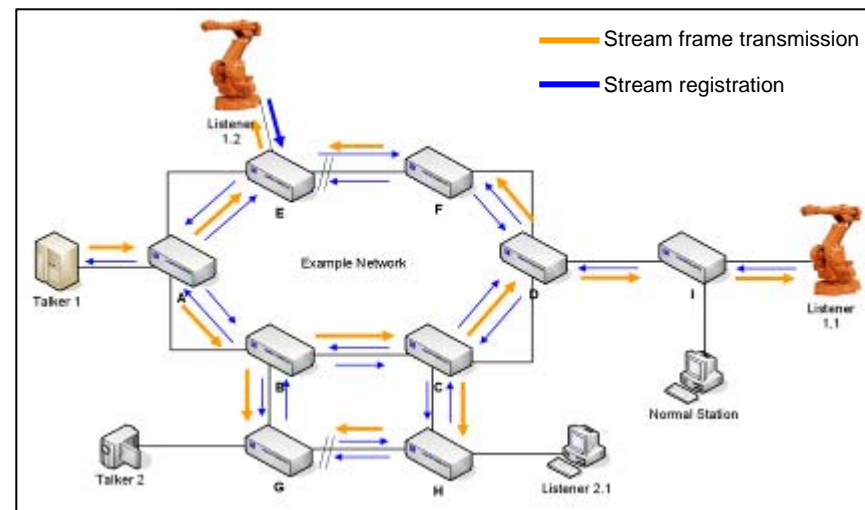


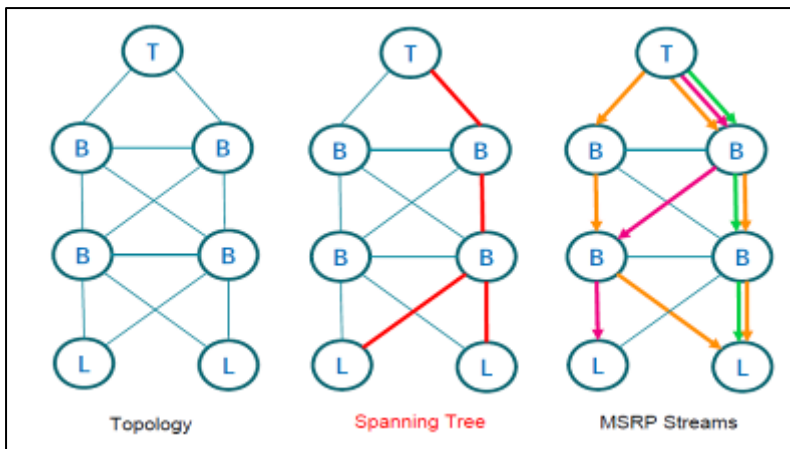
Figure 4:  
HSR Configuration

# Multi-Path SRP

- Allows stream registration on more than one single path at a time
- Enables usage of SRP with redundancy protocols to increase fault-tolerance
- No binding of SRP to specific (redundancy) protocols, but...
- Registration on all available paths and...
- (Redundancy) protocols can decide which paths to use for stream frame transmission
- ... through a service interface



<http://www.ieee802.org/1/files/public/docs2011/at-kleineberg-AVB-media-redundancy-0311-v02.pdf>



<http://www.ieee802.org/1/files/public/docs2011/avb-phkl-srp-stream-path-selection-1111-v01.pdf>

- This allows the flexibility needed to...
- address future application scenarios (e.g. specific topology setups) and
- Routing and redundancy protocols can access and shape the logical topology through this service interface
- allows future protocols needed in new applications fields to shape stream flows according to their requirements

**Flexible and future-proof approach!**



# Summary

- New Ethernet based Applications are coming up with mission critical and safety relevant requirements
- Lowest latency and highest reliability are needed – yet the mechanism needs to be highly adaptable to meet future application needs
- A communication protocol is needed to address those requirements
- **AVB generation 2 can be the solution if it does meet those requirements!**

