AVB for low latency / industrial networks:

Redundancy for fault tolerance and AVB - continuation

Oliver Kleineberg, Hirschmann Automation & Control
(oliver.kleineberg@belden.com)
Philippe Klein, Broadcom
(philippe@broadcom.com)

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Redundancy and AVB

- **Aims of this presentation:**
- **Show that mechanisms added to SRP to enable redundancy could be kept to a minimum**
- **Any additional mechanism for stream control should be done at a higher layer**
- **Show that it is a feasible method for engineered networks (meshed networks vs. highly structured networks typical for e.g. industrial automation)**
- **Give examples on how additional administration could influence stream registration**
- **Show requirements on „Layer 2 routing“ (for live network reconfiguration) for a feasible use, in conjunction with high-performance redundancy mechanisms**

Flashback to Singapore

Flashback to Singapore

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Flashback to Singapore

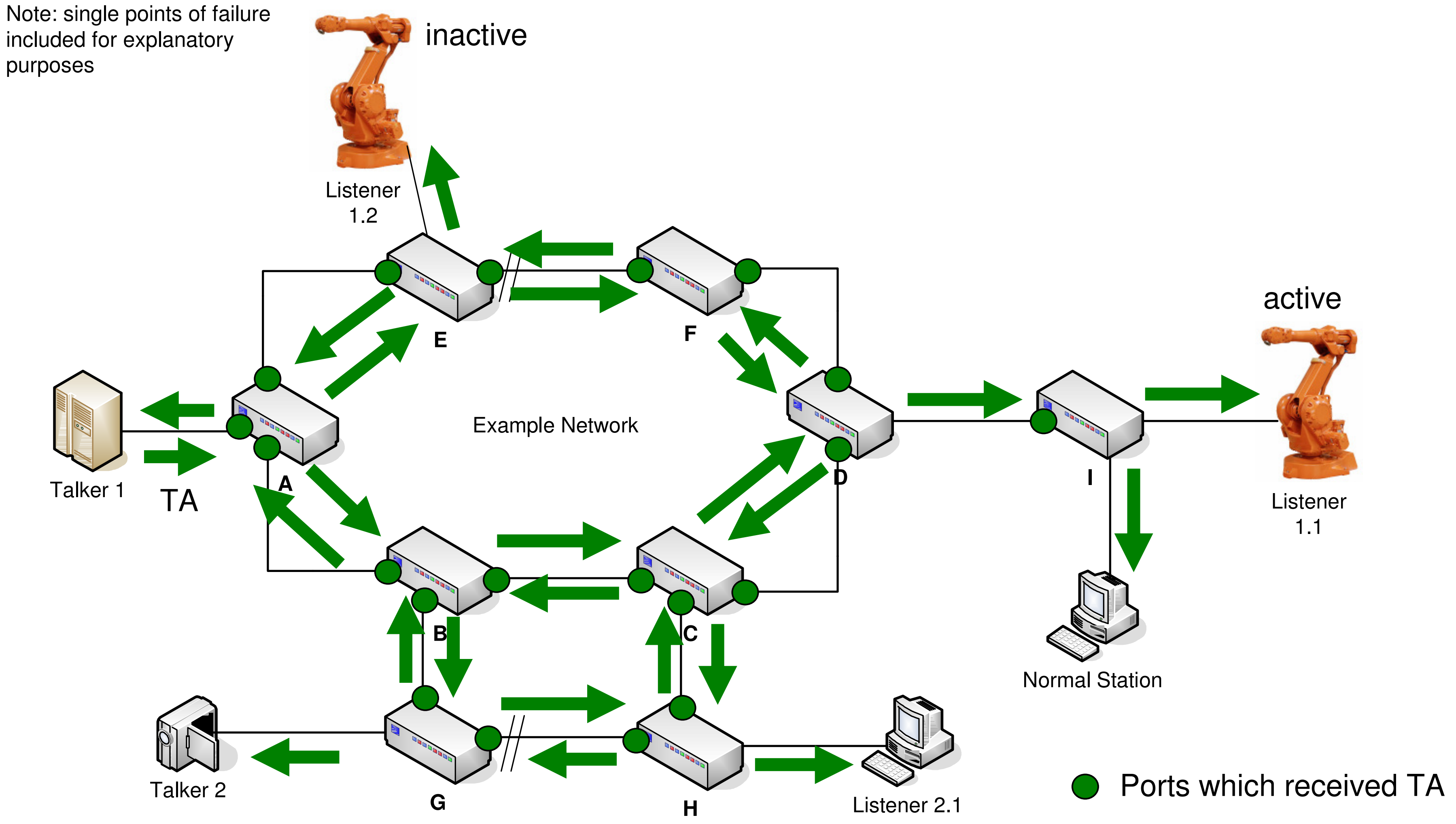
Presented at the Singapore plenary meeting:
http://www.ieee802.org/1/files/public/docs2011/at-kleineberg-AVB-media-redundancy-0311-v02.pdf

• Shows a method to register SRP streams simultaneously through different paths

• The method is not dependant on spanning tree mechanisms, streams are registered over discarding ports

• Traffic and loop prevention have to be handled by the redundancy control protocol (e.g. Discarding Port with RSTP or Duplicate Detection with IEC 62439-3 HSR)

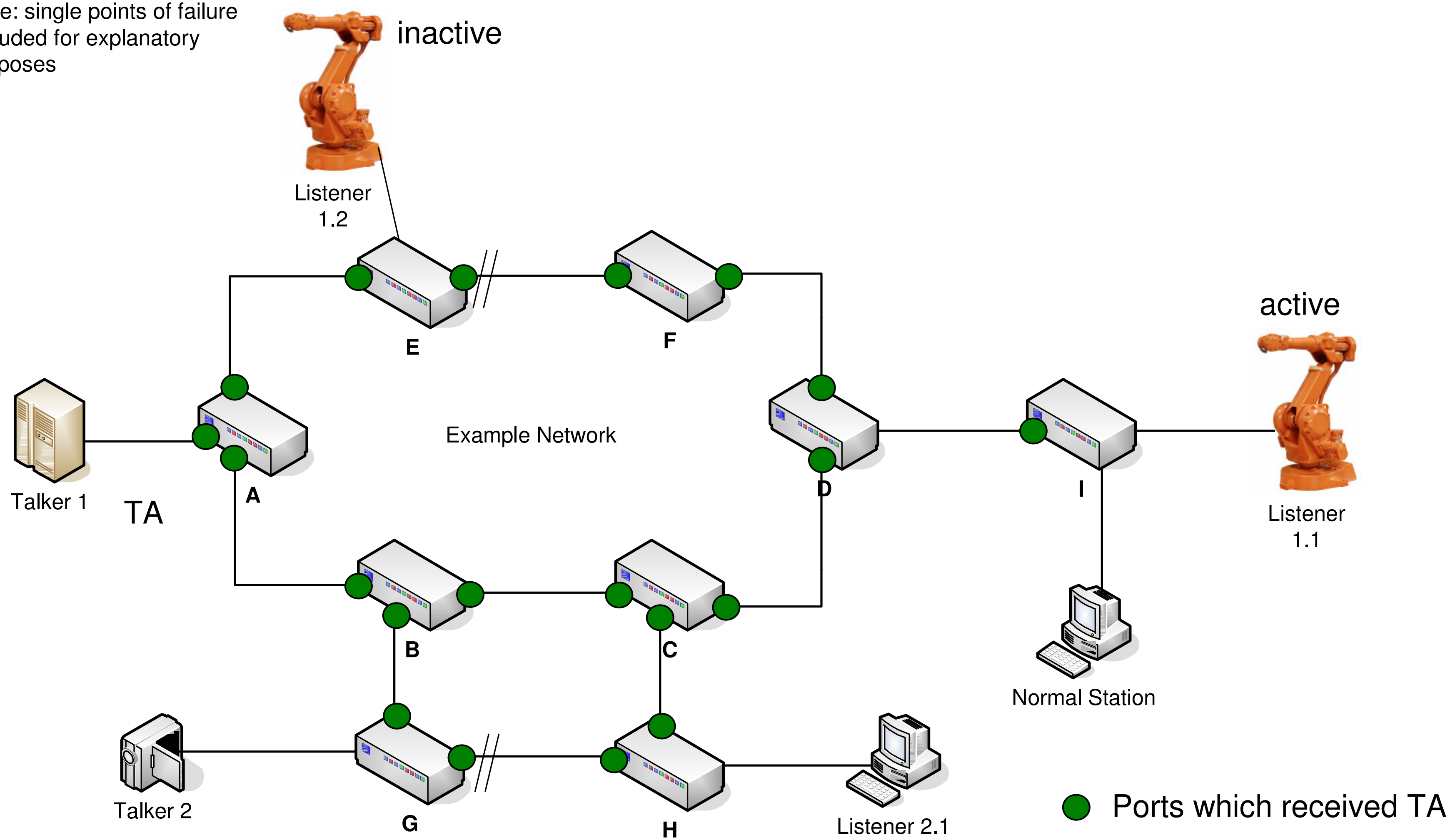
Flashback to Singapore



Talker advertisements are sent by bridges on all ports except the ports the same advertisement has been sent to already (and on which the same TA has been received)

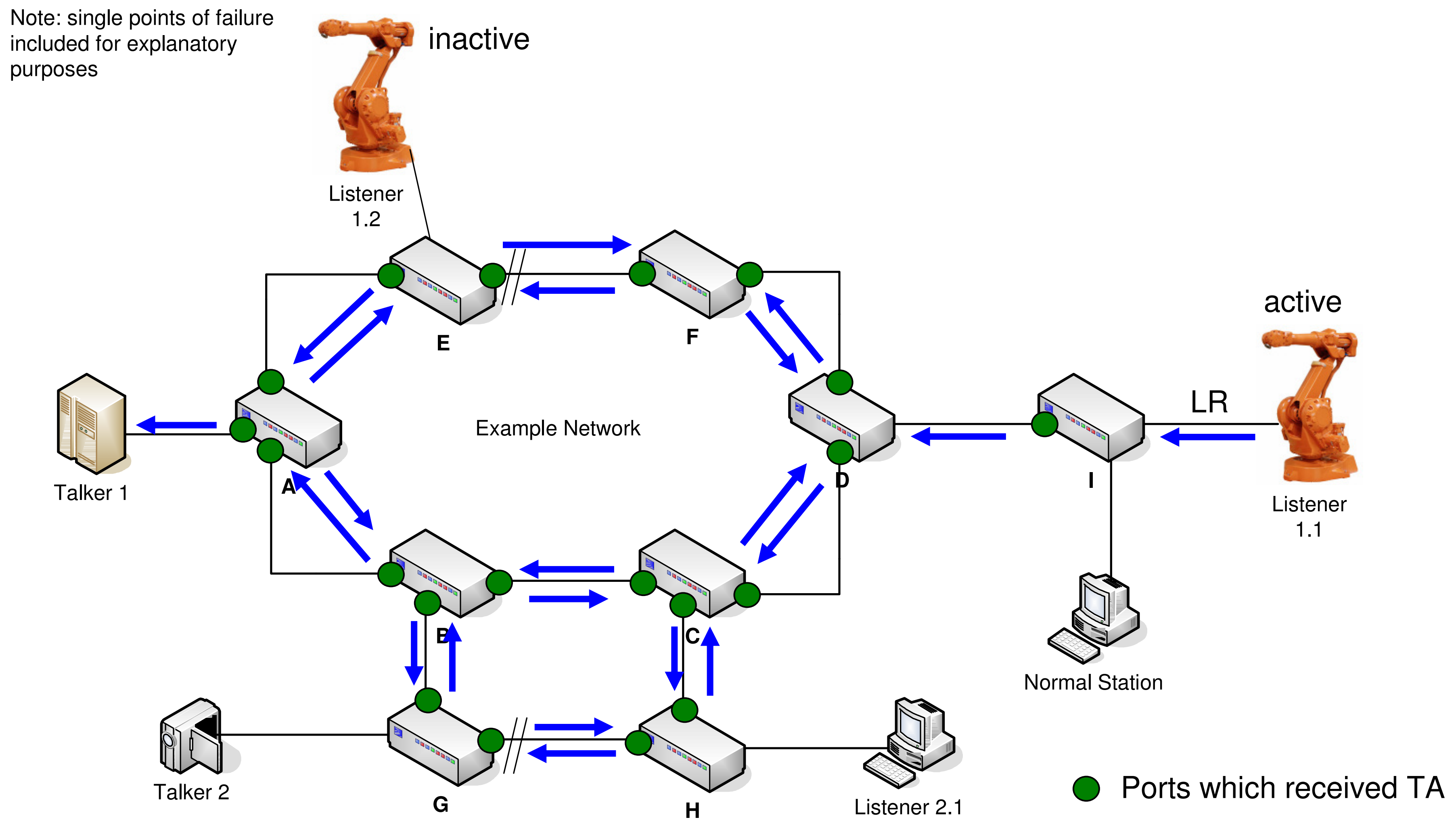
Flashback to Singapore

Note: single points of failure included for explanatory purposes



Bridges now know on which ports they can „reach“ the talker (The ports on which they recieved the TA)

Flashback to Singapore



Bridges send „listener ready“ on all ports they received a „talker advertise“ (except the receiving port)

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Flashback to Singapore – and new ideas!

The impact on SRP protocol mechanisms is limited:

• A new attribute needs to be added to mark streams as "redundant" (e.g. add. "redundant stream attribute") → results in streams that can be either "non-redundant" (old) or "redundant" (new)

• Stream registration must be allowed over discarding ports (not stream payload frame transmission, just registration) → removing dependence of stream registration on RSTP topology tree

• Bridges must be able to remove "looping" TA / LR

• Interface must be available for higher layer entities to influence (redundant) stream registration (e.g. MIB)

Additional SRP Talker Advertise Attributes

- **New SRP Talker Advertise Attributes:**
  - Source Port ID (could either be the Talker ports or any subsequent "splitting" bridge's ports)
  - **Sequence ID** ("easiest" option for loop protection; small counter is good enough)
  - Link Cost (computed from multiple metrics, specific computation on a per profile base) or Link Metrics
  - ~~Single Egress (for Redundancy without Single Point of Failure)~~
  - **Stream Reference Count :**
    - **indicates the number of TA with different source Port ID handled by the bridge for a given stream ID**
    - **propagates the highest reference count along the path**
    - **If a listener requires redundancy without single point of failure, it will select the TAs with a Stream Reference Count equal to 1. If such TAs are not received by the Listener, it indicates a network engineering issue for which the fix is beyond the scope of SRP.**

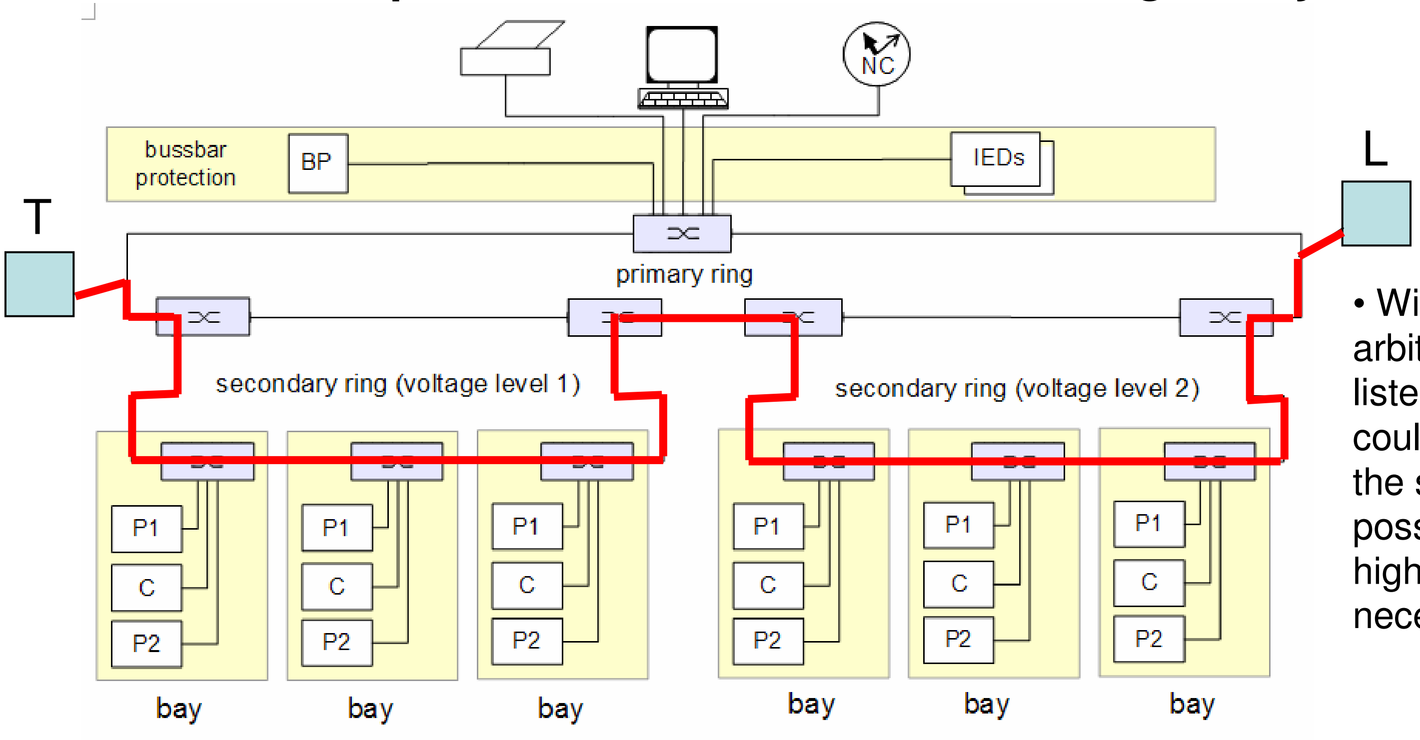
Bridge’s TA Propagation

- **TA are forwarded over every bridge’s egress port (regardless of their RSTP port state)**
  - Loop protection by blocking duplicated TAs **based on sequence ID**
- **Configurable bridge selection between same Stream TA based on:**
  - Source Port & Link Cost (configurable computation) / Metrics (configurable precedence between metrics)
  - Lowest Stream Reference Count

Flashback to Singapore

- This will enable SRP to work with any kind of redundancy protocol and with any arbitrary meshed topology

- But: For engineered networks, additional steps (out of SRP scope) need to be taken. → **Requires well-defined interface to higher layers**



- Without any stream arbitration, talkers and listeners on the primary ring could communicate through the secondary rings, possibly experiencing higher latency than necessary

Structured networks vs. meshed networks

Structured networks vs. Meshed networks

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Structured networks vs. meshed networks

Assumption: Basics of redundant stream registration done in SRP, all additional methods of administration done on a “higher” protocol level

Why is that okay, especially for industrial control / automotive networks?

• Industrial control networks and especially automotive networks are (more or less) fixed installations with little to no dynamic change

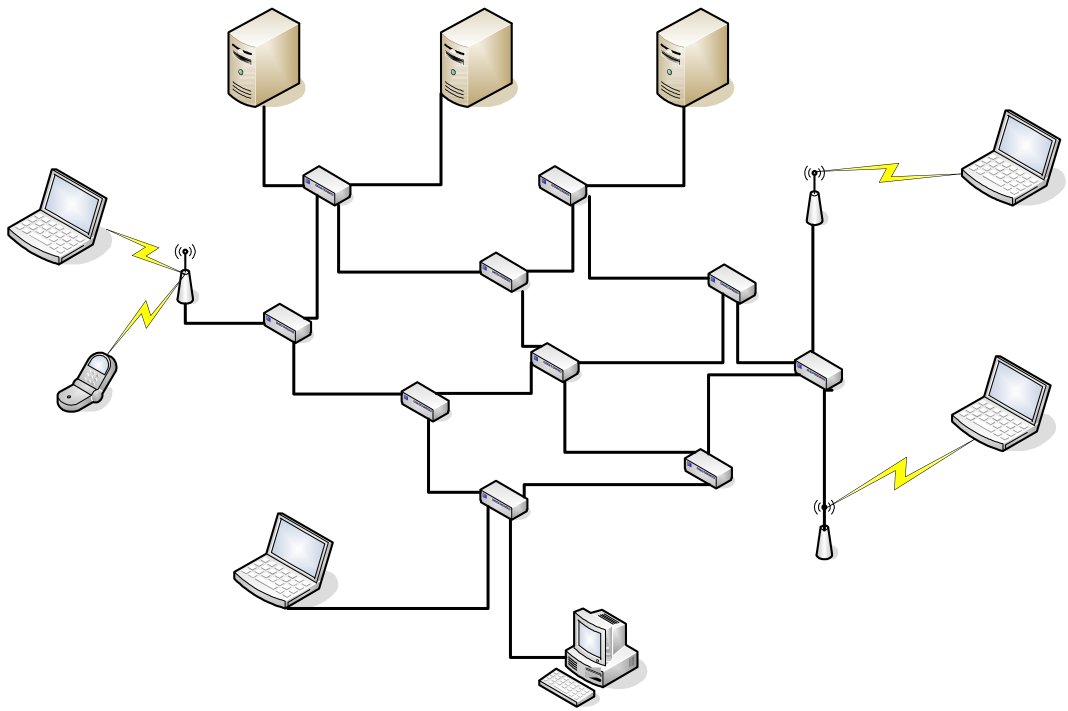
• In industrial control, networks are usually engineered once and then monitored using a network management/engineering system

• Depending on the use case, networks could even be configured completely fixed (even streams), functioning “headless” without any elaborate administration system (e.g. automotive)

→ For engineered low-latency networks, this is the normal case, meshes are the exception… and, there will almost certainly be a “higher level” engineering system in place

Structured networks vs. meshed networks

Example: „Typical“ meshed network



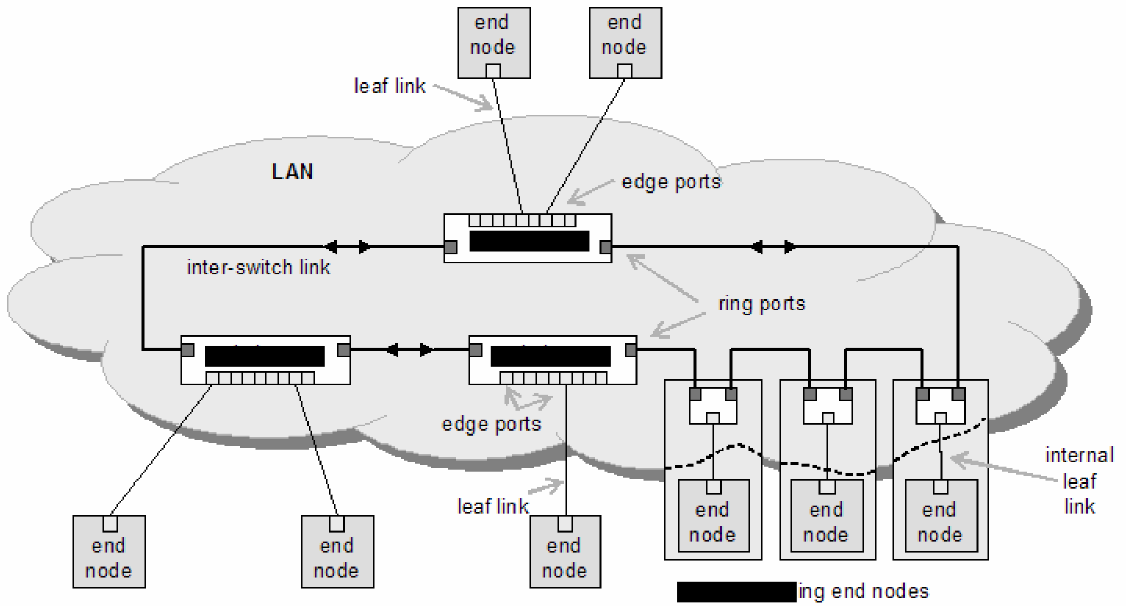
Comments:

- “Typical” access network
- Could work just with redundancy – enabled SRP “out of the box
- Little to intermediate real-time requirements (uncritical voice, video…)
- Probably uses RSTP as redundancy control protocol

- Frequent network reconfigurations
- (Partially) unstructured network design
- High degree of intermeshing

Structured networks vs. meshed networks

Example: „Typical“ automation network



- Infrequent network reconfigurations (mostly due to repair actions)
- Highly structrued network design
- Little to no intermeshing

Comments:

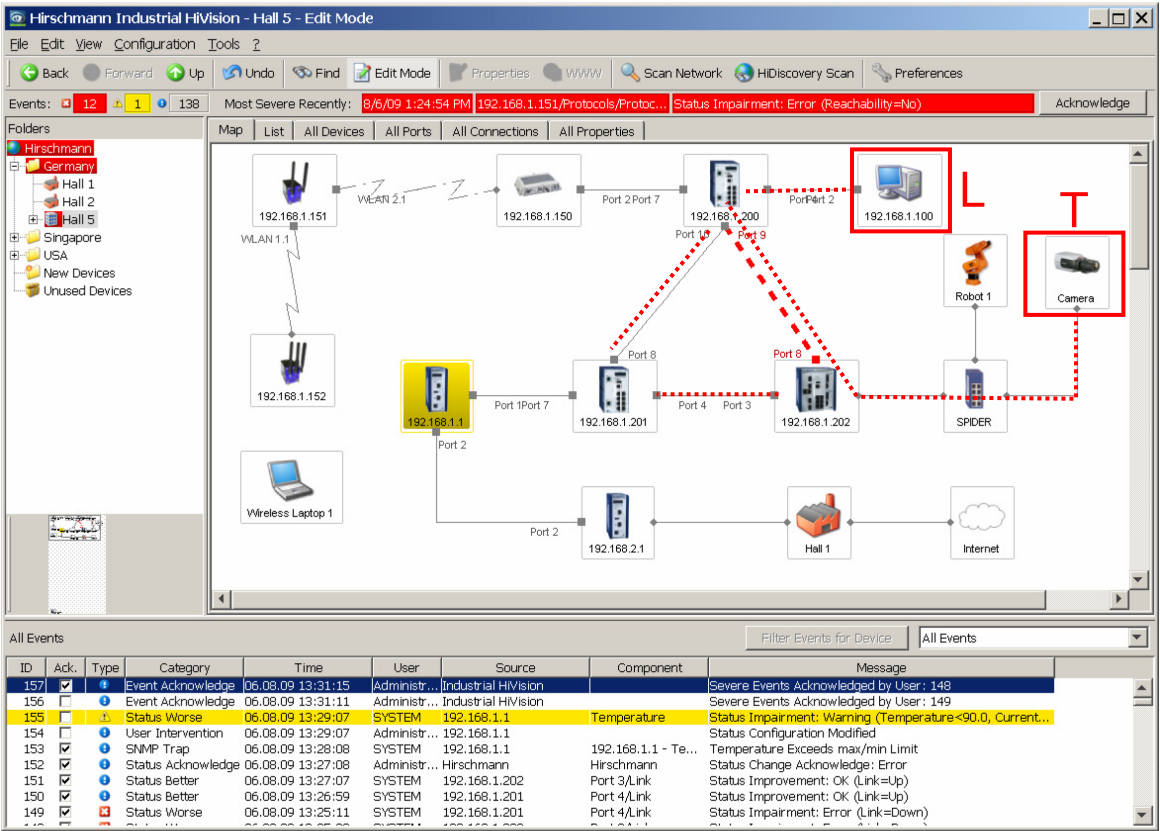
- “Typical” industrial control line network, closed to a ring
- Could work just with redundancy – enabled SRP “out of the box as well (because of the limited topology)
- More complex topologies will require additional engineering
- High to very high real-time requirements (motion control, sampled values, poss. Safety-critical…)
- Probably uses seamless redundancy protocol

Decouple SRP from higher layer path selection

Decouple SRP from higher layer path selection

Decouple Stream registration mechanisms

Stream flow could be entirely configured on engineering level:



Configure Talkers/Listeners and especially bridges through topology-aware network management system – control redundant TA proliferation e.g. through port configuration on bridges

Decouple Stream registration mechanisms

Other methods:

- Stream configuration through “Layer 2 routing” protocol at engineering time
- …

Again: Strong requirement on definition of elaborate interface (MIB) to acquire SRP information and execute control from a higher layer (e.g. engineering)

Layer 2 „routing“ mechanisms and redundancy

Layer 2 „routing“ mechanisms and redundancy

Routing mechanisms used at engineering time that yield a specific redundant network configuration are usable. They do not require any reconfiguration at runtime, everything is done before (probably at engineering level).

Routing mechanisms used at runtime are usually not usable in low-latency networking, as long as any kind of logical path reconfiguration (and communication interruption) is happening

They are only usable if the grace time (T_grace) of the application is not violated:

T_grace > T_rec_routing + T_rec_SRP

Note: This timing has to be guaranteed! For motion control, T_grace is in the µs region

Note: T_rec_SRP can be reduced to 0 with the above mentioned method of flooding the TA. For redundancy protocols like IEC 62439- 3 HSR, T_rec_routing needs to be 0 as well!

FIN

Thank you for your attention!