TSN-IA Domains & Constructability

IEC/IEEE 60802 – May 2019 – Salt Lake City

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Intent

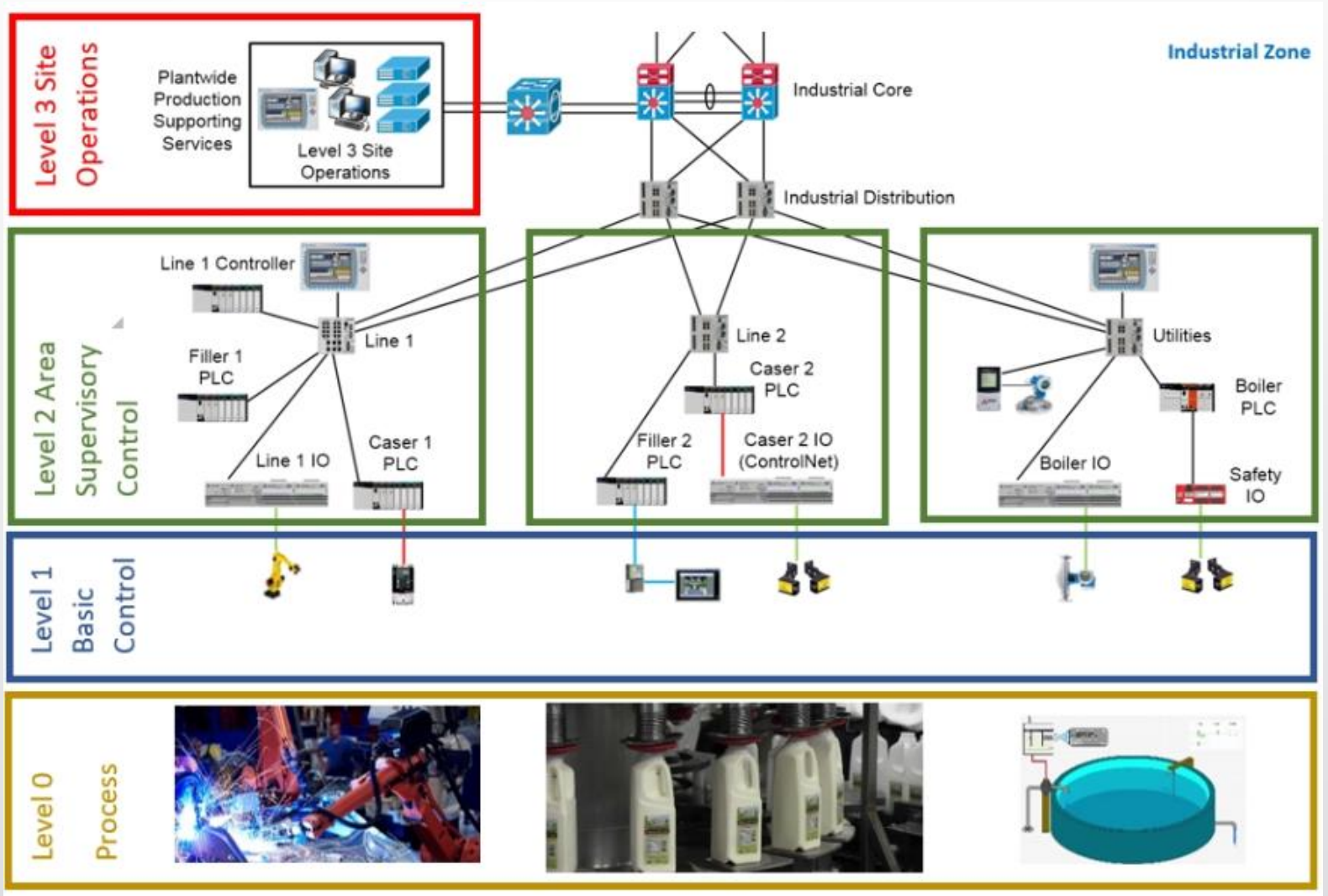
- The intent of this presentation is to continue the conversation around TSN constructability with a focus on TSN-IA (Industrial Automation) Domains
- This presentation attempts to include previous contributions from the use cases document and presentations given by Guenter Steindl, Taro Harima, Marius Stanica, Lihao Chen & the author
- If there is group consensus the “contribution” slides should be added to 802.1 specifications and the next draft of 60802

Intent

- This presentation does not seek to define TSN domains as we have a definition in the 60802 profile currently
- The definition of TSN domains seems to align with the high-level concept of "Functional Entities" that is being described in other standards activities. If possible, these concepts should be merged.

Background

- When looking at the construction of TSN Domains for Industrial Automation, Industrial Automation networks and how they traditionally have been constructed should first be evaluated



Background

- To further break this down, different stages in the lifecycle of an industrial automation network will be examined. They are meant to show a representative set of use cases that the concept of TSN-IA Domains are meant to solve.
  - The Network Design Stage
  - The Network Commissioning Stage
  - The Network Management Stage

IA Network Design Stage

- At design time, different machine builders are commissioned to create *something*
  - The scope could be as small as a machine enhancement or as large as a plant
- When the design is being created the overall network layout is often done, with plans for subnetting and communications
- Simulations need to be run using Network Calculus or Qbv scheduling to ensure TSN-IA Domains have the capacity to meet the current and planned future needs of member devices
- Data Sheets which contain device capabilities will allow vendors to select compatible hardware [1]
- TSN-IA Domains need to be defined and their member devices need to be identified at this time [2]
- Common TSN-IA domain identification mechanisms need to be specified [3]

IA Network Commissioning Stage

- At commissioning time, different machine builders and different fieldbuses are brought together on one network
- If the scheduling/network calculus that is done during the design stage specified everything perfectly, it should work but still needs to be tested
- If devices/machines are being integrated that are brownfield/off-the-shelf they will need to be integrated separately
  - TSN Gateway functions such as stream transformation can be used for brownfield devices [4]
  - Off-the-shelf machines may include their own TSN-IA domain(s) and either may have strict predefined inter-domain communications or may allow integrator defined inter-domain communications to be integrated with a larger network [5]

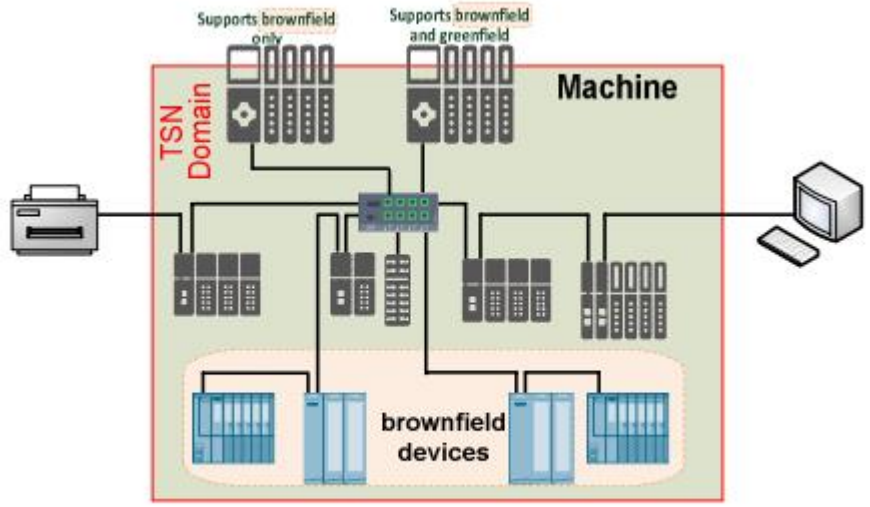


Figure 39 – New machine with brownfield devices

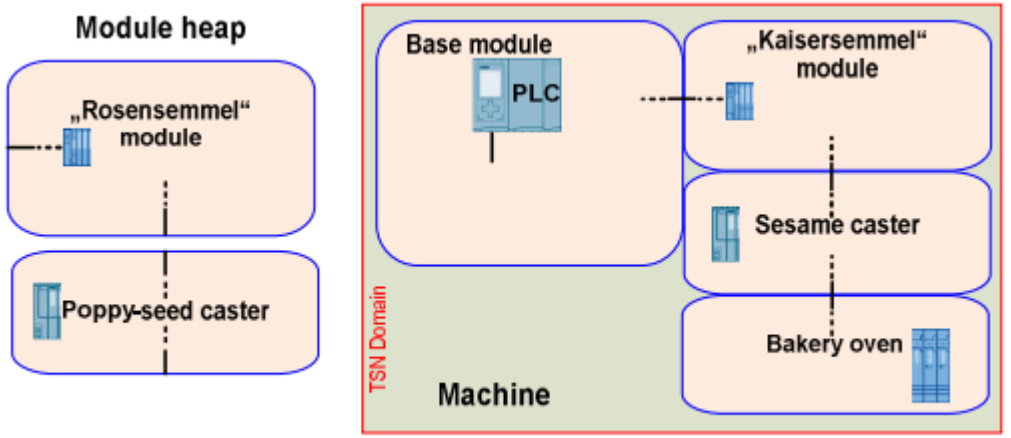


Figure 59 – modular bread-machine

IA Network Management Stage

- Once an industrial automation network is running, provisions need to be included to keep the network running including
  - Enhancing the network by adding devices [6]
  - Replacing devices due to upgrades or failures [7]
  - Modifying the network for retooling or to otherwise meet business needs [8][9]

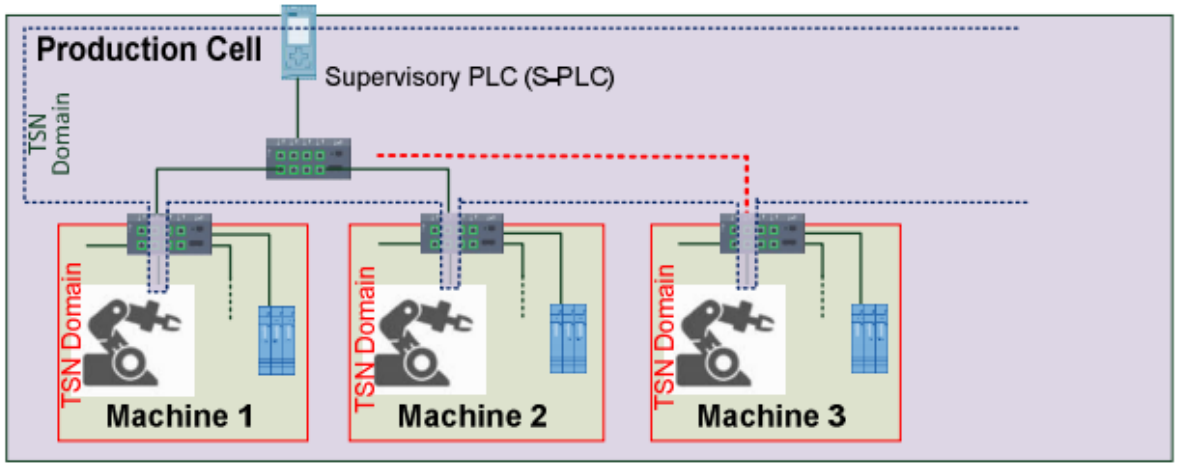


Figure 64 – add machine

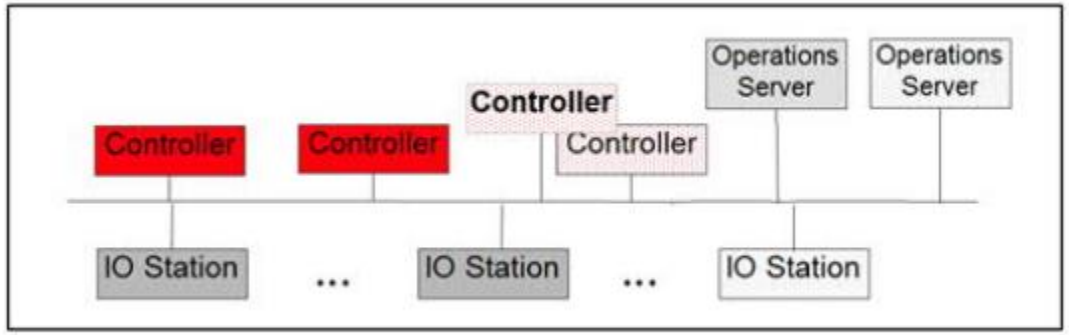


Figure 68 – Device level reconfiguration use cases

Assumptions

- One single management entity (whether centralized, fully distributed or hybrid) will have configuration responsibility for a TSN-IA domain
- Extend RAP or existing "management" to handle configuration model selection and failover within a TSN-IA domain [10] [3]
  - Include IP address of CNC in "configuration" if it exists
  - Include IP address of NME in "configuration" if it exists
- The concept of TSN domain protection needs to be considered, but is separate from the core concept of a TSN-IA domain

802.1 Suggested Contributions

- Since support needs to be provided by 802.1 for the concept of TSN-IA domains, perhaps a normative generic TSN domain concept needs to be extended in 802.1Q (A reminder that some informative text already exists in 802.1Qcc Appendix U.2 part 7)

802.1 Suggested Contributions

- Suggestions for inclusion in LRP or RAP
  - A purpose built protocol such as a Controller-Controller-Protocol using LRP could be developed, per forthcoming proposal from Lihao Chen
  - Or RAP could be extended with:
    - A TSN-IA domain managed object to convey an identifier
    - A TSN-IA domain boundary configuration to set up stream transformation
- Suggestions for inclusion for a revision to 802.1Qcc
  - Include A TSN-IA identifier in the UNI for talkers & listeners in 46.2.3 and 46.2.4
  - Add a definition of stream transformation for TSN-IA domains in a bridge in 35.2.2.10.5 part c, 46.1.4 and Appendix U.2 part 7

P60802 Suggested Contributions

- TSN-IA Domain Identification
  - A single TSN-IA Domain Identifier per port must be included through LLDP
  - Bridge Ports should be configured to certain TSN-IA Domains
    - This configuration can be pushed down through a data sheet (assuming 60802 adopts the data sheet model), or through RAP (assuming Feng includes knobs and dials for this), or from a CNC (assuming a revision to 802.1Qcc adopts it)
    - Unconfigured bridges will pick up TSN-IA domain port configuration from adjacent devices through LLDP. This enables device replacement and plug-and-play for bridged end-stations
    - If bridges receive different TSN-IA configurations on different ports, only the ports that receive adjacent configurations through LLDP will be configured
    - If the two ends of a link between two ports doesn't have matching TSN-IA configuration data plane communications on that link will not be established

P60802 Suggested Contributions

- TSN-IA Domain Identification
  - The TSN-IA Domain Identifier should be human readable and unique [3]
  - Cloning a machine with a TSN-IA Domain should create a unique identifier
  - Network Management Entities need to be able to configure devices even if the data plane is unusable due to mismatched TSN-IA Domain Configuration[3]

P60802 Suggested Contributions

- TSN-IA Domain Boundaries
  - TSN-IA Domain Boundaries exist within bridges
  - They automatically occur when any ports within a bridge have a different TSN-IA domain configurations
  - This is a "TSN-Domain-Connector" function [3]
  - When streams are configured that go across a specific TSN-IA domain boundary, that TSN-IA boundary needs to be configured to know how to handle those streams
    - If strict-priority is being used, stream transformation may need to be used to normalize priorities between domains
    - If Qbv scheduling is being used, a shared schedule may need to be generated with multiple CNCs.
      - The TSN-IA boundary should be responsible for requesting the resource from a partner CNC just as though it were another end station.
      - An enhancement for this would be for a Head CNC to analyze the most efficient schedule between CNCs [11]

References

- [1] http://www.ieee802.org/1/files/public/docs2019/60802-Hantel-Data-Sheet-Model-0119-v00.pdf
- [2] http://www.ieee802.org/1/files/public/docs2018/60802-industrial-use-cases-0918-v13.pdf Use Case 33
- [3] http://www.ieee802.org/1/files/public/docs2019/60802-Steindl-ExampleSelections-0119-v02.pdf
- [4] http://www.ieee802.org/1/files/public/docs2018/60802-industrial-use-cases-0918-v13.pdf Use Case 12
- [5] http://www.ieee802.org/1/files/public/docs2018/60802-industrial-use-cases-0918-v13.pdf Use Case 19
- [6] http://www.ieee802.org/1/files/public/docs2018/60802-industrial-use-cases-0918-v13.pdf Use Case 23
- [7] http://www.ieee802.org/1/files/public/docs2018/60802-industrial-use-cases-0918-v13.pdf Use Case 35
- [8] http://www.ieee802.org/1/files/public/docs2018/60802-industrial-use-cases-0918-v13.pdf Use Case 27
- [9] http://www.ieee802.org/1/files/public/docs2018/60802-industrial-use-cases-0918-v13.pdf Use Case 28
- [10] http://www.ieee802.org/1/files/public/docs2019/60802-chen-TSN-management-0119-v00.pdf
- [11] http://www.ieee802.org/1/files/public/docs2018/60802-stanica-convergence-coexistence-0718-v03.pptx