IEC/IEEE 60802
Inter TSN domain communication concept

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Mission and Scope

Recapitulation 1)

- **TSN domain [IEC/IEEE 60802, Rev d1-1]:**
  - The term “TSN domain” is work in progress in IEC/IEEE 60802:
    “A TSN domain is an administrative group of devices.”
- **Contribution “Example Selection” to IEC/IEEE60802 [2]:**
  - Up to 64 TSN domains per layer 2 broadcast domain

- **Problem statement: How can the use cases (e.g. machine-to-machine communication) be realized?**
  - Machines can be in different TSN domain
  - Converged TSN (multiple applications) should run on top of the whole Layer 2 network
  - Any configuration model (e.g. centralized or distributed) can be applied inside a TSN domain

  ➔ Goal: One solution for communication between TSN domains

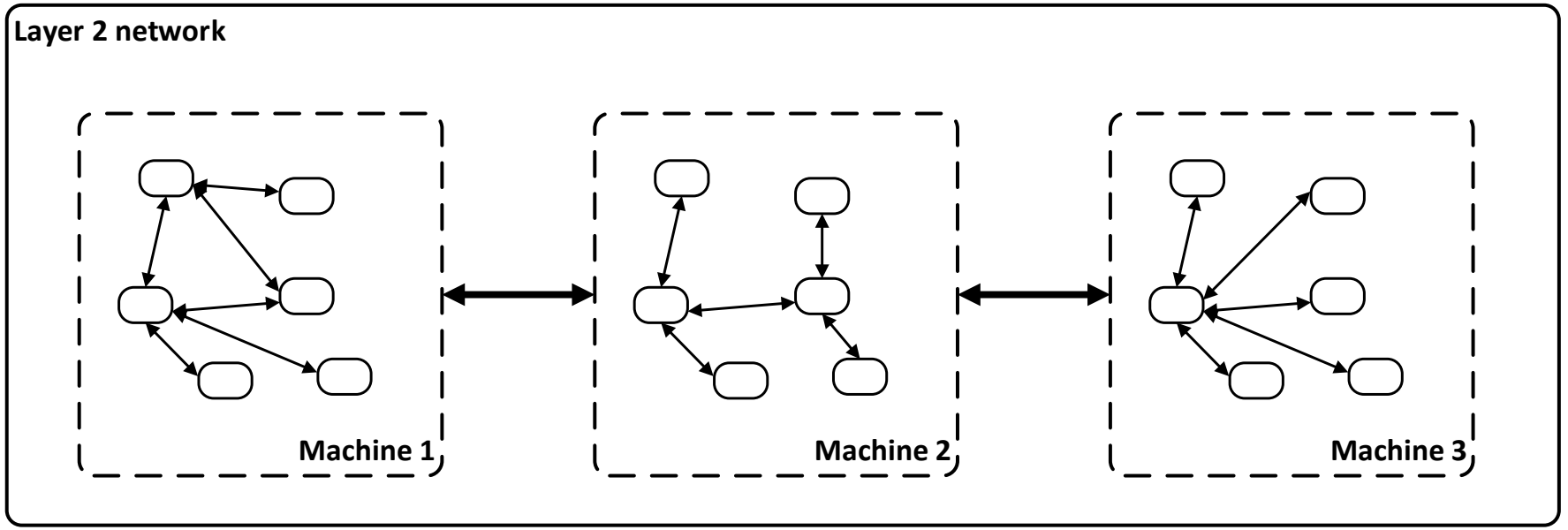
- **Concept: TSN domains are considered as black boxes**

1) http://www.ieee802.org/1/files/public/docs2020/new-Steindl-TSN-inter-domain-communication-0120-v4.pdf
2) http://www.ieee802.org/1/files/public/docs2020/60802-Steindl-et-al-ExampleSelectionTables-0420-v23.pdf

Why TSN domains in IEC/IEEE 60802?

Recapitulation 1)

- **TSN domains** are required:
  - Liability, responsibility, guarantee/warranty (e.g. machine), product limitations (constraint devices), ...
  - Structuring of the network using TSN domains reduces the complexity (e.g. path finding, resource management)



1) http://www.ieee802.org/1/files/public/docs2020/new-Steindl-TSN-inter-domain-communication-0120-v4.pdf

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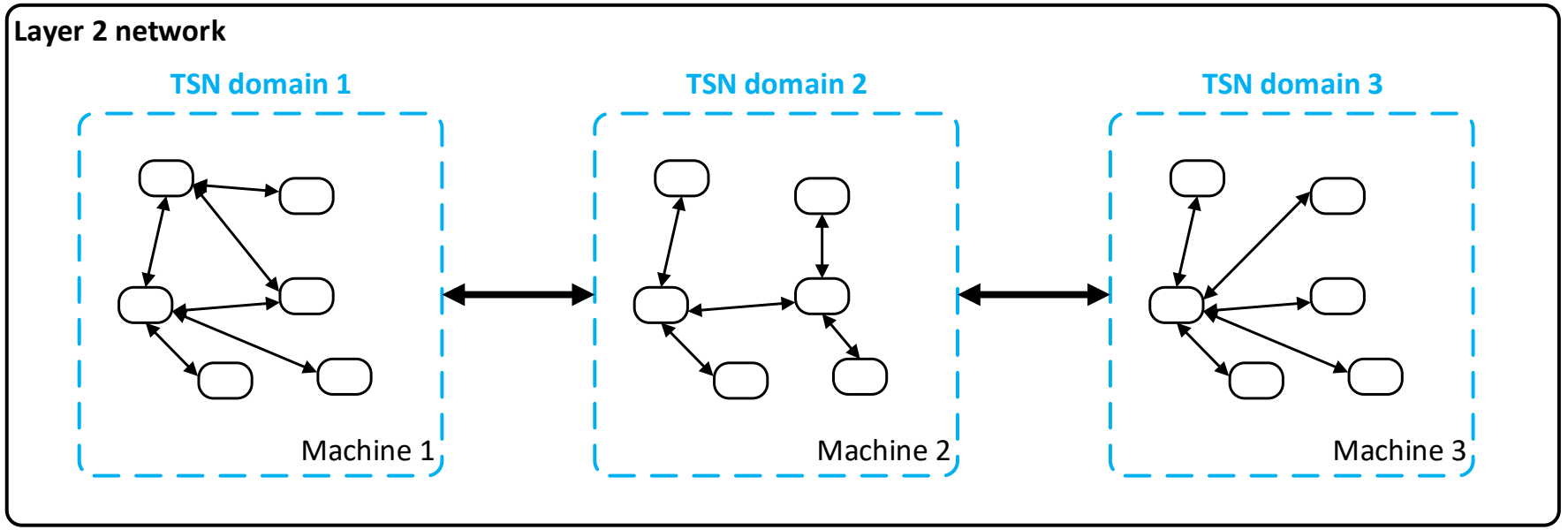

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TSN domain definition proposal

- **TSN Domain:**
  - A set of stations (end stations and/or bridges) and their ports that share a common TSN configuration model (centralized, hybrid or fully distributed).
  - Note: A TSN domain is an administrative group of stations.

- **TSN Domain Characteristics**:
  - The TSN configuration model of a TSN domain is only “known” inside the TSN domain (black box)
  - One or more TSN domains may exist within a layer 2 broadcast domain
  - A TSN domain is limited to one layer 2 broadcast domain
  - Each bridge component[1] is clearly assigned to a TSN domain (TSN domain membership is NOT on a port level)
  - A TSN domain shall not expand automatically when e.g. two machines get connected via an unplanned and unintended link
  - A TSN domain shall ensure, that external traffic (e.g. inter TSN domain traffic) does not disturb internal traffic (e.g. TSN domain only accepts a certain number of inter TSN domain streams to ensure internal best effort traffic)
  - Stations that do not support TSN cannot be part the TSN domain
  - A TSN domain must be coherent (i.e. TSN communication must be possible between all TSN domain members)
  - Each TSN domain has an unique identifier

[1] *Definition “VLAN bridge component”: IEEE802.1Q-2018 – chapter 3.292*

TSN domain identifier

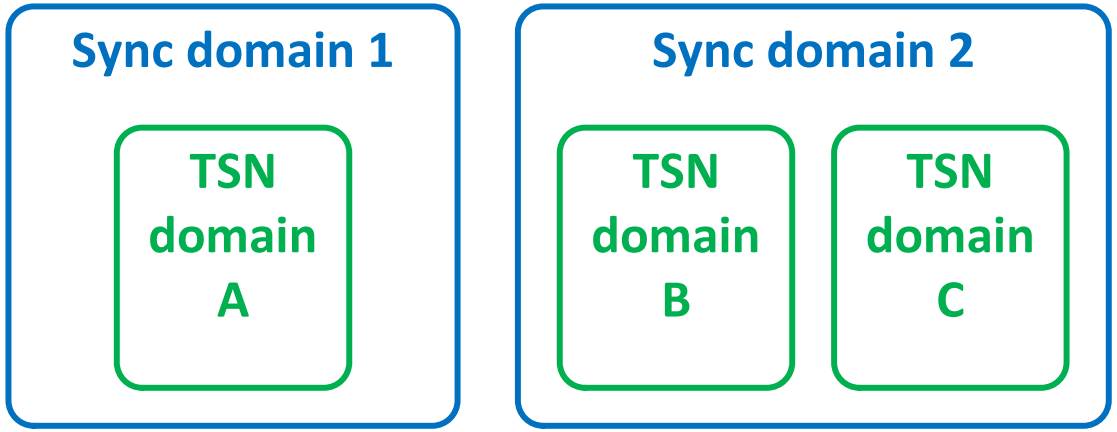
- TSN domain identifier is used to uniquely identify a TSN domain and its devices (bridges, end stations) in a network
- **Requirements so far:**
  - The TSN Domain Identifier should be human readable and unique [1)]
  - Cloning a machine with a TSN Domain should create a unique identifier [1)]

- Proposed solution:
  - TSN domain ID should be a **Universally Unique Identifier (UUID)** [2) 3)]
  - Additional naming concepts are possible
    - Out of scope for the TSN domain definition
    - In the TSN domain context, a UUID is used

1) *Mark Hantel: http://www.ieee802.org/1/files/public/docs2019/dj-Hantel-TSN-Domain-Proposal-1119-v03.pdf*
2) *ISO/IEC 9834-8:2014, Information technology — Procedures for the operation of object identifier registration authorities — Part 8: Generation of universally unique identifiers (UUIDs) and their use in object identifiers*
3) *128bit - Globally Unique Identifier*

Comparison of TSN domain and sync domain

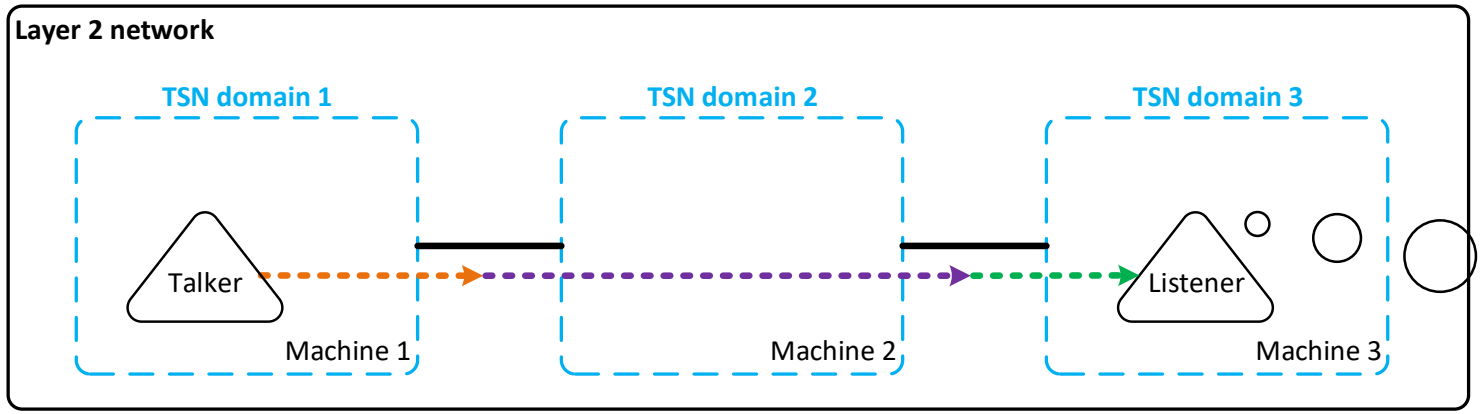
- **A TSN domain corresponds a (working clock) sync domain**
  - One or more TSN domains can be in the same (working clock) sync domain
  - A TSN domain cannot be part of multiple (working clock) sync domains



Concept for inter TSN domain communication

Approach: Considering TSN domains as black boxes

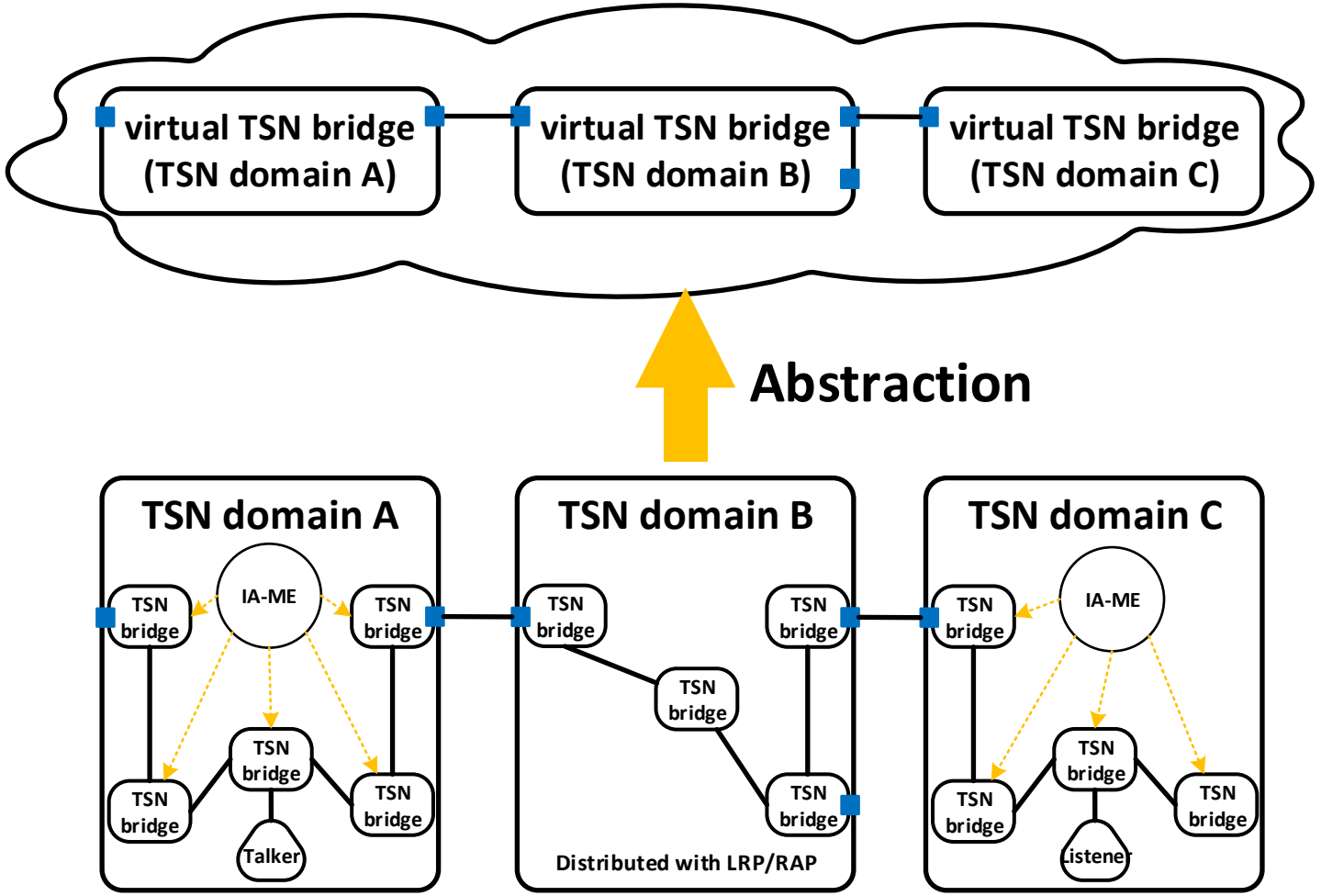
- **TSN domains are black boxes**, i.e. their internals doesn't matter to the outside world
  - Each TSN domain is responsible for the stream establishment and teardown inside its domain



Establishment of partial streams is under control of the domain itself
➔ **Delegation**

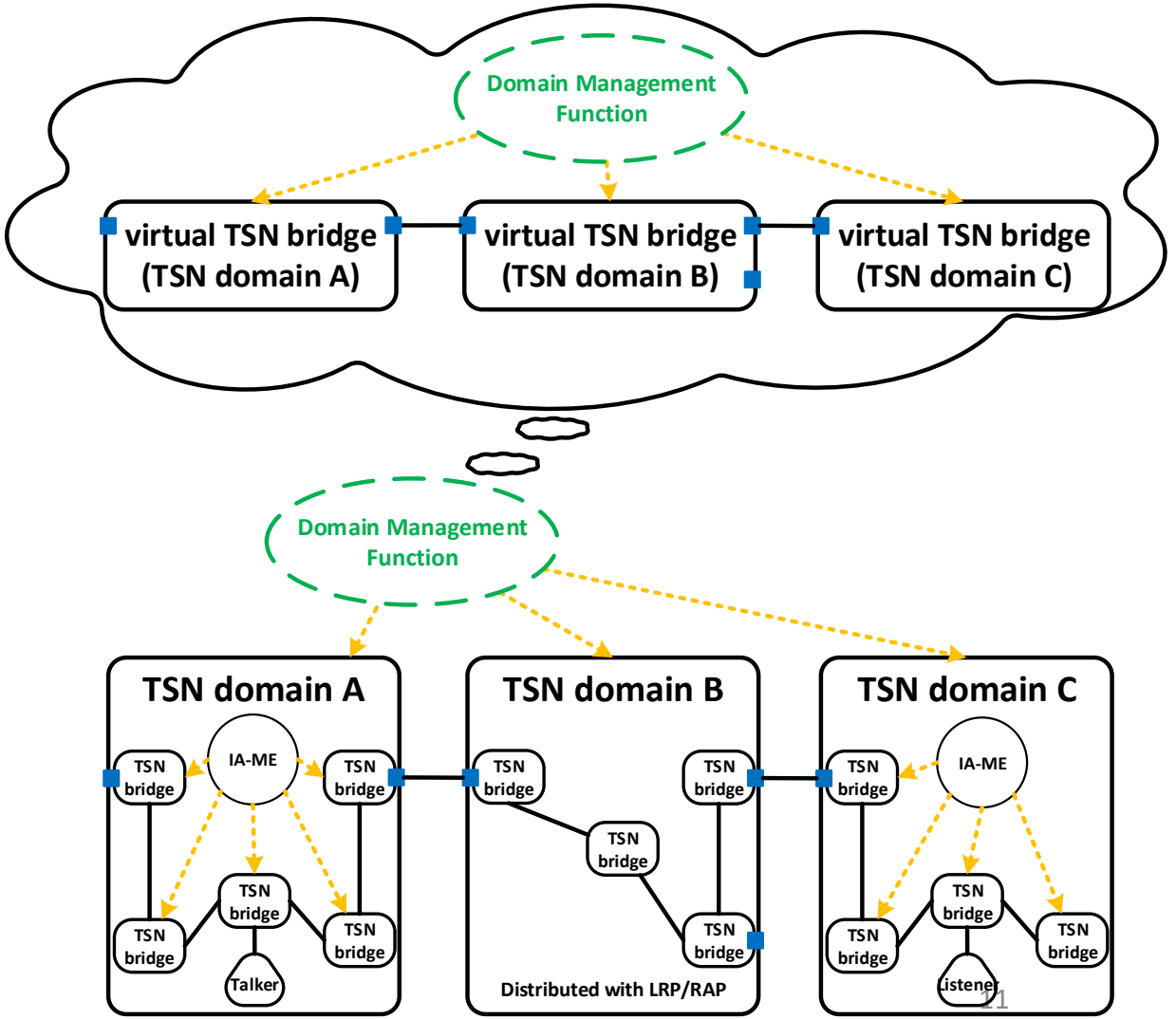
- Inter TSN domain communication - separation of different steps / tasks:
  1. Identify and find talker and listener, e.g. by DNS
  2. TSN domain discovery
  3. Path computation and reservation
  4. Reservation of partial streams along this path

Abstraction of TSN domains as virtual bridges



Proposal: Domain Management Function (DMF)

- **Today:**
  - IA-ME is responsible for all bridges (and end stations) in a TSN domain
- **Previous proposal [1]:**
  - Head IA-ME → Has knowledge of internals of all TSN domains → scaling issue, violation of black box approach
- **Black Box approach: ➔ Stacked TSN domains**
  - IA-ME is only responsible for its domain
  - Abstraction of TSN domains into virtual TSN bridges



1) Marius Stanica: Coexistence & Convergence in TSN-based industrial automation networks

DMF approach

- **Black Box approach: ➔ Stacked TSN domains**
  - IA-ME is responsible for its domain
  - Abstraction of TSN domains as virtual TSN bridges

  ➔Apply well-known delegation principles (e.g. by DNS)

- **Domain Management Function manages the “network” of these virtual bridges**
  - DMF establishes inter TSN domain streams on a domain to domain level
  - The establishment of partial streams inside the domain is done by respective IA-ME (delegation)
  - DMF has no knowledge of bridges and streams inside a domain
  - DMF has no knowledge about resources of network components

- **DMF is a logical function:**
  - Could be an additional function of an IA-ME

DMF’s tasks

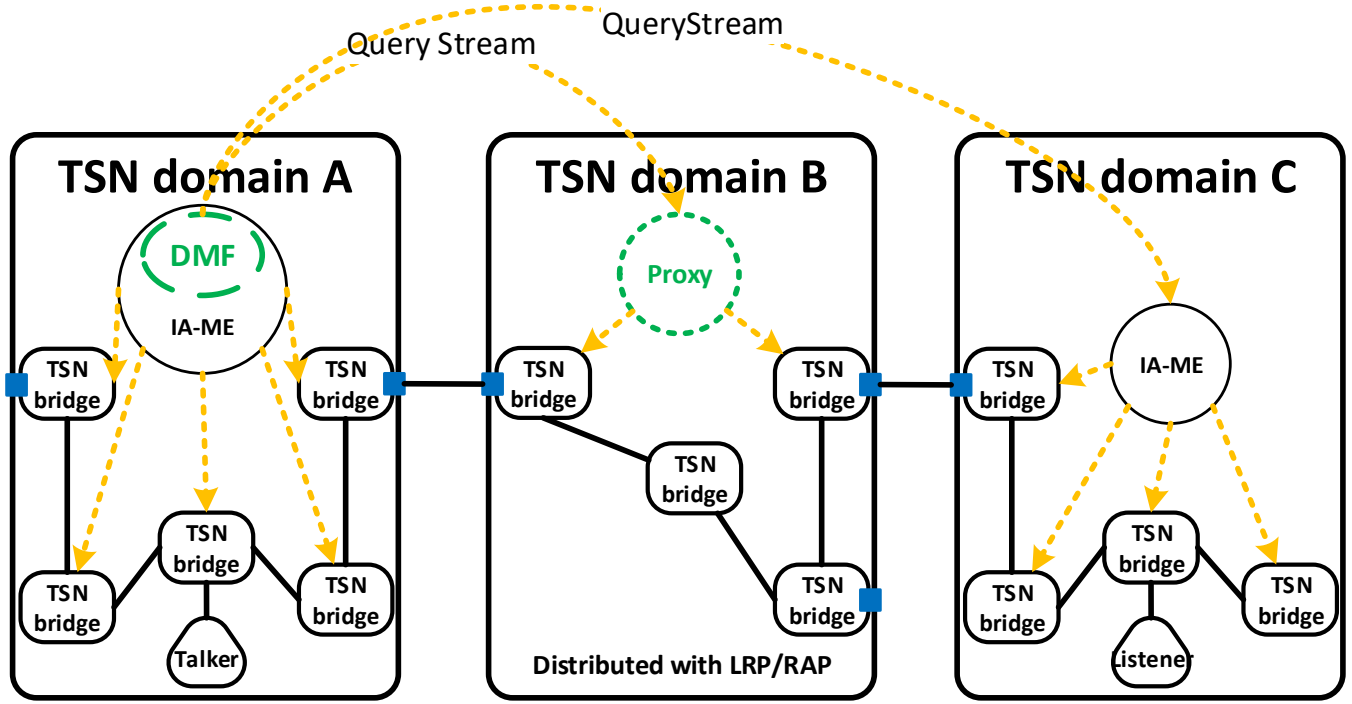
- **Tasks for DMF**
  - **Discovery**:
    - DMF knows of all TSN domains, their boundary port and neighbors
    - DMF generates TSN domain topology
    - Information could be spread by LRP means between the DMFs of the different TSN domain
  - **Path computation** (including redundant paths) on a TSN domain level
    (NO routing protocol necessary!)
  - Delegation of partial **stream reservation** requests to TSN domain
    - QueryStream request for domains with IA-ME
    - Distributed domains need a proxy which receives QueryStream and translates to talker advertise / listener join

- Redundancy concepts for DMF could be necessary
  - Every IA-ME has DMF role (database sync), one IA-ME is active DMF (→ Active-Backup-Approach)

Collaborative DMF

- Single DMF for whole layer-2-network does not fulfill requirements!

- **DMF function in each TSN domain (→ collaborative DMF)**
  - Each IA-ME has DMF
  - Each DMF knows topology of TSN domains
  - DMF does path computation on TSN domain level
  - Based on this TSN domain path, it creates a QueryStream request in each domain



Summary

- TSN domain concept seems suitable for structuring layer 2 networks (e.g. into independent machines)
- TSN domain as a black box allows usage of centralized and distributed configuration model in one layer 2 network
- TSN streams between TSN domains require “inter TSN domain communication” for stream establishment

- Proposal: establishment of inter TSN domain streams via a domain management function (DMF)
- DMF added to each IA-ME

➔ Inter TSN domain stream can be considered as “normal” TSN stream within a network of virtual TSN bridges (each representing a TSN domain)

- Open topics:
  - TSN domain discovery (e.g. by DMF-DMF communication)
  - Identify Talker and Listener and their TSN domain

Questions?