New Data Objects & New Protocols

Supporting new TSN features in a decentralized and centralized controlled network

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Motivation: TSN for Industrial Automation

- TSN has introduced a huge number of new features for deterministic Ethernet.
- Flexibility and connectivity is a strong requirement within Industrial Automation!
- Network management and network control has to support the automatically configuration of the new features in a decentralized or centralized organized automation network.

Current Discussion!

The current .1Qcc draft shows three concepts for network configuration:

1. Fully Distributed Model

2. Centralized Network (based on system protocols) ***/ Distributed User Model***

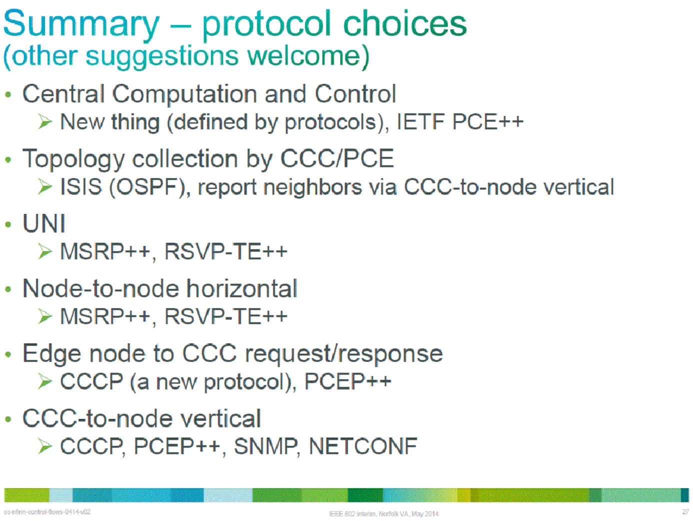
3. Fully Centralized Model (based on system protocols) + supporting “Scheduled Traffic”

This presentation is focused ONLY on two (based on models already introduced in IEEE802.1):

1. Fully Distributed Model (not supporting “Scheduled Traffic”)

2. Centralized Network (*based on .1Qca*) ***/ Distributed User Model*** + supporting “Scheduled Traffic”

See also slides 4,5,6 of presentation: http://www.ieee802.org/1/files/public/docs2014/cc-nfinn-control-flows-0414-v02.pdf



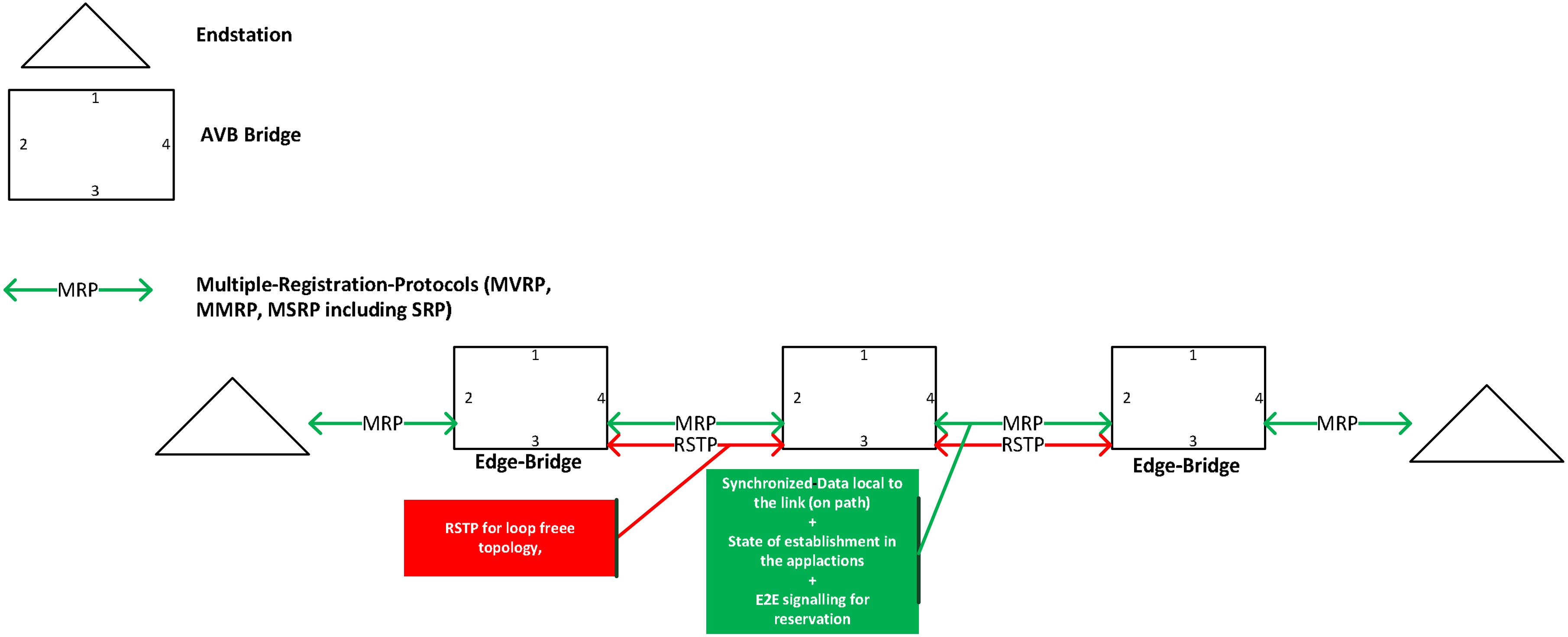
Summary – protocol choices
(other suggestions welcome)

- Central Computation and Control
  - New thing (defined by protocols), IETF PCE++
- Topology collection by CCC/PCE
  - ISIS (OSPF), report neighbors via CCC-to-node vertical
- UNI
  - MSRP++, RSVP-TE++
- Node-to-node horizontal
  - MSRP++, RSVP-TE++
- Edge node to CCC request/response
  - CCCP (a new protocol), PCEP++
- CCC-to-node vertical
  - CCCP, PCEP++, SNMP, NETCONF

cc-nfinn-control-flows-0414-v02 IEEE 802 interim, Norfolk VA, May 2014 27

AVB: Decentralized controlled Network with Registration & Reservation based on RSTP

1. Fully Distributed Model (specified with AVB)



RSTP for loop freee topology,

Synchronized Data local to the link (on path)
+
State of establishment in the applactions
+
E2E signalling for reservation

ASSUMPTION:

- *Loop free topology based on STP (spanning tree protocol)*

TSN: Decentralized controlled Network
with Path Computation, Registration & Reservation

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***TSN** has introduced **new features** like (seamless) redundancy based on path computing.*

*To support the new features like **“Seamless Redundancy”** in a **decentralized controlled network** additional data objects and protocols are necessary:*

- ISIS-PCR (specified in .1Qca) for topology discovery and path computing
  (also path computing algorithm like Dijkstra, SP – shortest path or MRT – Multiple-Redundant-Tree)
  => **BLCE’s** – Bridge-Local-Computing-Elements (specified in .1Qca)
- NEW MRRP Multiple-Relation-Registration Protocol to nail down the path for the registration of network attributes (see: http://www.ieee802.org/1/files/public/docs2015/new-goetz-schmitt-dyn-registration-on-ISIS-PCR-0309-v01.pdf)
- MVRP is used to establish the data planes (VLAN’s / VID’s)
- MMRP (optional) to configure the forwarding behavior for unregistered MAC addresses
- MSRP to register the Stream Attributes (e.g. SR-DA, Tspec, availability, ..)
- SRP to do stream reservation (min. latency, max latency, ..)

TSN: Decentralized controlled Network with Path Computation, Registration & Reservation

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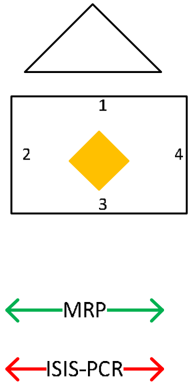
1. Fully Distributed Model (for TSN to support redundancy)

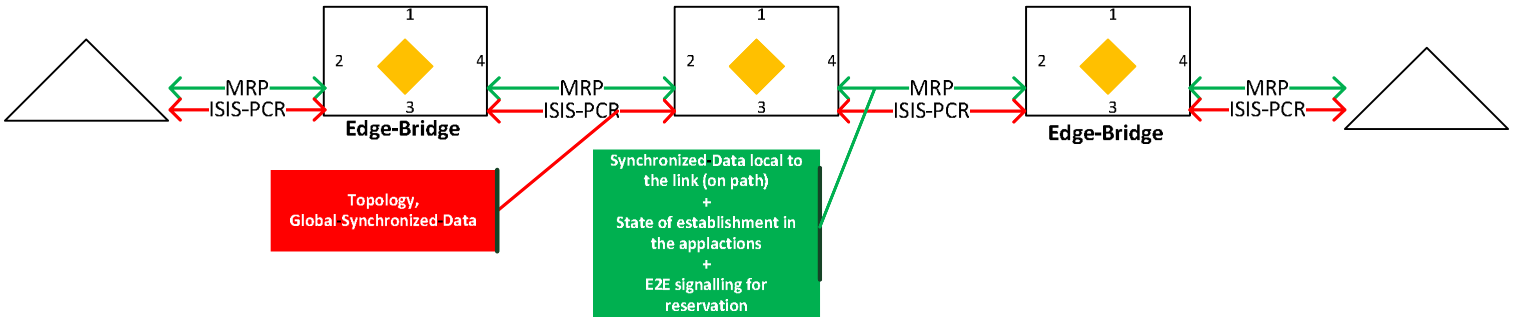


Endstation

BLCE (= Bridge-Local-Computing-Engine, distributed network control)

Multiple-Registration-Protocols (MRRP, MVRP, MMRP, MSRP including SRP)

Intermediate-System-to-Intermediate-System



Topology, Global Synchronized Data

Synchronized Data local to the link (on path)
+
State of establishment in the applactions
+
E2E signalling for reservation

NEW:

- ***Each bridge has to support BLCE functionality*** *(specified in .1Qca,* ***distributed*** *path computation)*
- ***ISIS-PCR just for topology discovery***
- ***New MRP application MRRP – Multiple Relation-Registration protocol to nail down the path for Stream registration & reservation*** *(is a replacement of RSTP)*

TSN: Decentralized / centralized controlled Network with Path Computation, Registration & Reservation

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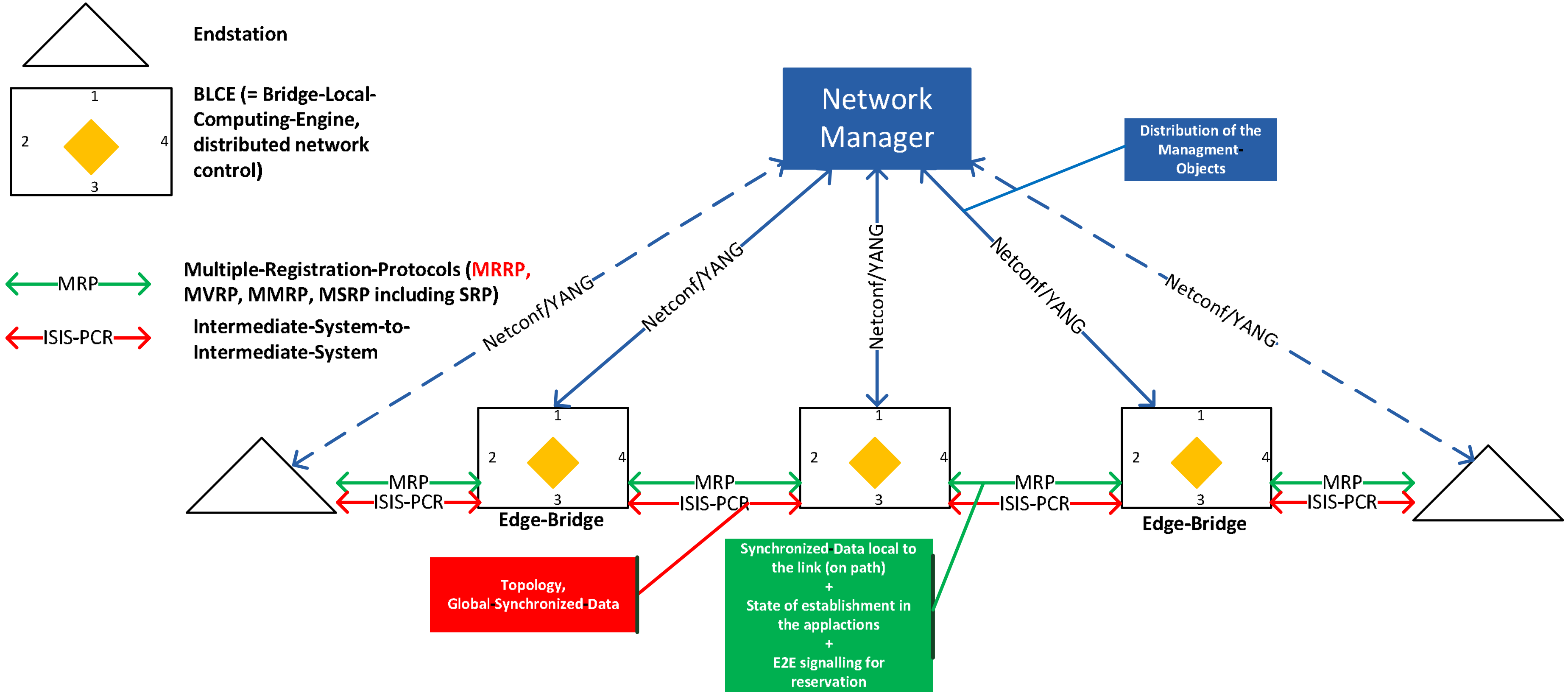
BUT in TSN we need mechanisms that allow Stream Reservation class (SR class) parameters to be configured because TSN has introduced new shaper, pre-emption, CT, … (in comparison to AVB we have predefined traffic classes)

- *Managed Objects are required to configure traffic classes for a time sensitive network*
  (observation interval, priority, VID, shaper, redundancy, max. MTU size, …)
- Managed Objects are required to configure max. available bandwidth for each traffic class
  (traffic classes for stream and traffic classes for best effort traffic)
- …

TSN: Decentralized controlled Network with Path Computation, Registration & Reservation

1. Fully Distributed Model (with Network Manager)



Endstation

BLCE (= Bridge-Local-Computing-Engine, distributed network control)

MRP: Multiple-Registration-Protocols (MRRP, MVRP, MMRP, MSRP including SRP)

ISIS-PCR: Intermediate-System-to-Intermediate-System

Network Manager

Distribution of the Managment-Objects

Topology, Global-Synchronized-Data

Synchronized-Data local to the link (on path)
+
State of establishment in the applactions
+
E2E signalling for reservation

NEW:

- ***Network manager to distribute managed objects*** *(supporting new managed objects for new TSN features)*

TSN: Decentralized controlled Network with Path Computation, Registration & Reservation

BUT within TSN we still have the requirement to (parts of the .1QCC PAR)

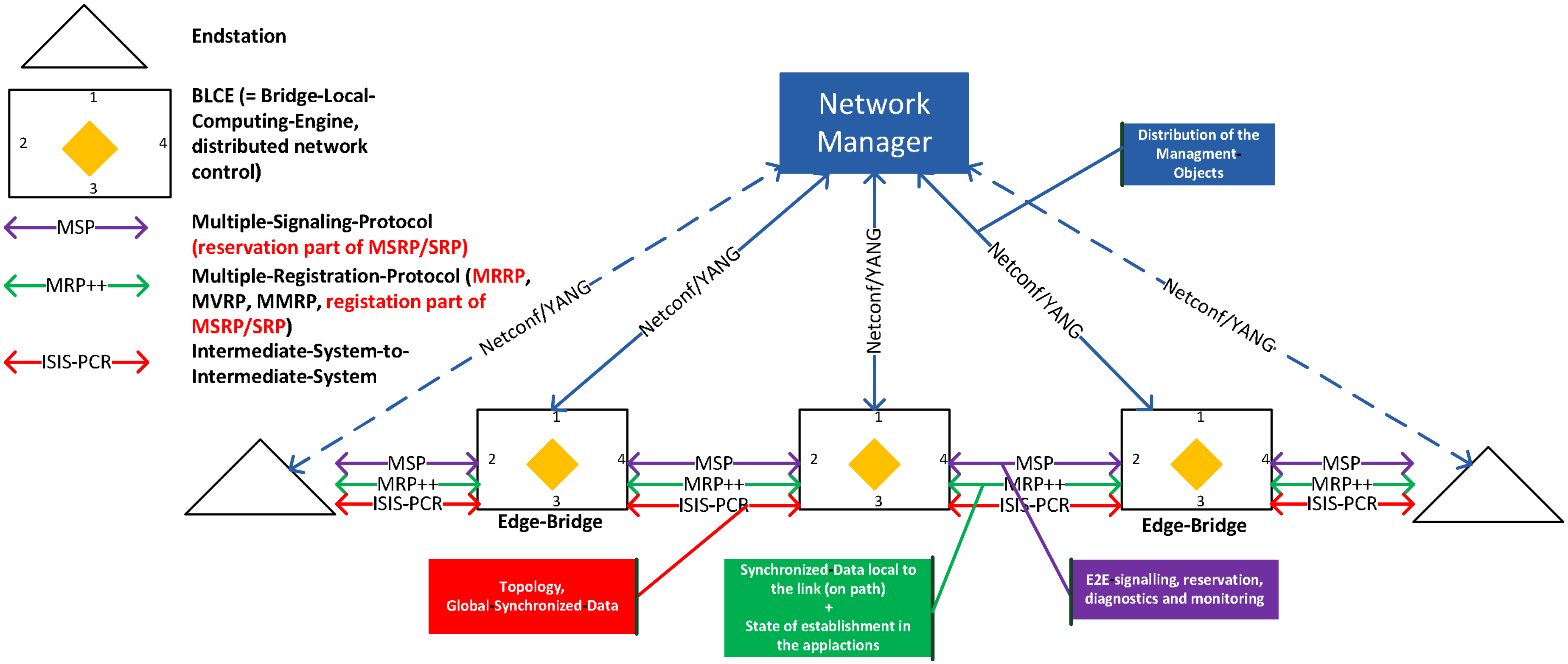
- *Support for more streams. The current worst case limit is less than 500 streams; there are use cases hat require two orders of magnitude greater than this.*
- *Inclusion of additional parameters and mechanisms in the stream reservation protocol that support additional applications, such as higher reliability, latency requirements, and latency changes due to network reconfiguration.*
- *Support for higher layer streaming sessions, such as Real-Time Protocol (RTP)-based sessions.*
- *Deterministic stream reservation convergence.*

With MSRP/SRP we have already overloaded MRP AND with MRRP and additional parameters to describe streams (supporting high reliability). TSN is continuing overloading MRP *(more data objects, more MRP PDU's, more applications, more …)*

Proposal:
Splitting Registration and Reservation into MRP++ for registration and MSP for reservation (more details see pages 20 … 24)

Decentralized controlled Network
with Path Computation, Registration & Reservation

1. Fully Distributed Model (distinguishing registration & reservation)



Endstation

BLCE (= Bridge-Local-Computing-Engine, distributed network control)

Multiple-Signaling-Protocol (reservation part of MSRP/SRP)

Multiple-Registration-Protocol (MRRP, MVRP, MMRP, registation part of MSRP/SRP)

Intermediate-System-to-Intermediate-System

Distribution of the Managment-Objects

Topology, Global Synchronized Data

Synchronized-Data local to the link (on path) + State of establishment in the applctions

E2E signalling, reservation, diagnostics and monitoring

NEW:

- ***MRP++ for registration to support more data objects, streams, … with one PDU*** (ISIS like on link)
- ***MSP for reservation to support better performance and to support more reservation applications*** (which a necessary for converged networks like rate constrained best effort traffic)

TSN: Decentralized controlled Network with Path Computation, Registration & Reservation

BUT

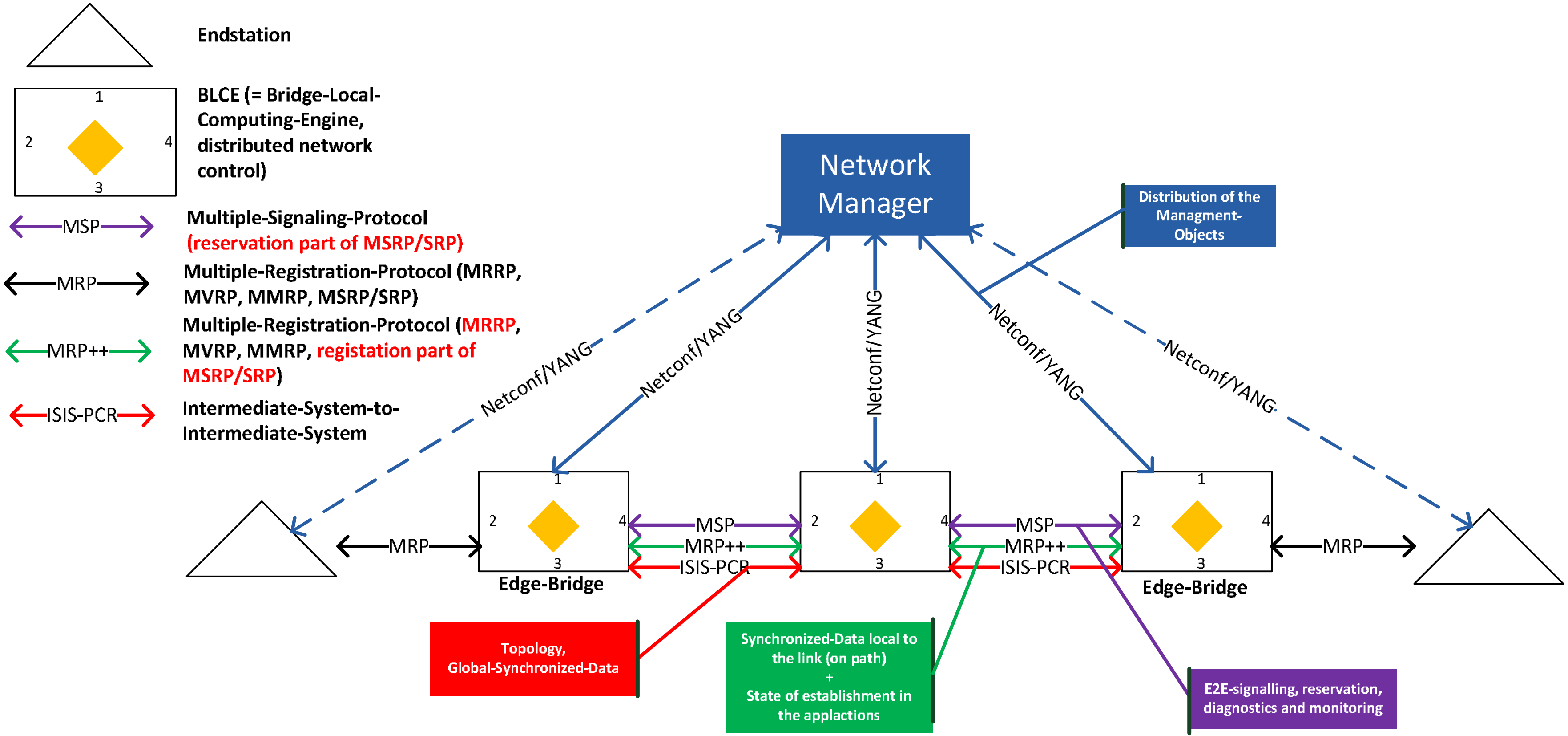
we have to be compatible to the current version of MRP (MRRP, MVRP, MMRP, MSRP/SRP)

AND

we should expand the current version of MRP to support the new TSN features.

Decentralized controlled Network
with Path Computation, Registration & Reservation

1. Fully Distributed Model (using existing MSRP/SRP as outbound interface)



Endstation

BLCE (= Bridge-Local-Computing-Engine, distributed network control)

MSP: Multiple-Signaling-Protocol (reservation part of MSRP/SRP)

MRP: Multiple-Registration-Protocol (MRRP, MVRP, MMRP, MSRP/SRP)

MRP++: Multiple-Registration-Protocol (MRRP, MVRP, MMRP, registation part of MSRP/SRP)

ISIS-PCR: Intermediate-System-to-Intermediate-System

Network Manager

Distribution of the Managment-Objects

Edge-Bridge

Edge-Bridge

Topology, Global-Synchronized-Data

Synchronized-Data local to the link (on path) + State of establishment in the applactions

E2E-signalling, reservation, diagnostics and monitoring

ToDo:

- ***Using existing MRP (including MRRP, MVRP, MMRP, MSRP/SRP) for registration & reservation between end station and edge bridge*** *(guess UNI-Interface)*
- ***Adding to existing MRP data objects for control (TLV's) to support new TSN features like redundancy***

Centralized Network / *Distributed User Model* with Path Computation, Registration & Reservation

ISIS-PCR, specified in .1Qca, supports also a centralized controlled network by introducing PCEs (Path-Computing-Element specified in IETF).

New TSN features like (seamless) redundancy, time aware shaper (TAS) are based on path computing.

Proposal 1 - Using ISIS-PCR also for registration:

- Using PCE for centralized path computing
- ISIS-PCR is used for topology discovery
  - and to distribute Stream specification (currently not in .1Qca)
  - and to distribute the “Explicit Trees” for streams
- Using MSP for Stream reservation (E2E signaling)

Centralized Network / *Distributed User Model* with Path Computation, Registration & Reservation

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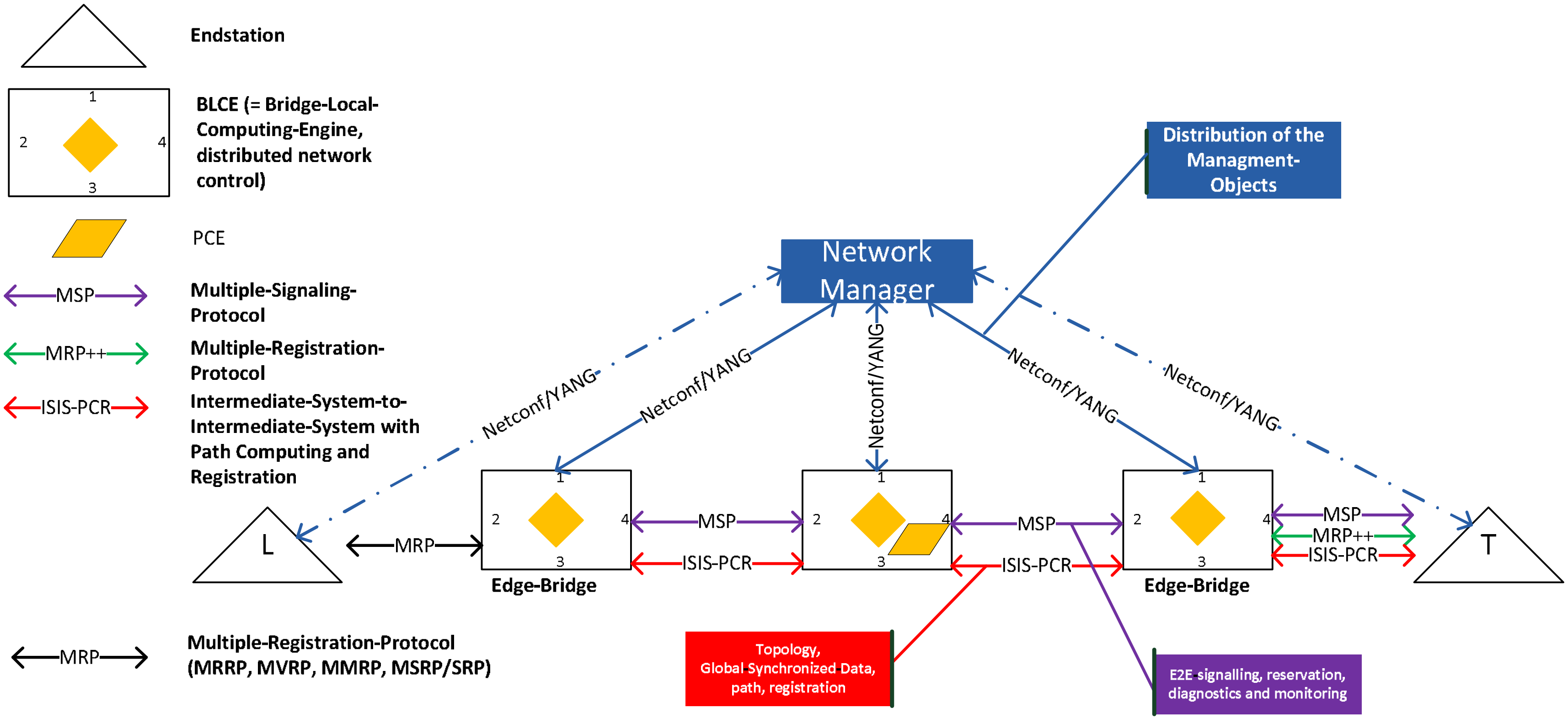
2. Centralized Network / *Distributed User Model* (Using ISIS-PCR also for registration)



Endstation
1
2
4
3
BLCE (= Bridge-Local-Computing-Engine, distributed network control)
PCE
MSP
Multiple-Signaling-Protocol
MRP++
Multiple-Registration-Protocol
ISIS-PCR
Intermediate-System-to-Intermediate-System with Path Computing and Registration
MRP
Multiple-Registration-Protocol (MRRP, MVRP, MMRP, MSRP/SRP)
Distribution of the Managment-Objects
Network Manager
Netconf/YANG
Netconf/YANG
Netconf/YANG
Netconf/YANG
Netconf/YANG
L
T
MRP
MSP
ISIS-PCR
MSP
ISIS-PCR
MSP
MRP++
ISIS-PCR
Edge-Bridge
Edge-Bridge
Topology, Global Synchronized Data, path, registration
E2E signalling, reservation, diagnostics and monitoring

Proposal 1:

- ***PCE for centralized path computing***
- ***ISIS-PCR is used for topology discover and distributing registration for data objects for network control*** *(e.g. stream specification)*
- ***MSP is used for stream reservation and also E2E signaling***

Centralized Network / *Distributed User Model* with Path Computation, Registration & Reservation

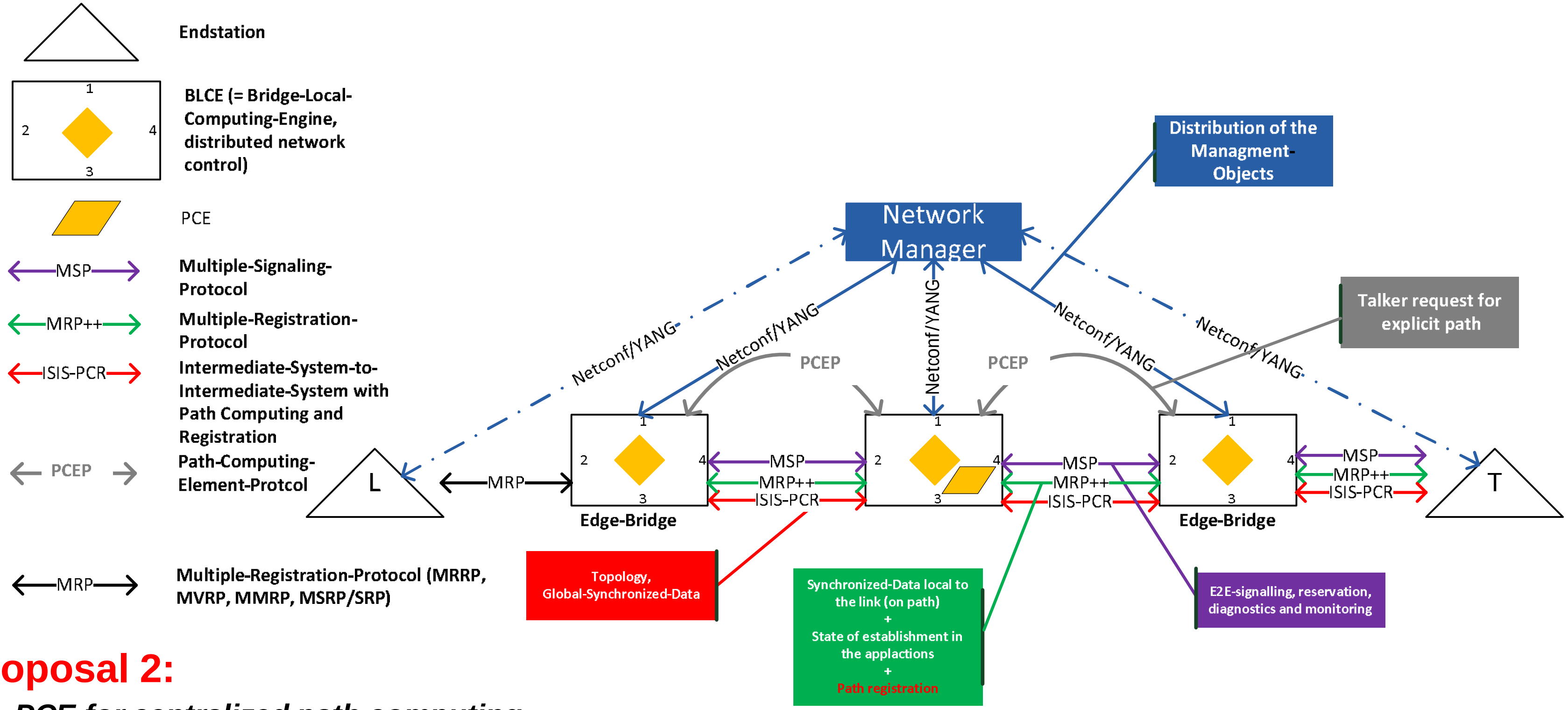
ISIS-PCR, specified in .1Qca supports also a centralized controlled network by introducing PCE's (Path-Computing-Element specified in IETF) supporting the new TSN features like (seamless) redundancy based on path computing

Proposal 2 - Introducing PCEP for path computing request / response and using MRP++ for "Explicit Tree" registration:

- Using PCE for centralized path computing
- Using ISIS-PCR for topology discovery
- Introducing PCEP (Path-Computing-Element-Protocol original specified in IETF) to
  - request / response for path-computing (communication relation)
- Using MRP++ to distribute
  - "Explicit Tree" for streams (gained by PCEP response)
  - stream specification
- Using MSP for Stream reservation (E2E signaling)

Centralized Network / *Distributed User Model* with Path Computation, Registration & Reservation

2. Centralized Network / *Distributed User Model* (Introducing PCEP for path computing request / response and using MRP++ for “Explicit Tree” registration)



Endstation
1
2
4
3
BLCE (= Bridge-Local-Computing-Engine, distributed network control)
PCE
MSP
Multiple-Signaling-Protocol
MRP++
Multiple-Registration-Protocol
ISIS-PCR
Intermediate-System-to-Intermediate-System with Path Computing and Registration
PCEP
Path-Computing-Element-Protocol
MRP
Multiple-Registration-Protocol (MRRP, MVRP, MMRP, MSRP/SRP)
Distribution of the Managment-Objects
Network Manager
Talker request for explicit path
Netconf/YANG
Netconf/YANG
Netconf/YANG
Netconf/YANG
Netconf/YANG
PCEP
PCEP
L
MRP
Edge-Bridge
MSP
MRP++
ISIS-PCR
MSP
MRP++
ISIS-PCR
MSP
MRP++
ISIS-PCR
Edge-Bridge
T
Topology, Global-Synchronized-Data
Synchronized-Data local to the link (on path) + State of establishment in the applactions + Path registration
E2E-signalling, reservation, diagnostics and monitoring

Proposal 2:

- *PCE for centralized path computing*
- *ISIS-PCR is only used for topology discover*
- *PCEP is used to request / response path computing for streams*
- *MRP++ is used for distributing also the data object for “Explicit Tree” and all the others*
- *MSP is used for stream reservation and also E2E signaling*

Centralized Network / *Distributed User Model* with Path Computation, Registration & Reservation

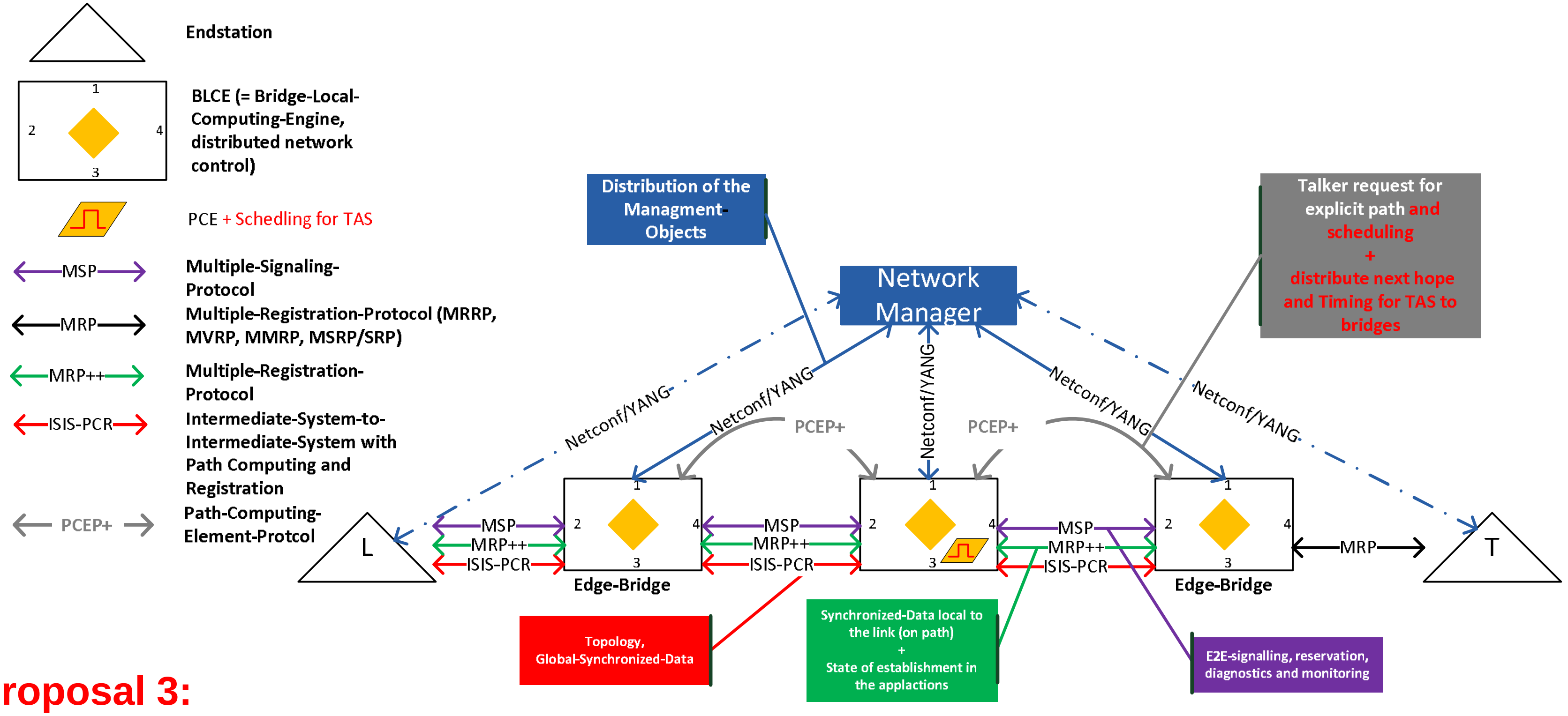
BUT to support SCHEDULING (TAS- time-aware-shaper) introducing new SCHEDULING-Function into PCEs is necessary. The current functionality of PCEP and also MRP must be extended.

Proposal 3 – Supporting "SCHEDULING":

- Using PCE for centralized path computing
- Using ISIS-PCR die topology discovery
- Using PCE for centralized path computing and scheduling for TAS (time aware shaper)
- Using PCEP+ to
  - request / response for path-computing and for scheduling for specified streams
  - the "Next Hop" for streams
  - distributing the window size for each scheduled traffic class and also distributing the information like which streams are scheduled
- Using MRP++ for registration of data objects for network control
- Using MSP for Stream reservation (looking that the Stream is correctly scheduled)

Centralized Network / *Distributed User Model* with Path Computation, Registration & Reservation

2. Centralized Network / *Distributed User Model* (supporting "SCHEDULING")



Endstation

BLCE (= Bridge-Local-Computing-Engine, distributed network control)

PCE + Schedling for TAS

MSP Multiple-Signaling-Protocol

MRP Multiple-Registration-Protocol (MRRP, MVRP, MMRP, MSRP/SRP)

MRP++ Multiple-Registration-Protocol

ISIS-PCR Intermediate-System-to-Intermediate-System with Path Computing and Registration

PCEP+ Path-Computing-Element-Protocol

Distribution of the Managment-Objects

Talker request for explicit path and scheduling + distribute next hope and Timing for TAS to bridges

Topology, Global-Synchronized-Data

Synchronized-Data local to the link (on path) + State of establishment in the applactions

E2E-signalling, reservation, diagnostics and monitoring

Proposal 3:

- *PCE for centralized path computing*
- *ISIS-PCR is used for topology discover*
- *PCEP+ is used to request / response path computing and scheduling + distributing data objects to each bridge along the path like window size, next hop information*
- *MRP++ to register data objects for network control, stream specification, …*
- *MSP is used for stream reservation and also E2E signaling*

Conclusion for
decentralized and centralized Approaches

General

- *Ongoing task in .1Qcc*
  - *Adding to existing MRP data objects for control (TLV's) to support new TSN features like redundancy*
  - *Specifying new Managed Objects which required to configure traffic classes*
- *New work item:*
  - Splitting Registration and Reservation into MRP++ for registration and MSP for reservation

For the "Centralized Network / Distributed User Model" there are 3 proposals:

- *Proposal 1 - Using ISIS-PCR also for registration -> will overload ISIS-PCR (scaling issue)!*
- *Proposal 2 - Introducing PCEP for path computing request / response and using MRP++ for "Explicit Tree" registration*
- *Proposal 3 - Supporting "SCHEDULING"*

New Work item for Proposal 2 + 3:

- *Standardizing PCEP and its date objects for Ethernet (supporting also optional "Scheduled Traffic") within IEEE 802.1*

=> Discussion: How to proceed?

Thank you for your attention!

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Backup

The following slides contain further details!

Motivation splitting Registration and Reservation in MRP++ (MRPv2) and MSP

Motivation for V2 MRP (Multiple Registation Protocol) and V1 MSP (Multiple Signaling Protocol)

MRP v1		MRP v2 "transport-protocol" for applications like MVRP, MMRP, MSRP, ...
Pro (also Supported by new Version)	**Cons**	**Features**
Distribution of network attributes over context	No fragmentation - limits the number of attributes. This problem is partly solved by spending one seperate frame for each application or application instance. The disadvantige of the current solution that high computing power is required for serialization and dserialization.	+' Support Fragmentation '+' One MRP frame for all applications (including all attribute lists and states) '+' Sperate checksum for each attribute list
One basic machnism for different applications (MVRP, MMRP,...)	Very complex and intransparent state machines -> difficult to synchronize implementations from different vendors	+' Simplified state machine and synchronization mechanism
Common architecture (aplication-->instance-->attribute)		
	MSRP combines registration and reservation, the attribute size (advertise) is very large and extended the MAP mechanism and introduced four packed events exclusiv for MSRP	+' MSRPv2 is only a registration protocol to register stream attributes (e.g. TSpec, TC, SR-DA, SR-ID, VID, ...)
	The pack mechanism form MRP is not practical (only for special use cases)	+' By introducing fragmentation the packed mechnism is no longer necessary
		+' Extending existing apllications (MVRP, MMRP, MSRP) to support redundancy and seamless redundancy on precalculated trees '+' If necessary add a new application like MRRP
		+' Optional suport for higher layers like IP (e.g. transport higher layer addresses, QoS specifier, ..) by e.g. using TLV's
		+' Managed Objects
		+' TLV's are used to specify the MRP attributes
		+' The mechanism to synchronize the attribute list on a link is compareable to the synchronziation mechanism used by ISIS (ISIS-like)
		MSP ("RSVP like") ("MSP is a seperate transport-protocol" for e.g. stream reservation)
	MSRP combines registration and reservation, the attribute size (advertise) is very large and extended the MAP mechanism and introduced four packed events exclusiv for MSRP	+' MSSP (Multiple Stream Signaling Protocol) is a applicaiton for MSP which is used for stream reservation, e2e signalling and diagnostic. The context, which is required for forwarding the signal / reservation, is either built by MRP or ISIS-PCR
		+' Optional suport for higher layers like IP (e.g. transport higher layer addresses, QoS specifier, ..) by e.g. using TLV's
		+' Managed Objects

Support for more streams. The current worst case limit is less than 500 streams; there are use cases that require two orders of magnitude greater than this.

Support for higher layer streaming sessions, such as Real-Time Protocol (RTP)-based sessions

Deterministic stream reservation convergence -> request for performance

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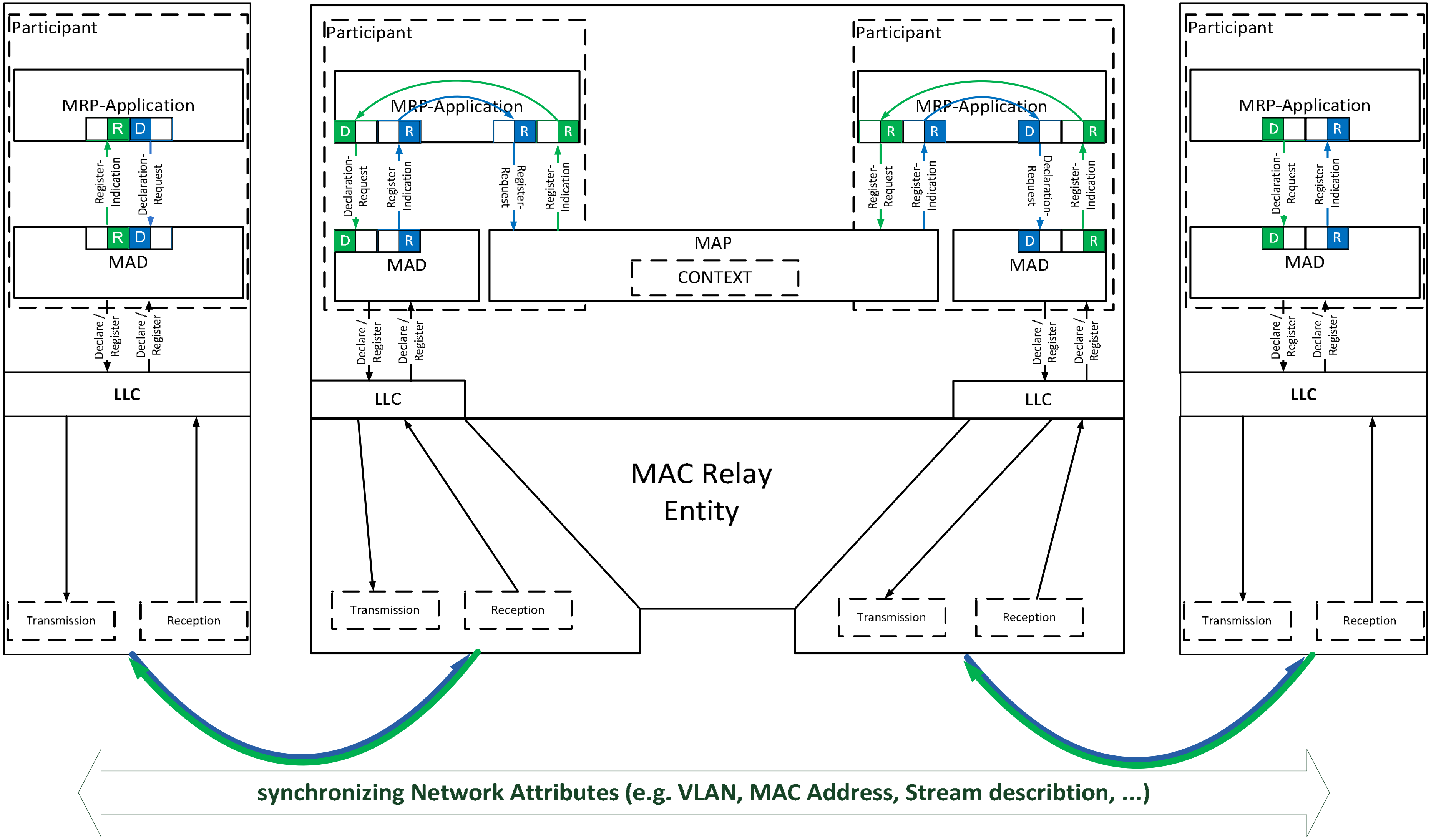
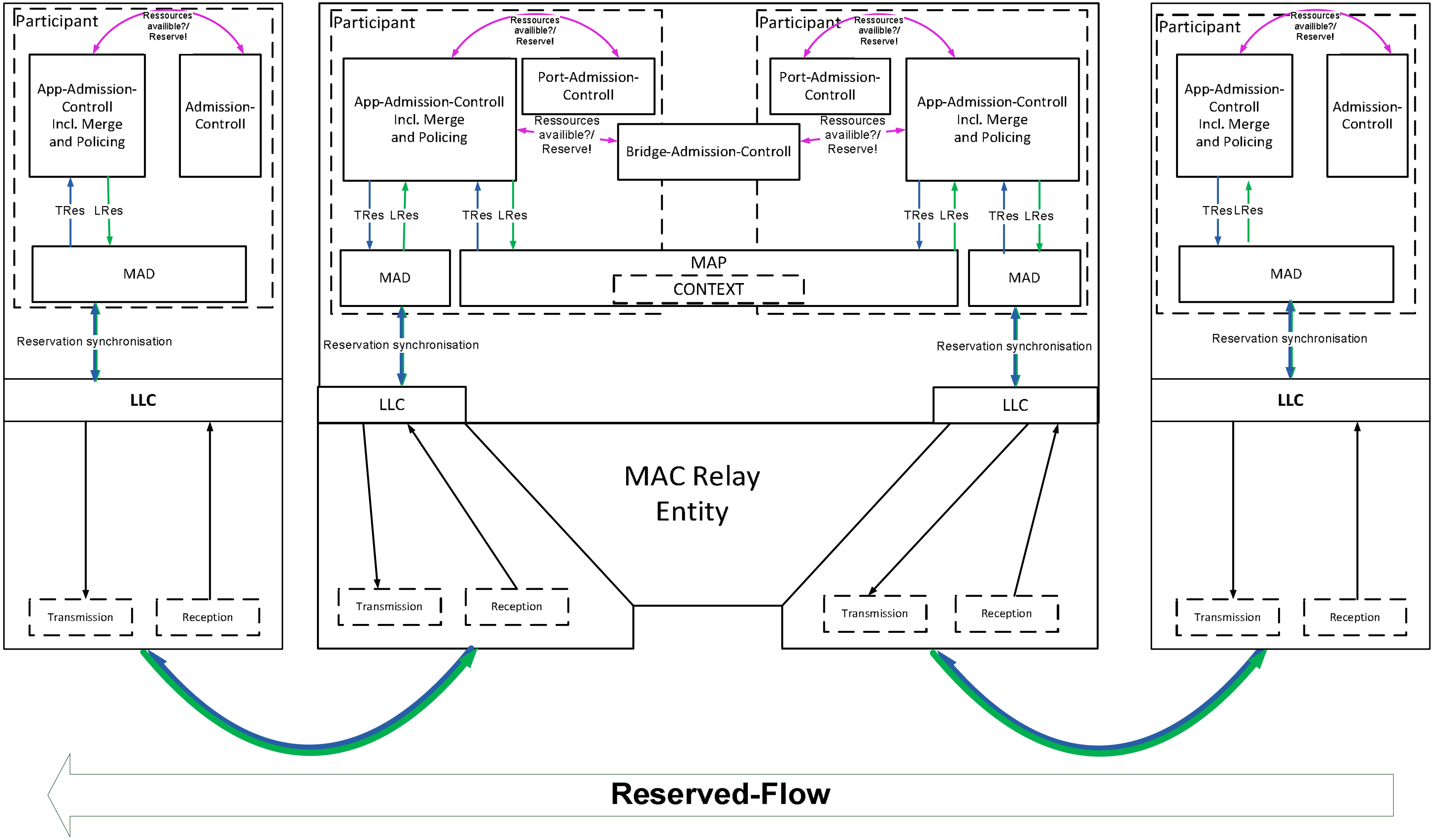
MRP++ Architecture



MSP Architecture


Participant
Ressources availible?/ Reserve!
App-Admission-Controll Incl. Merge and Policing
Admission-Controll
TRes
LRes
MAD
Reservation synchronisation
LLC
Transmission
Reception
Participant
Ressources availible?/ Reserve!
App-Admission-Controll Incl. Merge and Policing
Port-Admission-Controll
Ressources availible?/ Reserve!
Bridge-Admission-Controll
TRes
LRes
TRes
LRes
MAD
MAP
CONTEXT
Reservation synchronisation
LLC
Participant
Ressources availible?/ Reserve!
Port-Admission-Controll
App-Admission-Controll Incl. Merge and Policing
Ressources availible?/ Reserve!
TRes
LRes
TRes
LRes
MAD
Reservation synchronisation
LLC
MAC Relay Entity
Transmission
Reception
Transmission
Reception
Participant
Ressources availible?/ Reserve!
App-Admission-Controll Incl. Merge and Policing
Admission-Controll
TRes
LRes
MAD
Reservation synchronisation
LLC
Transmission
Reception
Reserved-Flow

Data model for splitting the existing MSRP to MSRP on MRP++ and MSSP on MSP

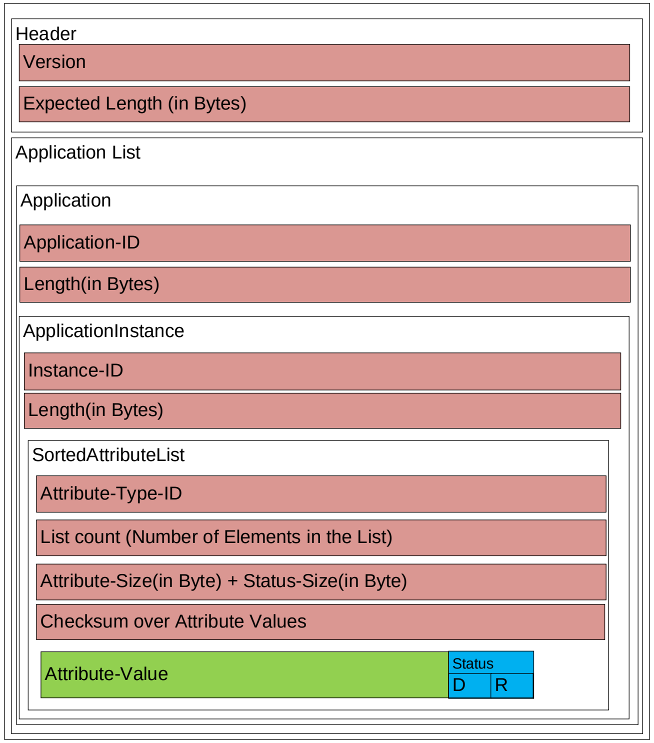
New
Static Information
Dynamic Information

	Talker Advertise		*Talker Failed*		*Listener*		*Domain*
MSRP on MRP	StreamID	Talker Sys-ID	StreamID	Talker Sys-ID	StreamID	Talker Sys-ID	StreamClassID
		Unique-ID		Unique-ID		Unique-ID	StreamClassPriority
	DataFrameParameters	Dest-Address	DataFrameParameters	Dest-Address	FourPackedEvent	Ready / ReadyFailed / AskingFailed / Ignore	StreamClassVid
		VID		VID			
	Tspec	MaxFrameSize	Tspec	MaxFrameSize			
		MaxInterval		MaxInterval			
	PriorityAndRank	DataFramePriority	PriorityAndRank	DataFramePriority			
		Rank		Rank			
	AccumulatedLatency	portTxMaxLatency	AccumulatedLatency	portTxMaxLatency			
			FailureInformation	BridgeID			
				FailureCode			

	Talker Advertise		*Listener*		*Domain*
MSRPv2 on MRP++	StreamID	Talker Sys-ID	StreamID	Talker Sys-ID	StreamClassID
		Unique-ID		Unique-ID	StreamClassPriority
	DataFrameParameters	Dest-Address	Rspec	MinRecvInterval	StreamClassVid
		VID	Listener ID	Listener Sys-ID	
	Tspec	MaxFrameSize			
		MaxInterval			
	PriorityAndRank	DataFramePriority			
		Rank			
MSSP on MSP	StreamID	Talker Sys-ID	StreamID	Talker Sys-ID	
		Unique-ID		Unique-ID	
	AccumulatedLatency (Calculated downstream)	portTxMinLatency	RequiredLatency (Calculated upstream)	portRxMinLatency	
		portTxMaxLatency		portRxMaxLatency	
	State	ok?	AccumulatedRspec	AccMinRecvInterval	
	List<FailureInformation>	BridgeID	State	Ready / ReadyFailed / Failed	
		FailureCode	List<FailureInformation>	BridgeID	
				FailureCode	

MRP++ Frame Format

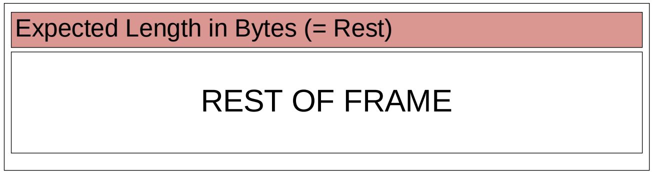
Frame:



MRP-PDU	→ Header, ApplicationList
Header	→ Version, ExpectedLength
Version	→ UINT8
ExpectedLength	→ Length
Length	→ UINT16
ApplicationList	→ Application*
Application	→ ***ApplicationId***,Length,ApplicationInstance*
ApplicationId	→ ID
ID	-> UINT8
ApplicationInstance	→ InstanceID,Length,SortedAttributeList*
InstanceID	→ UINT16
SortedAttributeList	→ ListHeader,ListBody
ListHeader	→ ***AttTypeId***,ListCount,***AttributeSize,***Checksum
AttTypeId	→ ID
ListCount	→ UINT8
AttributeSize	→ UINT8
Checksum	→ Fletcher-16
ListBody	→ Attribute*
Attribute	→ Value,State
Value	→ ***Attribute value defined by Application***
State	→ Declarator, Registrar
Declarator	→ BIT
Registrar	→ BIT

Red: TBD(unsure)
Green: Defined By Application
**** := 0 - N***

Fragment:



Expected Length in Bytes (= Rest)
REST OF FRAME