cc-cummings-time-sync-uni/D0.2

Proposal for Reservation of Time Sync Resources in the TSN UNI

Editor's Foreword

The user/network interface (UNI) of 802.1Qcc is specified in clause 99 of the latest draft for task group ballot, available at:

http://ieee802.org/1/files/private/cc-drafts/

The 'user' of this interface represents a higher-layer application that requires time-sensitive networking (TSN) for its Talkers and Listeners. The 'network' of this interface represents various protocols and standards that deliver TSN features. The network protocols reserve resources such as entries for forwarding/filtering of frames, configuration of shaping and scheduling, queue space for required bandwidth, translation of IP packets to/from MAC/VLAN frames, seamless redundancy, and so on.

The benefits of the TSN UNI in 802.1Qcc include:

— **Abstraction of network details from user**: The user's application specifies only what it knows already... its data frame, and its requirements of the network (e.g. worst-case latency). The network handles the details from there.

— **Protocol independence**: Specific network protocols and configuration models are not forced on the user. The TSN UNI can be incorporated into existing user protocols. Different degrees of centralization are supported.

— **Configuration of network within user**: Existing user protocols can be used to configure network details within the user's hardware (i.e. end station).

These benefits also apply to reservation of resources for time synchronization (e.g. IEEE 1588 profiles).

This document contains a proposal for reservation of time sync resources in the TSN UNI. The contents are provided as amendment text to the recent 802.1Qcc draft. This proposal is not formally part of the 802.1Qcc project.

This document contains two new subclauses:

— **12.28.7 Redundant Time Sync**: Managed objects for Bridge that supports TSN remote management, to configure redundant time sync.

— **99.2.5 TimeApp Group, 99.2.6 TimeAppStatus Group**: User-level requirements for time sync, including redundancy algorithms above 802.1AS and 1588 specifications.

<<Editor's introduction to draft D0.0

This is the initial proposal in the form of draft amendments to 802.1Qcc draft text.

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12. Bridge management

12.28TSN remote management

Insert this new subclause at the end of subclause 12.28. Change "12.28.7" to the appropriate number for the last subclause. Change "Table 12-90" and subsequent table numbers to appropriate numbers for the last subclause.

12.28.7 Redundant Time Sync

A Bridge may support the capability of using multiple domains of a time synchronization profile (e.g. IEEE 802.1AS, IEEE 1588 Default P2P) for redundancy. The redundancy substantially reduces the probability of time synchronization loss due to equipment failures, including failures in the sources of time (e.g. IEEE 1588 grandmaster), intermediate systems (e.g. IEEE 1588 boundary clock), and the communication medium between stations. This subclause specifies attributes of managed objects that configure operation of redundant time sync.

There are one or more instances of the Redundant Time Sync managed object per Bridge component. The set of Redundant Time Sync managed object attributes is shown in Table 12-90.

Table 12-90—Redundant Time Sync Attributes

Name	Data type	Operations supported[a]	Conformance[b]	References
configChange	Boolean	RW	b	12.28.7.1
supportedRedundancyAlgorithms	list of unsigned integer	R	b	12.28.7.2
adminRedundancyAlgorithm	unsigned integer	RW	b	12.28.7.3
operRedundancyAlgorithm	unsigned integer	R	b	12.28.7.4
supportedProfileIdentifiers	list of octet[6]	R	b	12.28.7.5
adminProfileIdentifier	octet[6]	RW	b	12.28.7.6
operProfileIdentifier	octet[6]	R	b	12.28.7.7
supportedBridgeApplications	list of unsigned integer	R	b	12.28.7.8
adminBridgeApplications	list of unsigned integer	RW	b	12.28.7.9
operBridgeApplications	list of unsigned integer	R	b	12.28.7.10
supportedDomainNumsMax	unsigned integer	R	b	12.28.7.11
supportedGrandMaster	Boolean	R	b	12.28.7.14

[a]R = Read only access; RW = Read/Write access
[b]b = Optional for bridge or bridge component support of TSN remote management; if one attribute is supported, all attributes in the table shall be supported

There is one instance of the Redundant Time Sync Port managed object per Redundant Time Sync managed object, per Port. The set of Redundant Time Sync Port managed object attributes is shown in Table 12-91.

Table 12-91—Redundant Time Sync Port Attributes

Name	Data type	Operations supported[a]	Conformance[b]	References
adminDomainNums	list of unsigned integer	RW	b	12.28.7.12
operDomainNums	list of unsigned integer	R	b	12.28.7.13
adminGMDomainNums	list of unsigned integer	RW	b	12.28.7.15
operGMDomainNums	list of unsigned integer	R	b	12.28.7.16

[a]R = Read only access; RW = Read/Write access
[b]b = Optional for bridge or bridge component support of TSN remote management; if one attribute in Table 12-90 is supported, all attributes in Table 12-91 shall be supported

12.28.7.1 configChange

When configChange is set FALSE by management, nothing occurs. The default value is FALSE.

When configChange is set TRUE by management, that acts as a start signal for the following steps:

1) Shut down all operational time sync domains for redundancy (operDomainNums). Each domain shuts down as specified in the operational profile (operProfileIdentifier).
2) Shut down the operational redundancy algorithm (operRedundancyAlgorithm) as described in its specification.
3) If the operational time applications (operBridgeApplications) specify behavior when the underlying time shuts down, execute that behavior.
4) Copy each administrative attribute (prefix “admin”) in Table 12-90 and Table 12-91 to the corresponding operational attribute (prefix “oper”).
5) Initialize all operational time sync domains for redundancy (operDomainNums). Each domain initializes as specified in the operational profile (operProfileIdentifier).
6) Initialize the operational redundancy algorithm (operRedundancyAlgorithm) as described in its specification.
7) If the operational time applications (operBridgeApplications) specify behavior when the underlying time initializes, execute that behavior.
8) configChange is set FALSE by the Bridge.

12.28.7.2 supportedRedundancyAlgorithms

The supportedRedundancyAlgorithms attribute provides a list of all redundancy algorithm values supported by adminRedundancyAlgorithm (12.28.7.3) of this Bridge.

12.28.7.3 adminRedundancyAlgorithm

The adminRedundancyAlgorithm is an enumerated value that specifies the algorithm for redundant time sync of the domains listed in adminDomainNums (12.28.7.12). The enumeration uses an Organizationally Unique Identifer (OUI) or Company Identifier (CID) along with a type number, as shown in Table 12-92.

Table 12-92—Redundant Time Sync Algorithms

Enumeration	OUI / CID	Type number	Algorithm
Algo_BMCA	00-80-C2	0	Best Master Clock Algorithm (default)
Algo_None	00-80-C2	1	Single fixed grandmaster
	00-80-C2	2-255	reserved
	other		specified by entity owning the OUI or CID

The specifications for each algorithm in Table 12-92 are expected to specify the following:

a) What time sync profiles are supported for each domain?
b) What managed objects are specific to the algorithm?
c) What timescales and traceability does the algorithm support (e.g. IEEE Std 1588 ARB and/or PTP)?
d) What are the effects on precision/accuracy when a failure appears (and is resolved)?
e) Can a bounded (i.e. worst-case) precision/accuracy be provided to all stations using the algorithm?
f) If more than one domain is used:
   — How is frequency from the domains combined to form a single application time?
   — How is phase (epoch) from the domains combined to form a single application time?
   — What is the procedure for detecting and mitigating a failure?
   — How many failures can be mitigated?
   — What failure modes are mitigated (e.g. fail-silent, fail-inconsistent)?
   — For a given set of failure requirements, how many domains are used for multiple grandmasters?
   — For a given set of failure requirements, how many domains are used for multiple paths?

The default enumeration Algo_BMCA (00-80-C2, 0) specifies the Best Master Clock Algorithm (BMCA). The BMCA uses a single domain, and the grandmaster of that domain is chosen using a protocol on the network. The BMCA is specified by IEEE Std 1588, and it is the default algorithm for profiles of IEEE Std 1588. IEEE Std 1588 allows for profiles to specify an alternate BMCA that is specific to the profile. If the profile in adminProfileIdentifier specifies an alternate BMCA, the Algo_BMCA enumeration shall refer to that alternate BMCA, otherwise Algo_BMCA shall reference the IEEE Std 1588 BMCA.

NOTE 1 — IEEE Std 802.1AS specifies an alternate BMCA.

The enumeration Algo_None (00-80-C2, 1) specifies use of the external port state feature of IEEE Std 1588 (and IEEE Std 802.1AS), no BMCA, a single domain, a single grandmaster at a fixed location in the network, and master/slave port states for the path to each slave configured externally (i.e. by management, or preconfigured).

NOTE 2 — If a Bridge's support for redundant time sync is limited to Algo_BMCA and/or Algo_None, support for the Redundant Time Sync managed object is not typical. The Redundant Time Sync managed object is most appropriate for support of algorithms that use more than one domain.

<<Editor's note: The preceding NOTE 2 begs the obvious question: "Where are the multi-domain algorithms? A proposal with normative specs is in work for at least one algorithm, to be presented in future 802.1 meetings.>>

If management sets a value for adminRedundancyAlgorithm that is not listed in supportedRedundancyAlgorithms, an error shall be returned.

12.28.7.4 operRedundancyAlgorithm

The operRedundancyAlgorithm attribute provides the operational value for adminRedundancyAlgorithm (12.28.7.3). The configChange attribute (12.28.7.1) specifies the procedure for copying administrative attributes to operational attributes.

12.28.7.5 supportedProfileIdentifiers

The supportedProfileIdentifiers attribute provides a list of all profile identifier values supported by adminProfileIdentifier (12.28.7.6) of this Bridge.

12.28.7.6 adminProfileIdentifier

The adminProfileIdentifier attribute identifies the time sync profile (i.e. standard) that each domain in adminDomainNums uses. The encoding of the value shall use the profileIdentifier from IEEE Std 1588. The IEEE Std 1588 profileIdentifier consists of three octets for the OUI or CID of the organization defining the profile, following by one octet for the profileNumber that is unique within the organization, followed by one octet for the primaryVersion of the profile, followed by one octet for the revisionNumber within the primary version.

The default value of adminProfileIdentifier is product specific, using a value from supportedProfileIdentifiers.

If management sets a value for adminProfileIdentifier that is not listed in supportedProfileIdentifiers, an error shall be returned.

NOTE — A profile for time synchronization doesn't need to conform to IEEE Std 1588 in order to use the profileIdentifier encoding.

12.28.7.7 operProfileIdentifier

The operProfileIdentifier attribute provides the operational value for adminProfileIdentifier (12.28.7.6). The configChange attribute (12.28.7.1) specifies the procedure for copying administrative attributes to operational attributes.

12.28.7.8 supportedBridgeApplications

The supportedBridgeApplications attribute provides a list of all bridge application values supported by adminBridgeApplications (12.28.7.9) of this Bridge.

12.28.7.9 adminBridgeApplications

The adminBridgeApplications attribute specifies a list of enumerated values. Each enumerated value specifies an application within the Bridge that uses this redundant time as a source. Each enumeration uses an Organizationally Unique Identifer (OUI) or Company Identifier (CID) along with a type number, as shown in Table 12-93..

Table 12-93—Redundant Time Sync Bridge Applications

Enumeration	OUI / CID	Type number	Bridge application
App_Scheduled	00-80-C2	0	Scheduled traffic (8.6.8.4, 8.6.9)
	00-80-C2	1-255	reserved
	other		specified by entity owning the OUI or CID

The default value of adminBridgeApplications is an empty list, indicating that the Bridge transfers time as specified for adminProfileIdentifier and adminRedundancyAlgorithm, but no additional application in the Bridge makes use of that redundant time.

The enumeration App_Scheduled (00-80-C2, 0) specifies that the Bridge uses the redundant time as the source for scheduled traffic (8.6.8.4, 8.6.9).

If management sets a value for adminBridgeApplications that is not listed in supportedBridgeApplications, an error shall be returned.

NOTE — Each bridge application uses a single source of time. Therefore, if the same enumerated value is used in multiple adminBridgeApplications (i.e. multiple instances of the Redundant Time Sync managed object), the resulting configuration can be invalid.

<<Editor's note: This version of the proposal doesn't neccesarily consider a "profile gateway" that runs one profile A on some ports (e.g. 1 and 2), and a different profile B on other ports (e.g. 3 and 4). Nevertheless, such a product could be modeled with two Redundant Time Sync managed objects, both of which use App_Scheduled in adminBridgeApplications. That is why we don't to say that use of App_Scheduled twice is a "shall not".>>

12.28.7.10 operBridgeApplications

The operBridgeApplications attribute provides the operational value for adminBridgeApplications (12.28.7.9). The configChange attribute (12.28.7.1) specifies the procedure for copying administrative attributes to operational attributes.

12.28.7.11 supportedDomainNumsMax

The supportedDomainNumsMax attribute provides the maximum number of domain number values that can be successfully set in adminDomainNums (12.28.7.12) of all Ports of this Redundant Time Sync managed object.

12.28.7.12 adminDomainNums

The adminDomainNums attribute specifies the list of domain number values used for redundant time sync on this Port. Each domain number in the list is a single octet whose meaning is specified by the profile (adminProfileIdentifier).

The default value of adminDomainNums is an empty list, indicating that no domain numbers are configured on this Port.

If management sets a value for adminDomainNums such that the number of unique values in all adminDomainNums lists exceeds supportedDomainNumsMax, an error shall be returned.

12.28.7.13 operDomainNums

The operDomainNums attribute provides the operational value for adminDomainNums (12.28.7.12). The configChange attribute (12.28.7.1) specifies the procedure for copying administrative attributes to operational attributes.

12.28.7.14 supportedGrandMaster

The supportedGrandMaster attribute is a boolean that specifies whether the Bridge supports grandmaster (i.e. time source) capability.

12.28.7.15 adminGMDomainNums

The adminGMDomainNums attribute specifies the list of domain number values used as a grandmaster (i.e. time source) for redundant time sync on this Port. Each domain number can also be used as a slave (i.e. time sink), as specified by the adminRedundancyAlgorithm. Each domain number in the list is a single octet whose meaning is specified by the profile (adminProfileIdentifier).

The default value of adminGMDomainNums is an empty list, indicating that no domain numbers are configured as grandmaster on this Port.

If management sets a non-empty list for adminGMDomainNums when supportedGrandMaster is FALSE, an error shall be returned.

Prior to setting configChange to TRUE, the domain number values in adminGMDomainNums are expected to be a subset of the domain number values in adminDomainNums. The domain number values in adminDomainNums that are not listed in adminGMDomainNums are expected to be a slave only.

12.28.7.16 operGMDomainNums

The operGMDomainNums attribute provides the operational value for adminGMDomainNums (12.28.7.15). The configChange attribute (12.28.7.1) specifies the procedure for copying administrative attributes to operational attributes.

99. Time-Sensitive Networking (TSN) Configuration

99.2 User/Network Configuration

99.2.1 Protocol Integration

The TSN configuration information (UNI) consists of three high level groups:

— **Talker**: Elements from user to network that specify the Talker for a single Stream.

— **Listener**: Elements from user to network that specify the Listener for a single Stream.

— **Stream status**: Elements from network to user that specify the status of the Stream's network configuration. This group notifies the user when the Stream is ready for use (or a failure occured).

A protocol that supports TSN configuration shall integrate the three groups using the TLV or YANG specifications in this clause. The integration is provided in each protocol's specifications (not in this clause). Within each protocol's specifications, the TLV/YANG groups should be used by reference where feasible (rather than copy the text from this clause). One example of this integration is specified in the Stream Reservation Protocol (SRP) specifications of this standard (Clause 35).

Each TSN configuration protocol shall use the Stream ID of this clause (99.2.5.1) as the unique identifier of each Stream's configuration. This Stream ID shall be used to correlate each Talker/Listener group to its corresponding stream status group. The Stream ID identifies configuration not data, so it has no formal relation to the data frame encoding for the Stream.

Insert the following text as shown.

The TSN configuration information (UNI) may support two high level groups:

— **TimeApp**: Elements from user to network that specify time synchronization requirements for a specific application in the network. The application typically refers to a higher layer application protocol (e.g. IEEE Std 1722). These requirements can apply to multiple Streams in the end station, and multiple TimeApps can exist in each end station.

— **TimeAppStatus**: Elements from network to user that specify the status of the TimeApp's configuration in the network.

If the application makes use of a known time synchronization profile operating on a default domain (e.g. IEEE Std 802.1AS-2011, IEEE Std 1588-2008 Default E2E), the TimeApp groups are not needed. The TimeApp groups enable use of more than one domain, such as for redundant time sync algorithms.

<<Editor's note: If/when the TSN task group moves forward with this proposal, we may select a different term than 'TimeApp'. At that time the editor can search&replace TimeApp with the new term. >>

TSN configuration can be viewed conceptually as a request/response exchange:

— Request: End station transmits a protocol message that contains a single Talker or Listener group.

— Response: Bridge or CNC transmits a protocol message that contains a single stream status group.

99.2.5 TimeApp Group

YANG specification:

```
container TimeApp {
      description
            "The TimeApp group contains elements from user to network
            that specify time synchronization requirements for a
            specific application in the network. The application
            typically refers to a higher layer application protocol
            (e.g. IEEE Std 1722). These requirements can apply to
            multiple Streams in the end station, and multiple TimeApps
            can exist in each end station.";

      container TimeAppIdentifier { /* 99.2.5.1 */ }
      container EndStationInterfaces { /* 99.2.5.2 */ }
      container NetworkRequirements { /* 99.2.5.3 */ }
      container InterfaceCapabilities { /* 99.2.5.4 */ }
}
```

Figure 99-10 provides the TLV specification.

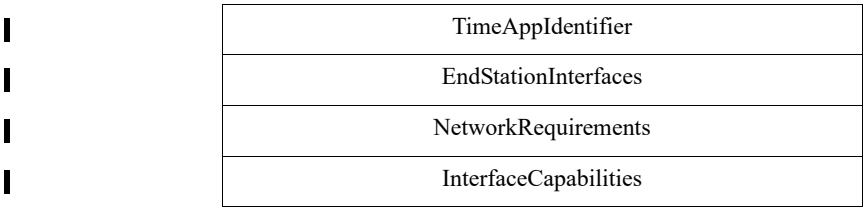

Figure 99-10 — TimeApp Group for TLV

99.2.5.1 TimeAppIdentifier

<<Editor's note: The encoding and semantics of TimeAppIdentifier will be the same as StreamIdentifier of Qcc: an individual MAC address and a 16-bit Unique ID. As with StreamIdentifier, the TimeAppIdentifier is used by the applications in end stations to agree on requirements and configuration, for reservation of time sync resources in the network. >>

99.2.5.2 EndStationInterfaces

<<Editor's note: The encoding and semantics of EndStationInterfaces will be the same as EndStationInterfaces of Qcc: unique and persistent identification of each interface in the end station, using MAC address. >>

99.2.5.3 NetworkRequirements

YANG specification:

```
container NetworkRequirements {
      description
            "This YANG grouping specifies specifies user requirements
            for the configuration of the time application (TimeApp)
            in the network.";

      leaf NumFailures {
            type uint8;
            description
                  "This specifies the number of simultaneous failures
                  that the TimeApp can tolerate in the network.
                  The failure can occur in a source of time
                  (e.g. IEEE 1588 grandmaster), a Bridge
                  (e.g IEEE 1588 boundary clock), or the communication
                  medium between stations.

                  NOTE: For many applications, mitigation of a single
                  point of failure is sufficient, and this value
                  can be set to 1.";
      }
      leaf FailureMode {
            type enumeration {
                  enum FailSilent {
                        value 0;
                        description
                              "When the failure occurs, the
                              failed component goes silent.
                              The failure is assumed to be
                              permanent (i.e. failed
                              component offline until replaced).";
                  }
                  enum FailConsistent {
                        value 1;
                        description
                              "When the failure occurs, the
                              failed component remains operational.
                              The operational behavior is assumed
                              to be consistent on all paths (i.e.
                              on all Ports of a Bridge). The operational
                              behavior is assumed to be transient
                              (i.e. sometimes valid, sometimes invalid).
                              Examples of transient behavior are
                              missing frames, incorrect number
                              of frames, and invalid values of fields
                              of frames (including time).";
                  }
                  enum FailInconsistent {
                        value 2;
                        description
                              "When the failure occurs, the
```

```
                                    failed component remains operational.
                                    The operational behavior is assumed
                                    to be inconsistent (i.e. different on
                                    one path compared to another path).
                                    The operational behavior is assumed
                                    to be transient (see FailConsistent).";
                        }
                  }
                  description
                        "This requirement summarizes the assumptions for
                        when and how the failure will occur.";
            }
            leaf MaxPrecision {
                  type int64;
                  description
                        "This specifies the required maximum precision
                        in the network that must be provided for time
                        at all slaves, including when NumFailures failures
                        appear and/or are resolved. Time precision must
                        remain within plus or minus the specified
                        MaxPrecision.

                        The value of MaxPrecision is expressed in units of
                        nanoseconds and multiplied by 2^16. For example,
                        2.5 ns is expressed as 0000 0000 0002 8000
                        hexadecimal.";
            }
            leaf Timescale {
                  type boolean;
                  description
                        "The value TRUE specifies that the TimeApp
                        requires time to use the PTP epoch as specified in
                        IEEE Std 1588 (1 January 1970 00:00:00 TAI).
                        Traceability of time is implied, but not
                        required.

                        "The value FALSE specifies that the TimeApp
                        allows time to use an arbitrary epoch.
                        Although the PTP epoch is not required, redundant
                        time sync shall provide the same epoch at all
                        systems (to within MaxPrecision). Traceability
                        is not required.

                        When IEEE Std 1588 is used, when Timescale is
                        TRUE, the IEEE Std 1588 data set member
                        timeProperties.ptpTimescale shall be TRUE.";
            }
}
```

<<Editor's note 1: Timescale corresponds to my assumptions for "Is it a Universal Clock (true), or Working Clock (false)?>>

<<Editor's note 2: I realize that the definition MaxPrecision will require more work. Using the latest draft of the Time Inaccuracy TLV in 1588 (v1.1, Mar 7 2016), the network (i.e. CNC or MSRP++)

must guarantee that no slave sees a sum of all four "max" values in the TLV such that the sum is greater than MaxPrecision. Redundancy algorithms for 1588-rev profiles should state this as a normative requirement.>>

Figure 99-TODO provides the TLV specification.

<<Editor's note: I am omitting TLV specifications until the task group agrees to move forward with the proposal .>>

99.2.5.4 InterfaceCapabilities

<<Editor's note: The managed objects for redundant time sync in the Bridge (12.28.7) specify capabilities in the attributes that use the prefix "supported". Since we have bridge management for these capabilities, that information model can be applied in this subclause, for use by end station protocols (e.g. MSRP or MSRP++).

If we decide to move forward with this proposal, this subclause will essentially reference the collection of "supported" attributes from 12.28.7. The main addition will be to specify equivalent TLVs. >>

99.2.6 TimeAppStatus Group

YANG specification:

```
container TimeAppStatus {
      description
            "The TimeAppStatus group contains elements from
            network to user that provide the status of time
            synchronization in the network for an
            application (TimeApp). TimeAppStatus also
            provides network configuration for the end station
            interface(s).

            This top-level group is delivered to each
            station that sends a TimeApp group with the
            corresponding TimeAppIdentifier.";

      container TimeAppIdentifier { /* 99.2.5.1 */ }
      container StatusInfo { /* 99.2.6.1 */ }
      container InterfaceConfiguration { /* 99.2.6.2 */ }
      container FailedBridgeInterfaces { /* 99.2.6.3 */ }
}
```

99.2.6.1 StatusInfo

YANG specification:

```
container StatusInfo {
      description
            "StatusInfo provides information regarding the status
            of a time application's configuration in the network.";

      leaf Status {
            type enumeration {
                  enum None {
                        value 0;
                        description
                              "Time application not configured.";
                  }
                  enum Ready {
                        value 1;
                        description
                              "Time application successfully
                              configured.";
                  }
                  enum Failed { value 2;
                        description
                              "Failure in configuration on time
                              application.";
                  }
            }
            description
```

```
                    "This is an enumeration for the status of
                    the time application's configuration
                    in the network.";
        }
        leaf FailureCode {
              type uint8;
              description
                    "If the time application encounters a failure
                    (Status is Failed), FailureCode provides a
                    non-zero code that specifies the
                    problem. Table TODO describes each code.";
        }
}
```

<<Editor's note: I am omitting the failure code table until the task group agrees to move forward with the proposal .>>

99.2.6.2 InterfaceConfiguration

<<Editor's note: The managed objects for redundant time sync in the Bridge (12.28.7) specify configuration in the attributes that use the prefix "admin". Since we have bridge management for these capabilities, that information model can be applied in this subclause, for use by end station protocols (e.g. MSRP or MSRP++).

If we decide to move forward with this proposal, this subclause will essentially reference the collection of "admin" attributes from 12.28.7. The Bridge attibutes in Table 12-90 will be specified at the top-level of InterfaceConfiguration, for all interfaces in the end station. The Port attributes in Table 12-91 will be specified in a list with a per-interface key (i.e. MAC Address from EndStationInterfaces), much like Qcc's StreamStatus. This subclause will also specify equivalent TLVs. >>

99.2.6.3 FailedBridgeInterfaces

<<Editor's note: The encoding and semantics of FailedBridgeInterfaces will be the same as FailedBridgeInterfaces of Qcc: optional identification of failed Bridges when StatusInfo.Status is Failed. >>