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YANG Data Model for FlexE Interface Management
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Abstract

This document defines YANG data models for the configuration of Flex Ethernet (FlexE) interfaces, including a FlexE group and its FlexE clients. The YANG modules in this document conforms to the Network Management Datastore Architecture (NMDA).

Status of this Memo

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[1. Introduction](#)

The Flex Ethernet (FlexE) 2.0 Implementation Agreement [[FLEXE](#)] defined by the OIF provides the support of a variety of Ethernet MAC rates that may or may not correspond to any existing Ethernet PHY rate. This includes MAC rates that are both greater than (through bonding) and less than (through sub-rate and channelization) the Ethernet PHY rates used to carry FlexE. Besides 100GBASE-R PHYs, FlexE 2.0 further supports the bonding of 200GBASE-R PHYs or 400GBASE-R PHYs respectively.

In the FlexE, multiple Ethernet PHYs (each PHY can further consist of one or more FlexE Instances) are bonded into a FlexE Group, and the total capacity of the FlexE Group is represented as a collection of slots (e.g., each slot has a granularity of 5Gbps or 25Gbps). Based on their bandwidth needs, FlexE Clients are each mapped into one or more slots in a FlexE group. The FlexE mechanism operates using a calendar consisting of these slots.

This calendar is partitioned into sub-calendars for each PHY (earlier than FlexE 2.0) or sub-calendars for each FlexE instance (FlexE 2.0 and above). For example, the calendar for a FlexE Group composed of n 100G PHYs is partitioned into 20n slots (each slot representing 5Gbps of bandwidth when the slot granularity is 5Gbps).

[FLEXE-PS] discusses the problem statements and requirements for FlexE interface management.

This document defines a YANG data model for the configuration of a Flex Ethernet interface (i.e., FlexE Group). The data model is augmented based on the generic interfaces data model as defined in [RFC8343], the FlexE attributes are based on the FlexE 2.0 Implementation Agreement as specified in [FLEXE]. With the help of this YANG data module, the FlexE Groups can be managed conveniently as ordinary network interfaces on a network device (e.g., a router or bridge).

This document also defines a YANG data model for the configuration of a Flex Ethernet client interface (i.e., FlexE Client). The data model is augmented based on the generic interfaces data model as defined in [RFC8343], currently it only includes mac-address and group-number attributes for a FlexE client.

The YANG modules in this document conforms to the Network Management Datastore Architecture (NMDA) [RFC8342].

1.1. Conventions used in this document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

1.2. Terminology

Most terminologies used in this document are extracted from [FLEXE].

FlexE: Flex Ethernet.

FlexE Client: An Ethernet flow based on a MAC data rate that may or may not correspond to any Ethernet PHY rate.

FlexE Group: A FlexE Group is composed of from 1 to n Ethernet PHYs.

FlexE Instance: A FlexE Instance is a unit of information consisting of 100G of capacity able to carry FlexE Client data, together with its associated overhead.

Ethernet PHY: an entity representing Ethernet Physical Coding Sublayer (PCS), Physical Media Attachment (PMA), and Physical Media

Dependent (PMD) layers. Each PHY is consisted of one or more FlexE Instance (e.g., a 400GBASE-R PHY has four FlexE Instances).

FlexE Calendar: The total capacity of a FlexE Group is represented as a collection of slots. The calendar for a FlexE Group composed of n PHYs is represented in each PHY as an array of slots (e.g., each representing 5Gbps of bandwidth), i.e., calendar-slot-list.

2. YANG model hierarchy for FlexE

This section describes the hierarchy of the YANG modules for the FlexE interface management and the FlexE client interface.

Configuration and status of FlexE group interface information include:

- flexe-group specifies a management interface for configuration of a FlexE group.
- flexe-phy-list specifies a list of PHYs in a Flex Group.
- flexe-client-list specifies a list of FlexE client, each client is mapped to some slots in this FlexE group. flexe-client-if references to a FlexE client interface. flexe-client-status indicates whether there is any fault in local or remote for this client.

Configuration and status of FlexE client interface information include:

- flexe-group specifies the FlexE Group number of the FlexE group to which this FlexE client belongs.
- mac-address specifies the MAC address for a FlexE client.

A flag calendar-protocol-enable is added to indicate that whether FlexE calendar negotiation protocol as described in Section 7.3 of [FLEXE] is enabled or not.

The readers are assumed to be familiar with FlexE 2.0, as all FlexE terminologies are described in details in [FLEXE].

In order to simplify the YANG module of the FlexE interface and to follow the YANG style of terminology, the full calendar in FlexE is not modelled explicitly. However, a calendar-slot-list per PHY is modeled which represents all the slots in a PHY (i.e., slots in all sub-calendars of the FlexE instances in this PHY), and the calendar

is actually a conglomerate of all the slots in calendar-slot-lists for all FlexE PHYs of this FlexE Group.

From FlexE 2.0 on, concept of "FlexE Instance" is introduced, which is equivalent to 100GBASE-R PHY, and slots for each instance is used and carried in the overhead. However, we decide not to model the instance, for the following reasons:

- instance numbers can be inferred from the FlexE PHY, and any slot in an instance is corresponding to a slot in a PHY;
- instance is an internal logical construct, there is no benefit in exposing it for management;
- instance is only introduced after FlexE 2.0, its construct will not be compatible with the early versions of FlexE. A simplified YANG tree diagram [RFC8340] representing the data model is typically used by YANG modules. This document uses the same tree diagram syntax as described in [RFC8340].

A tree diagram of the module for FlexE group interface is depicted as the following:

```
module: ietf-flexe
  augment /if:interfaces/if:interface:
    +-rw flexe-group
      +-rw group-number?          uint32
      +-rw slot-granularity?      slot-granularity-enum
      +-rw flexe-phy-type?        flexe-phy-enum
      +-rw calendar-protocol-enable? boolean
      +-rw flexe-phy-list* [flexe-phy-if]
        | +-rw flexe-phy-if?      if:interface-ref
        | +-rw phy-number         uint8
        | +-ro flexe-phy-status?   phy-status-enum
        | +-rw calendar-slot-list* [slot-id]
        |   +-rw slot-id          uint8
        |   +-rw flexe-slot-status? slot-status-enum
      +-rw flexe-client-list* [client-id]
        | +-rw client-id          uint16
        | +-rw flexe-client-if?    if:interface-ref
        | +-rw client-slot-list* [client-slot-id]
        | | +-rw client-slot-id    uint8
        | | +-rw mapped-phy-if?    if:interface-ref
        | | +-rw mapped-slot-id    uint8
        | +-ro flexe-client-status? client-status-enum
      +-ro flexe-group-status?     uint8
```

A tree diagram of the module for FlexE client interface is depicted as the following:

```
module: ietf-interfaces-flexec-client
  augment /if:interfaces/if:interface:
    +-rw flexec-client
      +--ro mac-address
      +--rw group-number?          uint32
```

3. YANG Module for FlexE group interface

The following YANG data module augments the interface container defined in [RFC 8343](#) for a FlexE group interface. It imports iana-if-type [[RFC7224](#)] and ietf-interfaces [[RFC8343](#)].

```
<CODE BEGINS> file "ietf-flexex@2019-10-30.yang"
module ietf-flexex {
  yang-version 1.1;
  namespace "urn:ietf:params:xml:ns:yang:ietf-flexex";
  prefix "flexex";

  import iana-if-type {
    prefix ianaift;
  }
  import ietf-interfaces {
    prefix if;
    reference
      "RFC8343: A YANG Data Model for Interface Management";
  }

  organization "IETF CCAMP Working Group";
  contact
    "WG Web: http://tools.ietf.org/wg/ccamp/
    WG List: <mailto:ccamp@ietf.org>
    Author: Yuanlong Jiang
           <mailto:jiangyuanlong@huawei.com>
    Author: Xiang He
           <mailto:hexiang@huawei.com>
    Author: Weiqiang Cheng
           <mailto:chengweiqiang@chinamobile.com>
    Author: Junfang Wang
           <mailto:wjf@fiberhome.com>
    Author: Yalei Han
           <mailto:ylhan@fiberhome.com>";
  description
    "This YANG module defines a data model for the configuration
    of FlexE interface.";

  revision "2019-10-30" {
    description "Initial version";
    reference
      "draft-jiang-ccamp-flexex-yang-02: YANG Data Model for FlexE
      Interface Management ";
  }
}
```

```
identity flexEthernet {
  base ianaift:iana-interface-type;
  description
    "Flex Ethernet.";
}

typedef slot-granularity-enumeration {
  type enumeration {
    enum slot-5g {
      value 1;
      description
        "5Gbps per slot.";
    }
    enum slot-25g {
      value 2;
      description
        "25Gbps per slot.";
    }
    enum slot-others {
      value 254;
      description
        "Other type of granularities per slot.";
    }
  }
  description
    "The bandwidth granularity of a slot. Options for this
    enumeration are specified by the OIF standard, currently only
    5G and 25G are defined.";
  reference
    "OIF Flex 2.0: Section 6.7";
}

typedef slot-status-enumeration {
  type enumeration {
    enum unavailable {
      value 1;
      description
        "slot is unavailable for a FlexE client.";
    }
    enum unused {
      value 2;
      description
        "slot is unused.";
    }
    enum used {
      value 3;
      description
```

```
        "slot is used.";
    }
}
description
    "The status of a slot in a PHY. Options for this enumeration
    are specified by the OIF standard, 'used' is implicit.";
reference
    "OIF Flex 2.0: Section 7.3.4 and Section 7.6";
}

typedef flexe-phy-enumeration {
    type enumeration {
        enum 'PHY-100GBASE-R' {
            value 1;
            description
                "100GBASE-R PHY, as defined in FlexE 1.0.";
        }
        enum 'PHY-200GBASE-R' {
            value 2;
            description
                "200GBASE-R PHY, as defined in FlexE 2.0.";
        }
        enum 'PHY-400GBASE-R' {
            value 3;
            description
                "400GBASE-R PHY, as defined in FlexE 2.0.";
        }
        enum 'PHY-50GBASE-R' {
            value 4;
            description
                "50GBASE-R PHY, as defined in FlexE 2.1.";
        }
    }
}

description
    "The current type of PHYs bonded in a FlexE Group. Values for
    this enumeration are specified by the OIF standard.";
reference
    "OIF Flex 2.0 and 2.1: Section 5.2.1.5";
}

typedef phy-status-enumeration {
    type enumeration {
        enum phy-status-OK {
            value 0;
            description
                "The FlexE PHY status is ok";
        }
    }
}
```

```
    }
    enum phy-status-LOF {
        value 1;
        description
            "The FlexE PHY status is Loss of Frame";
    }
    enum phy-status-RPF {
        value 2;
        description
            "The FlexE PHY status is Remote PHY Fault";
    }
    enum phy-status-LPF {
        value 3;
        description
            "The FlexE PHY status is Local PHY Fault";
    }
}
description
    "The current PHY status. RPF, LPF, LOF and OK are defined.";
reference
    "OIF Flex 2.0: Section 7.3.8";
}
```

```
typedef client-status-enumeration {

    type enumeration {
        enum flexe-client-status-OK {
            value 0;
            description
                "The FlexE client status is OK";
        }
        enum flexe-client-status-LF {
            value 1;
            description
                "The FlexE client status is Local Fault";
        }
        enum flexe-client-status-RF {
            value 2;
            description
                "The FlexE client status is Remote Fault";
        }
    }
}
description
    "The client status. RPF, LPF and OK are defined.";
reference
    "OIF Flex 2.0: Section 7.3.8";
```

```
}

augment "/if:interfaces/if:interface" {

  when "if:type = 'ianaift:flexEthernet'" {
    description "Applies to Flex bonded Ethernet interfaces";
  }

  description
    "Augment interface model with OIF Flex Ethernet interface
    specific configuration nodes. Each flexEthernet interface
    represents a FlexE Group configured in a device.";

  container flexe-group {
    description
      "The struct containing all FlexE related configuration
      (see OIF FlexE 2.0 Section 6.1).
      Note that max number of FlexE groups in a network is 63.";

    leaf group-number {
      type uint32 {
        range "1..1048574";
      }
      description
        "FlexE Group Number as defined in Section 7.3.6 of FlexE
        2.0.";
    }

    leaf slot-granularity {
      type slot-granularity-enum;
      default "slot-5g";
      description
        "The granularity of a slot in a FlexE group.";
    }

    leaf flexe-phy-type {
      type flexe-phy-enum;
      default "PHY-100GBASE-R";
      description
        "The type of PHYs bonded in a FlexE Group.";
    }

    leaf calendar-protocol-enable {
      type boolean;
      default true;
      description
        "Whether calendar negotiation protocol is enabled or
```

```
        not.";
      reference
        "OIF Flex 2.0: Section 7.3.4";
    }

    list flexe-phy-list {

      key "flexe-phy-if";
      description
        "List of PHYs bonded in a FlexE group.";

      leaf flexe-phy-if {
        type if:interface-ref;
        description
          "Reference to a Flexe PHY interface.";
      }

      leaf phy-number {
        type uint8 {
          range "1 .. 254";
        }
        description
          "PHY number of a FlexE PHY.
          If PHY type is 100GBASE-R, phy-number is [1,254].
          If PHY type is 200GBASE-R, phy-number is [1,126].
          If PHY type is 400GBASE-R, phy-number is [1, 62].";
      }

      leaf flexe-phy-status {
        type phy-status-enum;
        default "phy-status-OK";
        config false;
        description
          "The FlexE PHY status.";
      }

      list calendar-slot-list {
        key "slot-id";
        leaf slot-id {
          type uint8;
          description
            "slot id of a slot in a PHY.";
        }
        description
          "List of slots in a FlexE PHY. Max elements of
```

slot-list for a FlexE PHY is dependent on the PHY bandwidth (X)G and the slot granularity (Y)G, i.e., X/Y. For example, for a 400GBASE-R PHY:
If slot-granularity=slot-5g, max-elements is 80.
If slot-granularity=slot-25g, max-elements is 16.";

```
leaf flexe-slot-status {
  type slot-status-enumeration;
  default unused;
  config false;
  description
    "Slot status of a FlexE slot.";
}
} //calendar-slot-list
} //flexe-phy-list

list flexe-client-list {

  key "client-id";
  description
    "List of FlexE clients in a FlexE Group.";
  leaf client-id {
    type uint16 {
      range "1..65534";
    }
    description
      "FlexE Client field as defined in FlexE 2.0 Section 7.3.4.";
  }

  leaf flexe-client-if {
    type if:interface-ref;
    description
      "The type of a flexe client interface must be
      'flexeClient'.";
  }

  list client-slot-list {
    key "client-slot-id";
    min-elements 1;
    description
      "List of slots for a FlexE client.";
    leaf client-slot-id {
      type uint8;
      description
        "Client slot id of a client slot in sequence for a
        client.";
```

```
    }

    leaf mapped-phy-if {
      type if:interface-ref;
      description
        "Mapped PHY interface of a client slot.";
    }
    leaf mapped-slot-id {
      type uint8;
      description
        "Mapped Slot id of a client slot in the mapped PHY.
        If a slot [i] is mapped, flexe-slot-status[i] in the
        Mapped PHY MUST be set to 'used' ";
    }
  } // client-slot-list

  leaf flexe-client-status {
    type client-status-enum;
    default flexe-client-status-OK;
    config false;
    description
      "The FlexE client status.";
  }

} //flexe-client-list

leaf flexe-group-status {
  type uint8;
  config false;
  description
    "Status for a FlexE Group. If any PHY is in fault,
    or any FlexE configuration is mismatched, the FlexE
    Group status is indicated in fault. Status includes:
    OK, Local Fault, Remote Fault, mismatch and etc.";
}
} //flexe-group
} //augment
}
```

<CODE ENDS>

4. YANG Module for FlexE client interface

The following YANG data module augments the interface container defined in [RFC 8343](#) for a FlexE client interface.

<CODE BEGINS> file "ietf-interfaces-flex-e-client@2019-10-30.yang"

```
module ietf-interfaces-flexec-client {
  yang-version 1.1;

  namespace
    "urn:ietf:params:xml:ns:yang:ietf-interfaces-flexec-client";

  prefix flexcl;

  import ietf-interfaces {
    prefix if;
  }

  import ietf-yang-types {
    prefix yang;
  }

  import iana-if-type {
    prefix ianaift;
  }

  organization "IETF CCAMP Working Group";
  contact
    "WG Web: http://tools.ietf.org/wg/ccamp/  

    WG List: <mailto:ccamp@ietf.org>  

    Author: Yuanlong Jiang  

    <mailto:jiangyuanlong@huawei.com>  

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    Author: Junfang Wang  

    <mailto:wjf@fiberhome.com>  

    Author: Yalei Han  

    <mailto:ylhan@fiberhome.com>";

  description
    "This module contains YANG definitions for configuration of  

    'FlexE client' interfaces. FlexE Client is defined in  

    OIF Flexible Ethernet 2.0 Implementation Agreement.";

  revision 2019-10-30 {
    description "Initial revision";

    reference
      "Internet draft: draft-jiang-ccamp-flexec-yang-02";
  }
```

```
identity flexeClient {
  base ianaift:iana-interface-type;
  description
    "FlexE Client.";
}

/*
 * Configuration parameters for FlexE client interfaces.
 */
augment "/if:interfaces/if:interface" {
  when "derived-from-or-self(if:type, 'ianaift:flexeClient')" {
    description "Applies to FlexE client interfaces";
  }
  description
    "Augment the interface model with parameters for
    FlexE client interfaces";

  container flexe-client {
    description
      "Contains parameters for FlexE client interfaces
      which expose an Ethernet MAC layer.";
    leaf mac-address {
      type yang:mac-address;
      config false;
      description
        "The MAC address of the FlexE client.";
    }
    leaf group-number {
      type uint32 {
        range "1..1048574";
      }
      description
        "FlexE Group Number of the FlexE group to which this
        Client belongs.";
    }
    // statistics can further be defined for the MAC layer
  }
}
}
<CODE ENDS>
```

5. Security Considerations

The YANG module specified in this document defines a schema for data that is designed to be accessed via network management protocols such as NETCONF [[RFC6241](#)] or RESTCONF [[RFC8040](#)]. The lowest NETCONF layer is the secure transport layer, and the mandatory-to-implement secure transport is Secure Shell (SSH) [[RFC6242](#)]. The lowest

RESTCONF layer is HTTPS, and the mandatory-to-implement secure transport is TLS [[RFC8446](#)].

The NETCONF access control model [[RFC8341](#)] provides the means to restrict access for particular NETCONF or RESTCONF users to a preconfigured subset of all available NETCONF or RESTCONF protocol operations and content.

There are a number of data nodes defined in the YANG data modules in this document are writable, and the involved subtrees that are sensitive include:

`/flexe/flexe-group/flexe-phy-list` specifies a list of FlexE PHYs.

`/flexe/flexe-group/flexe-client-list` specifies a list of FlexE Client, and each client is mapped to some slots in a FlexE PHY.

`/flexcl/mac-address` specifies a MAC address for a FlexE client.

`/flexcl/group-number` specifies the group number of a FlexE Group to which a FlexE client belongs.

Write operations (e.g., edit-config) to these data nodes without proper protection can have a negative effect on network operations. Specifically, an inappropriate configuration of them may cause an interrupt of a FlexE client flow, drop of all Ethernet frames of a FlexE client, or even break down of a whole FlexE group interface.

6. IANA Considerations

It is proposed that IANA register the following URI in the "IETF XML registry" [[RFC3688](#)]:

URI: urn:ietf:params:xml:ns:yang:ietf-flex

Registrant Contact: The IESG

XML: N/A; the requested URI is an XML namespace

It is proposed that IANA register the following URI in the "IETF XML registry" [[RFC3688](#)]:

URI: urn:ietf:params:xml:ns:yang:ietf-interfaces-flex-client

Registrant Contact: The IESG

XML: N/A; the requested URI is an XML namespace

It is proposed that IANA register the following YANG module in the "YANG Module Names" registry:

Name: ietf-flex

Namespace: urn:ietf:params:xml:ns:yang:ietf-flex

Prefix: flex

Reference: this document

It is proposed that IANA register the following YANG module in the "YANG Module Names" registry:

Name: ietf-interfaces-flex-client

Namespace: urn:ietf:params:xml:ns:yang:ietf-interfaces-flex-client

Prefix: flexcl

Reference: this document

It is proposed that IANA register a new IANAifType TBD for the interface type of Flex Ethernet group in the "IANA Interface Type YANG Module" [[RFC7224](#)].

It is proposed that IANA register a new IANAifType TBD for the interface type of Flex Ethernet client in the "IANA Interface Type YANG Module" [[RFC7224](#)].

7. References

7.1. Normative References

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