CCAMP Working Group
Internet Draft
Intended status: Standards Track
Expires: January 3, 2018

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July 3, 2017

YANG data model for Flexi-Grid Optical Networks
draft-vergara-ccamp-flexigrid-yang-05.txt

Status of this Memo

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Abstract

This document defines a YANG model for managing flexi-grid optical Networks. The model described in this document defines a flexi-grid traffic engineering database. A complementary module is referenced to detail the flexi-grid media channels.

This module is grounded on other defined YANG abstract models.

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1. Introduction

Internet-based traffic is dramatically increasing every year. Moreover, such traffic is also becoming more dynamic. Thus, transport networks need to evolve from current DWDM systems towards elastic optical networks, based on flexi-grid transmission and switching technologies [RFC7698]. This technology aims at increasing both transport network scalability and flexibility, allowing the optimization of bandwidth usage.

This document presents a YANG model for flexi-grid objects in the dynamic optical network, including the nodes, transponders and links between them, as well as how such links interconnect nodes and transponders.

The YANG model for flexi-grid networks allows the representation of the flexi-grid optical layer of a network, combined with the underlying physical layer.

This document identifies the flexi-grid components, parameters and their values, characterizes the features and the performances of the flexi-grid elements. An application example is provided towards the end of the document to better understand their utility.

2. Conventions used in this document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2119].

In this document, these words will appear with that interpretation only when in ALL CAPS. Lower case uses of these words are not to be interpreted as carrying RFC-2119 significance.

In this document, the characters ">>" preceding an indented line(s) indicates a compliance requirement statement using the key words listed above. This convention aids reviewers in quickly identifying or finding the explicit compliance requirements of this RFC.

3. Flexi-grid network topology model overview

YANG is a data modeling language used to model configuration data manipulated by the NETCONF protocol. Several YANG models have already been specified for network configurations. For instance, the work in [I-D.draft-ietf-i2rs-yang-network-topo] has proposed a generic YANG model for network/service topologies and inventories. The work in [I-D.draft-ietf-teas-yang-te-topo] presents a data model to represent, retrieve and manipulate Traffic Engineering (TE) Topologies. These models serve as base models that other technology specific models can augment. A YANG model has also been proposed in [I-D.draft-dharini-ccamp-dwdm-if-yang] to manage single channel optical interface parameters of DWDM applications, and in

[I-D.draft-ietf-ccamp-wson-yang] another model has been specified for the routing and wavelength assignment TE topology in wavelength switched optical networks (WSONs). None of them are specific for flexi-grid technology.

Then, as stated before, we propose a model to describe a flexi-grid topology that is split in two YANG sub-modules:

- Flexi-grid-TED: In order to be compatible with existing proposals, we augment the definitions contained in [I-D.draft-ietf-i2rs-yang-network-topo] and [I-D.draft-ietf-teas-yang-te-topo], by defining the different elements we can find in a flexi-grid network: a node, a transponder and a link. For that, each of those elements is defined as a container that includes a group of attributes. References to the elements are provided to be later used in the definition of a media channel. It also includes the data types for the type of modulation, the flexi-grid technology, the FEC, etc.
- Media-channel: This module defines the whole path from a source transponder to the destination through a number of intermediate nodes and links. For this, it takes the information defined before in the flexi-grid TED. This module is described in [ID.draft-vergara-ccamp-flexigrid-media-channel-yang]

The following section provides a detailed view of the first module.

4. Main building blocks of the Flexi-grid TED

This section details the defined YANG module. It is listed below in section 6.

The description of the three main components, flexi-grid-node, flexi-grid-transponder and flexi-grid-link is provided below. flexi-grid-sliceable-transponders are also defined.

<flexi-grid-node> ::= <config> <state>

<flexi-grid-node>: This element designates a node in the network.

<config> ::= <flexi-grid-node-attributes-config>

<config>: Contains the configuration of a node.
<flexi-grid-node-attributes-config> ::= <list-interface>
<connectivity_matrix>

<flexi-grid-node-attributes-config>: Contains all the attributes related to the node configuration, such as its interfaces or its management addresses.

```
<list-interface> ::= <name> <port-number>
<input-port> <output-port> <description>
<interface-type>
[<numbered-interface> / <unnumbered-interface>]

    <list-interface>: The list containing all the
    information of the interfaces.

    <name>: Determines the interface name.

    <port-number>: Port number of the interface.

    <input-port>: Boolean value that defines
    whether the interface is input or not.

    <output-port>: Boolean value that defines
    whether the interface is output or not.

    <description>: Description of the usage of
    the interface.

    <interface-type>: Determines if the interface
    is numbered or unnumbered.

    <numbered-interface> ::= <n-i-ip-address>
        <numbered-interface>: An interface with
        its own IP address.

        <n-i-ip-address>: Only available if
        <interface-type> is "numbered-interface".
        Determines the IP address of the interface.

    <unnumbered-interface> ::= <u-i-ip-address>
    <label>
        <unnumbered-interface>: A interface that
        needs a label to be unique.

        <u-i-ip-address>: Only available if
        <interface-type> is "numbered-interface".
        Determines the node IP address, which with
        the label defines the interface.

        <label>: Label that determines the
        interface, joint with the node IP address.

<connectivity-matrix> ::= <connections>

    <connectivity-matrix>: Determines whether a
    connection port in/port out exists.

    <connections> ::= <input-port-id>
    <output-port-id>
```

<flexi-grid-transponder> ::= <transponder-type> <config> <state>

<flexi-grid-transponder>: This item designates a transponder of a node.

<config> ::= <flexi-grid-transponder-attributes-config>

<config>: Contains the configuration of a transponder.

<flexi-grid-transponder-attributes-config> ::= <available-operational-mode> <operational-mode>

<flexi-grid-transponder-attributes>: Contains all the attributes related to the transponder.

<available-operational-mode>: It provides a list of the operational modes available at this transponder.

<operational-mode>: Determines the type of operational mode in use.

<state> ::= <flexi-grid-transponder-attributes-config> <flexi-grid-transponder-attributes-state>

<state>: Contains the state of a transponder.

<flexi-grid-transponder-attributes-config>: See above.

<flexi-grid-transponder-attributes-state>: Contains the state of a transponder.

<link> ::= <config> <state>

<link>: This element describes all the information of a link.

<config> ::= <flexi-grid-link-attributes-config>

<config>: Contains the configuration of a link.

```
        <flexi-grid-link-attributes-config> ::= <technology-type>
        <available-label-flexi-grid> <N-max> <base-frequency>
        <nominal-central-frequency-granularity>
        <slot-width-granularity>

           <flexi-grid-link-attributes>: Contains all the
           attributes related to the link, such as its unique id,
           its N value, its latency, etc.

           <link-id>: Unique id of the link.

           <available-label-flexi-grid>: Array of bits that
           determines, with each bit, the availability of each
           interface for flexi-grid technology.

           <N-max>: The max value of N in this link, being N
           the number of slots.

           <base-frequency>: The default central frequency
           used in the link.

           <nominal-central-frequency-granularity>: It is the
           spacing between allowed nominal central frequencies
           and it is set to 6.25 GHz (note: sometimes referred
           to as 0.00625 THz).

           <slot-width-granularity>: 12.5 GHz, as defined
           in G.694.1.
    <state> ::= <flexi-grid-link-attributes-config>
    <flexi-grid-link-attributes-state>

        <state>: Contains the state of a link.

        <flexi-grid-link-attributes-config>: See above.

        <flexi-grid-link-attributes-state>: Contains all the
        the information related to the state of a link.
```

4.1. Formal Syntax

The previous syntax specification uses the augmented Backus-Naur Form (BNF) as described in [RFC5234].

5. Example of use

In order to explain how this model is used, we provide the following example. An optical network usually has multiple transponders, switches (nodes) and links between them. Figure 1 shows a simple topology, where two physical paths interconnect two optical transponders.

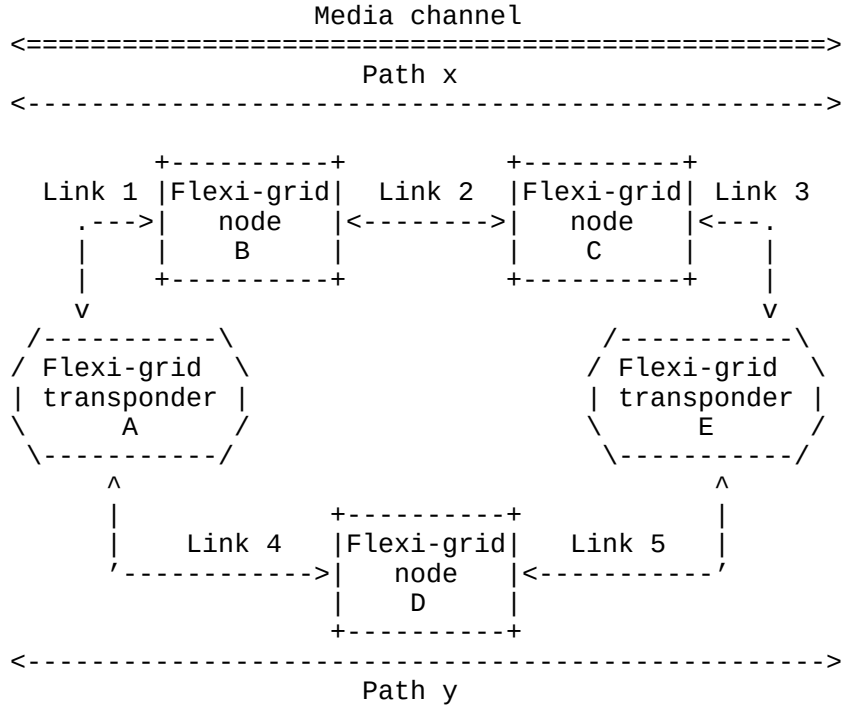

Figure 1. Topology example.

In order to configure a media channel to interconnect transponders A and E, first of all we have to populate the flexi-grid TED YANG model with all elements in the network:

1. We define the transponders A and E, including their FEC type, if enabled, and modulation type. We also provide node identifiers and addresses for the transponders, as well as interfaces included in the transponders. Sliceable transponders can also be defined if needed.

2. We do the same for the nodes B, C and D, providing their identifiers, addresses and interfaces, as well as the internal connectivity matrix between interfaces.

3. Then, we also define the links 1 to 5 that interconnect nodes and transponders, indicating which flexi-grid labels are available. Other information, such as the slot frequency and granularity are also provided.

Next, we can configure the media channel from the information we have stored in the flexi-grid TED, by querying which elements are available, and planning the resources that have to be provided on each situation. Note that every element in the flexi-grid TED has a reference, and this is the way in which they are called in the media channel. We refer to [I-D.draft-vergara-ccamp-flexigrid-media-channel-yang] to complete this example.

6. Flexi-grid TED YANG Model

6.1. Yang Model - Tree Structure

```
module: ietf-flexi-grid-topology
   augment /nd-s:networks/nd-s:network/nd-s:node/tet-s:te/
   tet-s:te-node-attributes:
    +--ro interfaces* [name]
       +--ro name                    string
       +--ro port-number?            uint32
       +--ro input-port?             boolean
       +--ro output-port?            boolean
       +--ro description?            string
       +--ro type?                   interface-type
       +--ro numbered-interface
       |  +--ro n-i-ip-address?   inet:ip-address
       +--ro unnumbered-interface
          +--ro u-i-ip-address?   inet:ip-address
          +--ro label?            uint32
flexi-grid-connectivity-matrix-attributes
   augment /nd:networks/nd:network/nd:node/tet:te/
   tet:te-node-attributes/tet:connectivity-matrices/
   tet:connectivity-matrix:
    +--rw connections* [input-port-id]
       +--rw input-port-id     flexi-grid-node-port-ref
       +--rw output-port-id?   flexi-grid-node-port-ref
flexi-grid-connectivity-matrix-attributes
   augment /nd-s:networks/nd-s:network/nd-s:node/tet-s:te/
   tet-s:te-node-attributes/tet-s:connectivity-matrices/
   tet-s:connectivity-matrix:
    +--ro connections* [input-port-id]
       +--ro input-port-id     flexi-grid-node-port-ref
       +--ro output-port-id?   flexi-grid-node-port-ref
flexi-grid-transponder
   augment /nd:networks/nd:network/nd:node/tet:te/
   tet:tunnel-termination-point:
    +--rw available-operational-mode*   operational-mode
    +--rw operational-mode?             operational-mode
flexi-grid-transponder
   augment /nd-s:networks/nd-s:network/nd-s:node/tet-s:te/
   tet-s:tunnel-termination-point:
    +--ro available-operational-mode*   operational-mode
    +--ro operational-mode?             operational-mode
```

A.2. YANG Model - Code

```
   <CODE BEGINS> file "ietf-flexi-grid-ted@2017-07-03.yang"
module ietf-flexi-grid-ted {
  yang-version 1.1;

  namespace "urn:ietf:params:xml:ns:yang:ietf-flexi-grid-ted";
  prefix "fg-ted";

  import ietf-network {
    prefix "nd";
  }
  import ietf-network-state {
    prefix "nd-s";
  }
  import ietf-network-topology {
    prefix "lnk";
  }
  import ietf-network-topology-state {
    prefix "lnk-s";
  }
  import ietf-te-topology {
    prefix "tet";
  }
  import ietf-te-topology-state {
    prefix "tet-s";
  }
   import ietf-inet-types {
      prefix "inet";
   }

  organization
         "IETF CCAMP Working Group";

      contact
         "Editor: Jorge Lopez de Vergara
                  <jorge.lopez_vergara@uam.es>";
      description
         "This module contains a collection of YANG definitions for
         a Flexi-Grid Traffic Engineering Database (TED).

         Copyright (c) 2017 IETF Trust and the persons identified as
         authors of the code.  All rights reserved.
```

```
         Redistribution and use in source and binary forms, with or
         without modification, is permitted pursuant to, and subject
         to the license terms contained in, the Simplified BSD
         License set forth in Section 4.c of the IETF Trust's Legal
         Provisions Relating to IETF Documents
         (http://trustee.ietf.org/license-info).";

      revision 2017-07-03 {
         description
            "version 5.";

         reference
             "RFC XXX: A Yang Data Model for
             Flexi-Grid Optical Networks ";
      }

  /*
    Typedefs
  */


  typedef operational-mode {
    type string;
    description
      "Vendor-specific mode that guarantees interoperability.
       It must be an string with the following format:
       B-DScW-ytz(v) where all these attributes are conformant
       to the ITU-T recomendation";
      reference "ITU-T G.698.2 (11/2009) Section 5.3";
  }

  typedef interface-type {
         type enumeration {
            enum numbered-interface {
                description "The interface is numbered";
            }
            enum unnumbered-interface {
                description "The interface is unnumbered";
            }
         }
         description
            "Enumeration that defines if an interface is numbered or
            unnumbered";
  }
```

```
   /*
      Typedef related to references
   */
      typedef flexi-grid-link-ref {
         type leafref {
            path
               "/nd:networks/nd:network/lnk:link/lnk:link-id";
         }

         description
            "This type is used by data models that need to reference
            a flexi-grid optical link.";
      }

      typedef flexi-grid-node-port-ref {
         type leafref {
            path "/nd:networks/nd:network/nd:node/tet:te/"
            +"tet:te-node-attributes/fg-ted:interfaces/"
            +"fg-ted:port-number";
         }
         description
            "This type is used by data models that need to reference
            a flexi-grid port.";
      }

      typedef flexi-grid-transponder-ref {
         type leafref {
            path "/nd:networks/nd:network/nd:node/tet:te/"+
            "tet:tunnel-termination-point/tet:tunnel-tp-id";
         }
         description
            "This type is used by data models that need to reference
            a trasponder.";
      }

   /*
      Groupings of attributes
   */
   grouping flexi-grid-network-type {
         container flexi-grid-network {
            presence "indicates a flexi-grid optical network";
            description "flexi-grid optical network";
         }
         description "If present, it indicates a flexi-grid
         optical TED network";
   }
```

```
   grouping flexi-grid-node-attributes {
         description "Set of attributes of an optical node.";

         list interfaces {
            key "name";
            unique "port-number"; // TODO Puerto y TP ID
            description "List of interfaces contained in the node";
            leaf name {
               type string;
               description "Interface name";
            }
            leaf port-number {
               type uint32;
               description "Number of the port used by the interface";
            }

            leaf input-port {
               type boolean;
               description "Determines if the port is an input port";
            }
            leaf output-port {
               type boolean;
               description
               "Determines if the port is an output port";
            }
            leaf description {
               type string;
               description "Description of the interface";
            }
            leaf type {
               type interface-type;
               description "Determines the type of the interface";
            }
            container numbered-interface {
               when "../fg-ted:type =
               'numbered-interface'" {
                 description
                 "If the interface is a numbered interface";
               }
               description "Container that defines an numbered
               interface with an ip-address";
               leaf n-i-ip-address{
                  type inet:ip-address;
                  description "IP address of the numbered interface";
               }
            }
```

```
            container unnumbered-interface {
               when "../fg-ted:type =
               'unnumbered-interface'" {
                 description
                   "If the interface is an unnumbered interface";
               }
               description "Container that defines an unnumbered
               interface with an ip-address and a label";
               leaf u-i-ip-address{
                  type inet:ip-address;
                  description "IP address of the interface";
               }
               leaf label {
                  type uint32;
                  description "Number as label for the interface";
               }
            }
         }
      }

   grouping flexi-grid-link-attributes {
         description "Set of attributes of an optical link";
            leaf-list available-label-flexi-grid {
               type bits {
                  bit is-available{
                    description "Set to 1 when it is available";
                  }
               }
               description
                  "Array of bits that determines whether a spectral
                  slot is available or not.";
            }

            leaf N-max {
               type int32;
               description "Maximum number of channels available.";
            }

            leaf base-frequency {
               type decimal64 {
                  fraction-digits 5;
               }
               units THz;
               default 193.1;
               description "Default central frequency";
               reference "rfc7698";
            }
```

```
            leaf nominal-central-frequency-granularity {
               type decimal64 {
                  fraction-digits 5;
               }
               units GHz;
               default 6.25;
               description
                  "It is the spacing between allowed nominal central
                  frequencies and it is set to 6.25 GHz";
               reference "rfc7698";
            }

            leaf slot-width-granularity {
               type decimal64 {
                  fraction-digits 5;
               }
               units GHz;
               default 12.5;
               description "Minimum space between slot widths";
               reference "rfc7698";
            }
   }

   grouping flexi-grid-transponder-attributes {
      description "Configuration of an optical transponder";
      //TODO Validate attributes
      leaf-list available-operational-mode {
         type operational-mode;
         description "List of all vendor-specific supported
         mode identifiers";
      }

      leaf operational-mode {
         type operational-mode;
         description "Vendor-specific mode identifier";
      }
   }
```

```
   grouping flexi-grid-connectivity-matrix-attributes {
      description "Connectivity matrix between the input and
          output ports";
      list connections {
         key "input-port-id";
         leaf input-port-id {
            type flexi-grid-node-port-ref;
            description "Identifier of the input port";
         }
         leaf output-port-id {
            type flexi-grid-node-port-ref;
            description "Identifier of the output port";
         }
         description "List of connections between input and
          output ports";
      }
   }

   /*
      Augments
   */
   augment "/nd:networks/nd:network/nd:network-types" {
            uses flexi-grid-network-type;
             description "Augment network-types including flexi-grid
             topology";
   }
   augment "/nd-s:networks/nd-s:network/nd-s:network-types" {
            uses flexi-grid-network-type;
             description "Augment network-types including flexi-grid
             topology";
   }
  augment "/nd:networks/nd:network/lnk:link/tet:te" +
   "/tet:te-link-attributes" {
    when "/nd:networks/nd:network/nd:network-types/
  fg-ted:flexi-grid-network" {
      description "Augment only for Flexigrid network.";
    }
    description "Augment link configuration";
    uses flexi-grid-link-attributes;
  }

  augment "/nd-s:networks/nd-s:network/lnk-s:link/tet-s:te" +
  "/tet-s:te-link-attributes" {
    when "/nd-s:networks/nd-s:network/nd-s:network-types/
  fg-ted:flexi-grid-network" {
      description "Augment only for Flexigrid network.";
    }

    description "Augment link state";
    uses flexi-grid-link-attributes;
  }
```

```
   augment "/nd:networks/nd:network/nd:node/tet:te" +
   "/tet:te-node-attributes" {
      when "/nd:networks/nd:network/nd:network-types/
    fg-ted:flexi-grid-network" {
         description "Augment only for Flexigrid network.";
      }
      uses flexi-grid-node-attributes;
      description "Augment node config with flexi-grid attributes";
   }

   augment "/nd-s:networks/nd-s:network/nd-s:node/tet-s:te" +
   "/tet-s:te-node-attributes" {
      when "/nd-s:networks/nd-s:network/nd-s:network-types/
    fg-ted:flexi-grid-network" {
         description "Augment only for Flexigrid network.";
      }

      uses flexi-grid-node-attributes;
      description "Augment node state with flexi-grid attributes";
   }
   augment "/nd:networks/nd:network/nd:node/tet:te"+
         "/tet:te-node-attributes/tet:connectivity-matrices/"+
         "tet:connectivity-matrix" {
       when "/nd:networks/nd:network/nd:network-types/
     fg-ted:flexi-grid-network" {
          description "Augment only for Flexigrid network.";
       }

      uses flexi-grid-connectivity-matrix-attributes;
      description "Augment node connectivity-matrix for node config";
    }

    augment "/nd-s:networks/nd-s:network/nd-s:node/tet-s:te"+
         "/tet-s:te-node-attributes/tet-s:connectivity-matrices/"+
         "tet-s:connectivity-matrix" {
       when "/nd-s:networks/nd-s:network/nd-s:network-types/
     fg-ted:flexi-grid-network"{
          description "Augment only for Flexigrid network.";
       }


      uses flexi-grid-connectivity-matrix-attributes;
      description "Augment node connectivity-matrix for node config";
    }
```

```
   augment "/nd:networks/nd:network/nd:node/tet:te"+
           "/tet:tunnel-termination-point" {
      when "/nd:networks/nd:network/nd:network-types/
      fg-ted:flexi-grid-network"{
          description "Augment only for Flexigrid network.";
       }
      uses flexi-grid-transponder-attributes;
      description "Augment node state with transponder attributes";
   }

   augment "/nd-s:networks/nd-s:network/nd-s:node/tet-s:te"+
           "/tet-s:tunnel-termination-point" {
      when "/nd-s:networks/nd-s:network/nd-s:network-types/
     fg-ted:flexi-grid-network"{
          description "Augment only for Flexigrid network.";
       }

      uses flexi-grid-transponder-attributes;
      description "Augment node state with transponder attributes";
   }

}

   <CODE ENDS>
```

A.3. License

7. Security Considerations

The transport protocol used for sending the managed information MUST support authentication and SHOULD support encryption.

The defined data-model by itself does not create any security implications.

8. IANA Considerations

The namespace used in the defined models is currently based on the METRO-HAUL project URI. Future versions of this document could register a URI in the IETF XML registry [RFC3688], as well as in the YANG Module Names registry [RFC6020].

9. References

9.1. Normative References

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[RFC6020] Bjorklund, M., Ed., "YANG - A Data Modeling Language for the Network Configuration Protocol (NETCONF)", RFC 6020, October 2010.

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9.2. Informative References

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[I-D.draft-ietf-teas-yang-te-topo] Liu, X., Bryskin, I., Pavan Beeram, V., Saad, T., Shah, H., Gonzalez De Dios, O., "YANG Data Model for TE Topologies", Internet Draft draft-ietf-teas-yang-te-topo-10.txt, 2017

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10. Contributors

The model presented in this paper was contributed to by more people than can be listed on the author list. Additional contributors include:

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- Daniel Michaud Vallinoto, Universidad Autonoma de Madrid

11. Acknowledgments

The work presented in this Internet-Draft has been partially funded by the European Commission under the project H2020 METRO-HAUL (Metro High bandwidth, 5G Application-aware optical network, with edge storage, compUte and low Latency), Grant Agreement number: 761727, and by the Spanish Ministry of Economy and Competitiveness under the project TRAFICA, MINECO/FEDER TEC2015-69417-C2-1-R.

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