YANG by Example

v0.1.1 (2015-11-05)

Overview and Objectives

This presentation uses an example to walk through all main features in the YANG data modeling language.

Our example uses standard and draft-standard YANG modules for static MPLS LSPs with the goal of creating valid configuration

After this presentation, you should be able to:

- Identify and describe common elements of a YANG model
- Examine a YANG model and create a valid configuration instance

YANG Models Used

IETF Standard Track YANG Models:

RFC 6991 Common YANG Data Types	ietf-yang-types@2013-07-15.yang
RFC 7277 IP Management	ietf-ip@2014-06-16.yang
RFC 7224 IANA Interface Type	iana-if-type@2014-05-08.yang
RFC 7223 Interface Management	ietf-interfaces@2014-05-08.yang

Draft YANG Models:

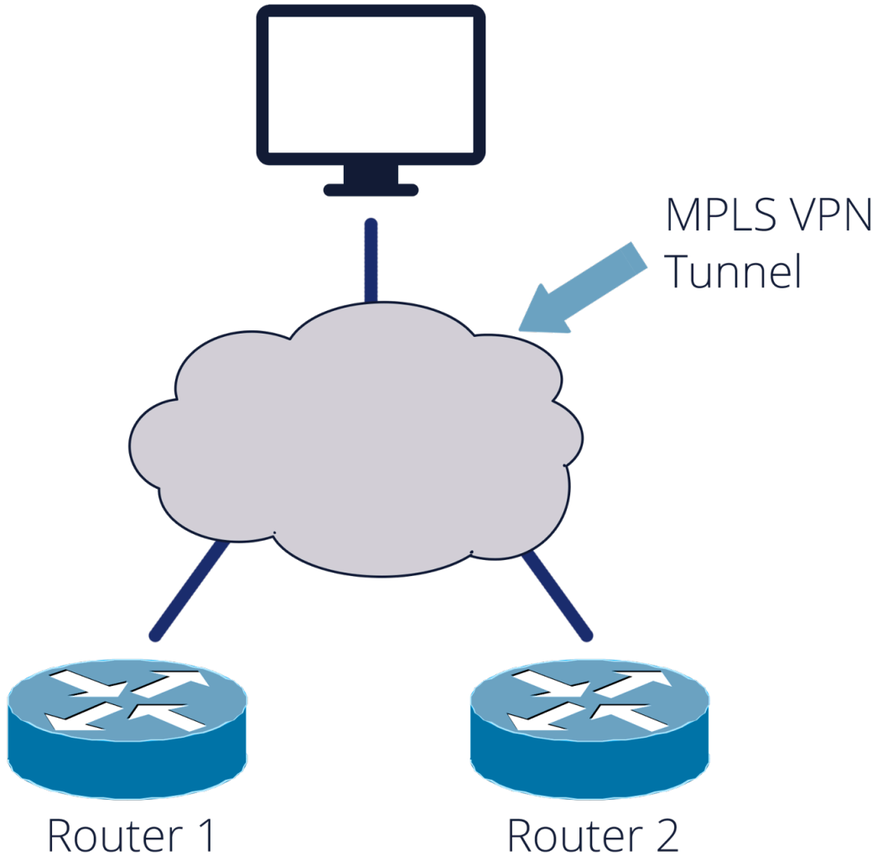
OpenConfig MPLS LSP Model

Feel free to download and follow!

Our Use Case – MPLS VPN Configuration

Tasks:

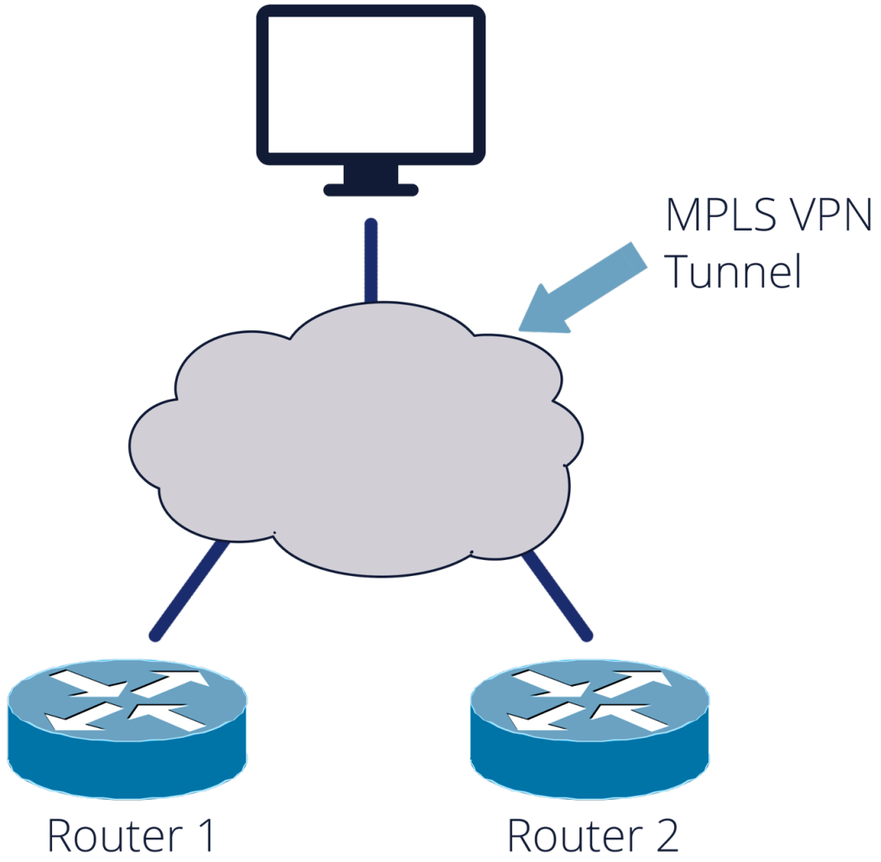
1. Enable interfaces on routers
2. Assign IPv6 addresses to interfaces
3. Configure Static MPLS LSPs



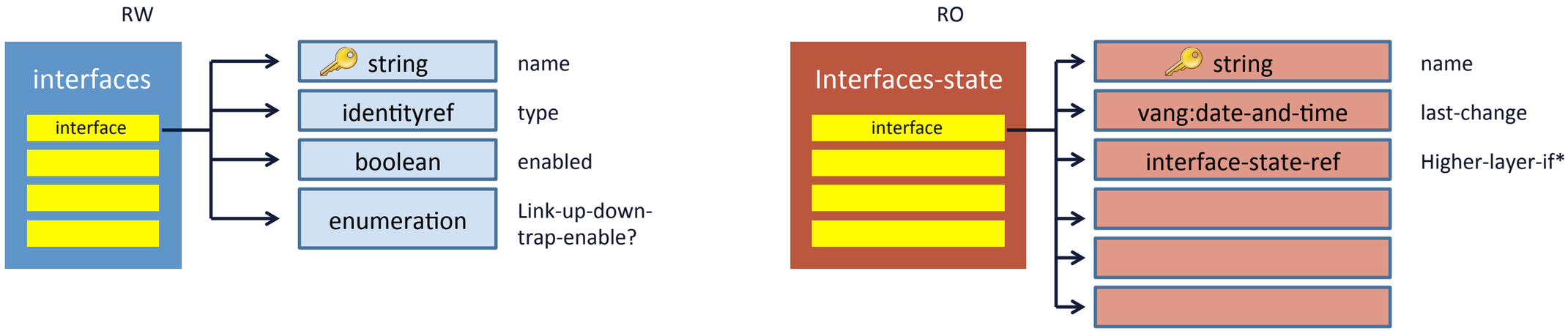

```
Router 1:
eth0: 2001:db8:c18:1::3/128
Router 2:
eth0: 2001:db8:c18:1::2/128
```

Task #1: Enabling the Interfaces

- We start with the Interface Management Model
- Examine model for YANG features:
  - Structure
  - Configuration and operational data
  - Built-in and customer data types
  - Conditional features
  - Abstract identities
  - Nodes references



Interface Management Model Structure



Two top-level containers:

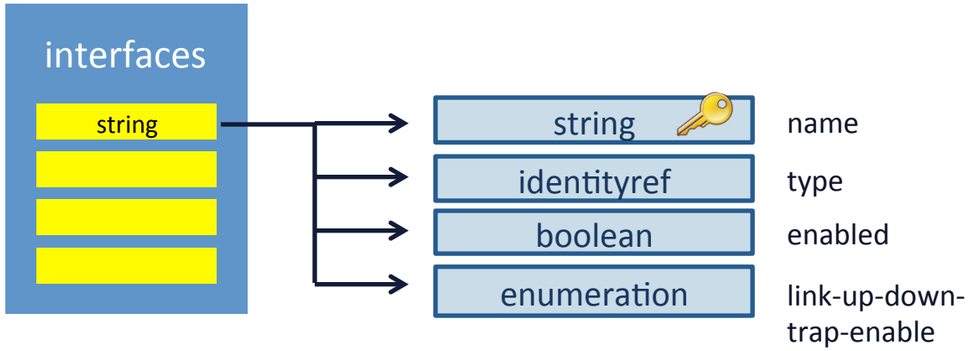
interfaces

- One entry per configured interface
- Contains all configuration per interface

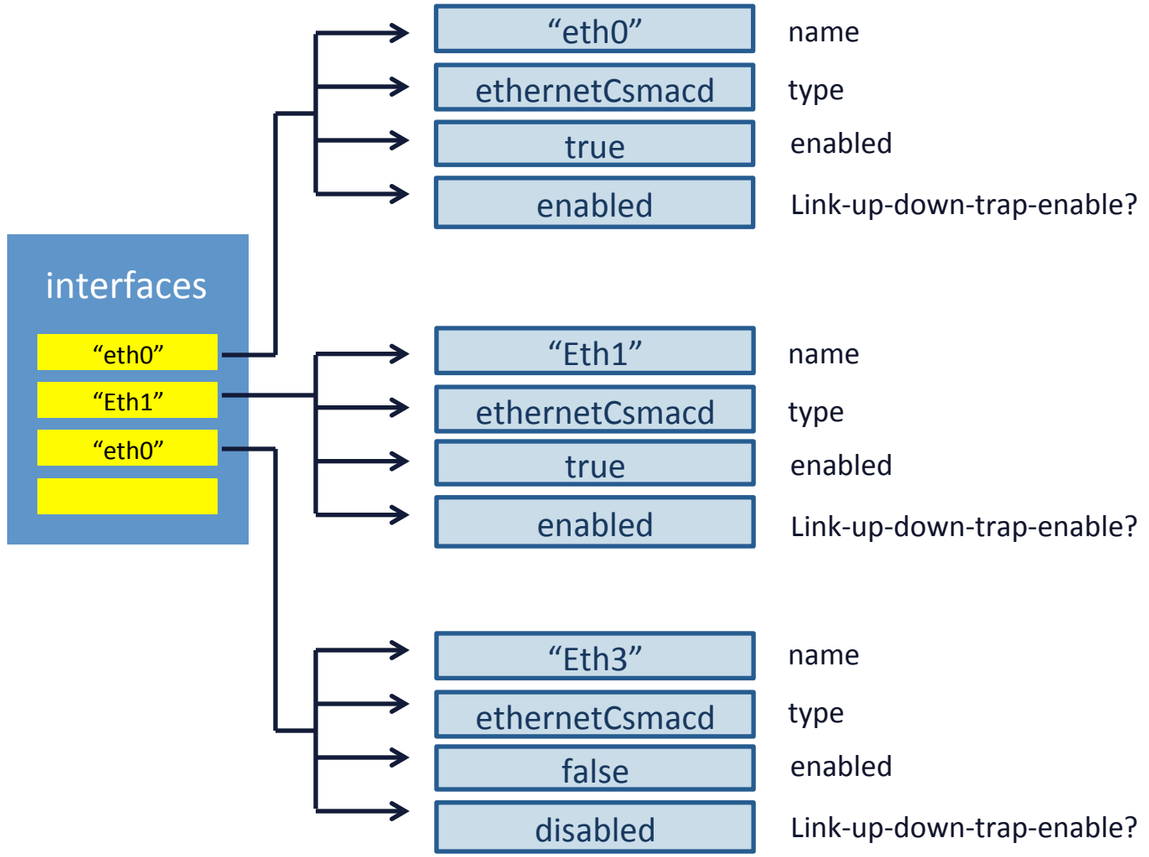
interfaces-state

- One entry per interface on the device
- Contains all operational state per interface

The Interfaces List

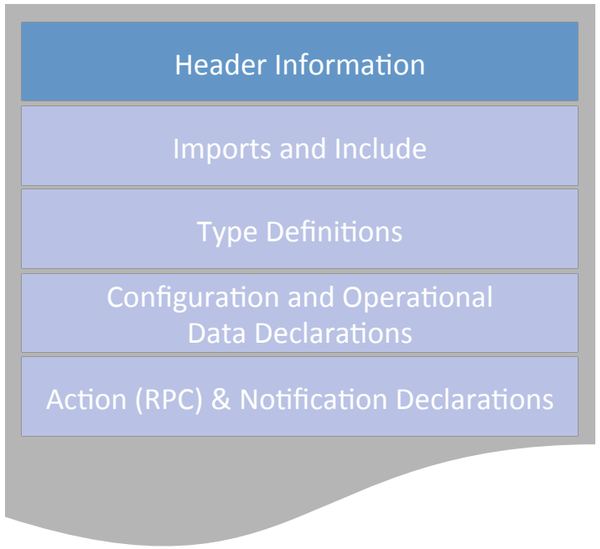


The Model



Example Instance data

The Module Header



RFC 7223 Interface Management

```
module ietf-interfaces {
  namespace "urn:ietf:params:xml:ns:yang:ietf-interfaces";
  prefix if;
  import ietf-yang-types {
    prefix yang;
  }
  organization
    "IETF NETMOD (NETCONF Data Modeling Language) Working
     Group";
  contact
    "WG Web:   <http://tools.ietf.org/wg/netmod/>
     WG List:  <mailto:netmod@ietf.org>
...
  description
    "This module contains a collection of YANG definitions for
     managing network interfaces.
...
revision 2014-05-08 {
    description
      "Initial revision.";
    reference
      "RFC 7223: A YANG Data Model for Interface Management";
  }
```

Defining a Container

Container statement:

- Defines an interior data node in the schema tree
- One argument - identifier
- No value, but has a list of child nodes in the data tree

```
container interfaces {
    description
        "Interface configuration parameters.”
  ...
}
```

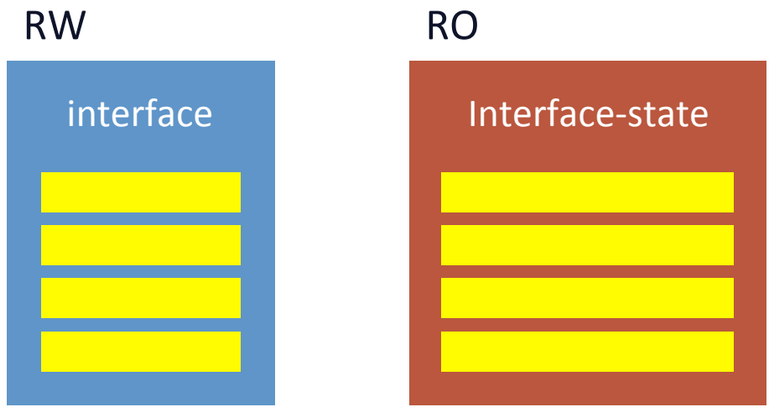
interfaces

Defining a List

List statement:

- Defines an interior data node in the schema tree.
- Single argument - identifier,
- Represents a collection of entries –each entry consists of one or more nodes

```
container interfaces{
   ...
   list interfaces {
      key "name";
      description
          "The list of configured
          interfaces on the device.";
   ...
   }
   list interfaces-state{
      config false;
      key "name";
      description
          "Data nodes for the operational
          state of interfaces."
   ...
   }
}
```



`config false` – Data under interfaces-state is read-only

Config (RW) and State (RO) clearly separated in this model

Defining Leaves

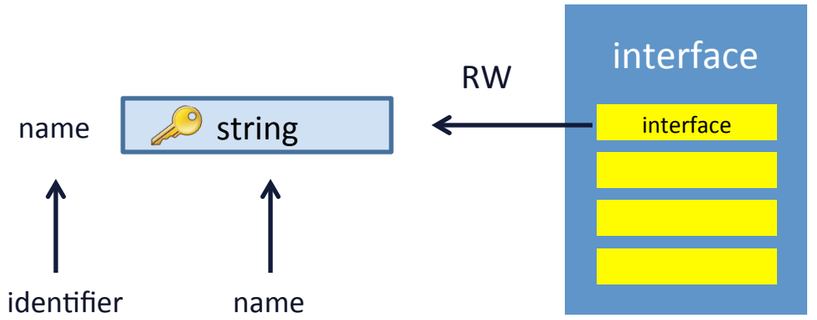
A leaf is defined by an identifier and has a type

```
list interface{
    key "name";
    description "...";

    leaf name {
        type string;
        description
            "The name of the interface"
      }

}
```

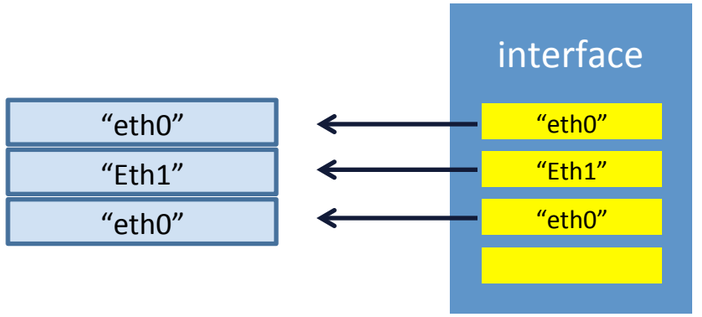
- Leaf `name` serves as list key
- The type is string

Switch order on graphic

The Model



An Instance of the Model



YANG Data Types

YANG has a set of built-in types, similar to those of many programming languages

- binary
- bits
- boolean
- decimal64
- empty
- enumeration
- identityref
- instance-identifier
- int8, int16, int32, int64
- leafref
- string
- uint8, uint16, uint32, uint64
- union

Use `pattern`, `range`, and `length` statements to restrict values

```
type string {
    length "0..4";
    pattern "[0-9a-fA-F]*";
}
```

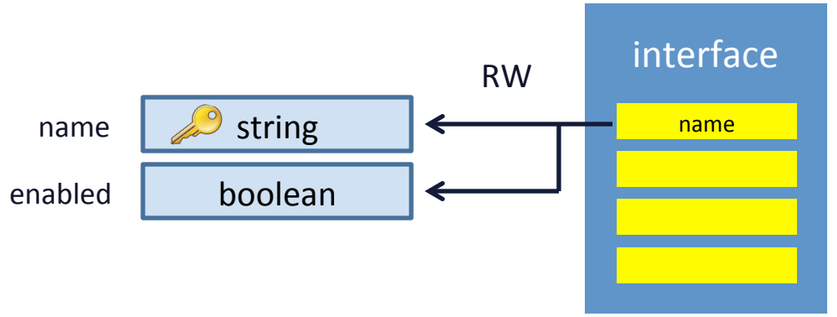
Leaf Types - Boolean

Leaf `enabled` with boolean value `true` or `false`

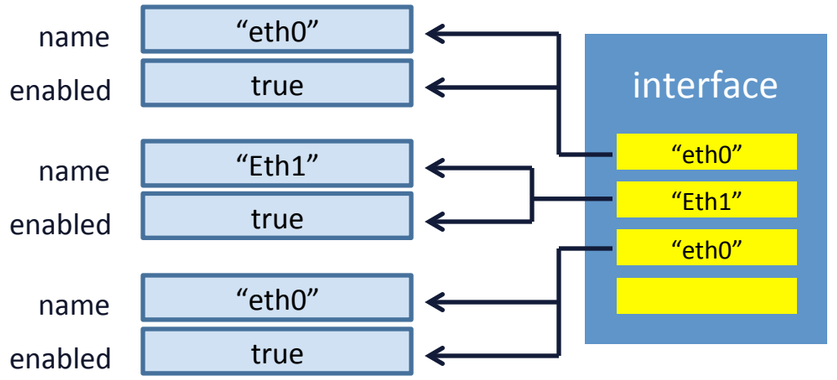
This is where the interface can be enabled and disabled

```
list interface{
    key “name”;
    description “...”;
    leaf name {...}

    leaf enabled {
        type boolean;
        default "true";
        description
            "This leaf contains the configured,
            desired state of the interface.”
    }
}
```

The Model



An Instance of the Model

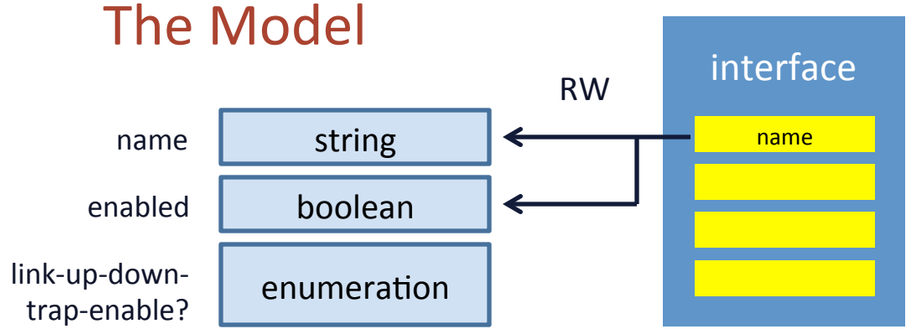


Leaf Types - Enumeration

Leaf `link-up-down-trap-enable` may take value `enabled` or `disabled`

```
list interface{
    key "name";
    leaf name {...}
    leaf enabled {...}

    leaf link-up-down-trap-enable {
        if-feature if-mib;
        type enumeration {
            enum enabled {value 1;}
            enum disabled {value 2;}
        }
        description
            "Controls whether linkUp/Down SNMP
            notifications should be generated";
     }
}
```

The Model



Switch order on graphic

Defining new types

New types can be defined using the `typedef` statement

```
typedef percent {
    type uint8 {
        range "0 .. 100";
    }
    description "Percentage";
 }
```

```
leaf completed {
    type percent;
}
```

RFC 6991: Common YANG Data Types

- ietf-inet-types (ipv4- and ipv6-addresses, domain-name, etc)
- ietf-yang-types (counters, gauges, date-and-time, etc)

Conditional Leaves - Features

The `feature` statement is used to mark parts of the model as conditional

The `if-feature` statement makes the parent statement conditional

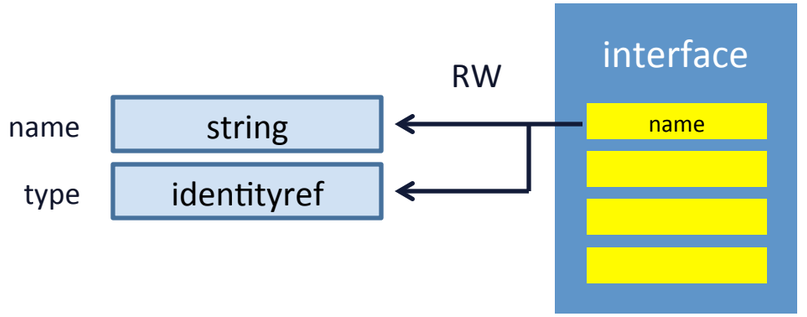
This leaf is a part of our model only If the `if-mib` feature is supported in the server

```
feature if-mib {
       description
         "This feature indicates that the
          device implements the IF-MIB.";
       reference
         "RFC 2863: The Interfaces Group MIB";
     }
...
list interface{
    key "name";
    leaf name {...}
    leaf enabled {...}

    leaf link-up-down-trap-enable {
        if-feature if-mib;
        type enumeration {
            enum enabled {value 1;}
            enum disabled {value 2;}
        }
        description
            "Controls whether linkUp/Down SNMP
            notifications should be generated";
     }
}
```

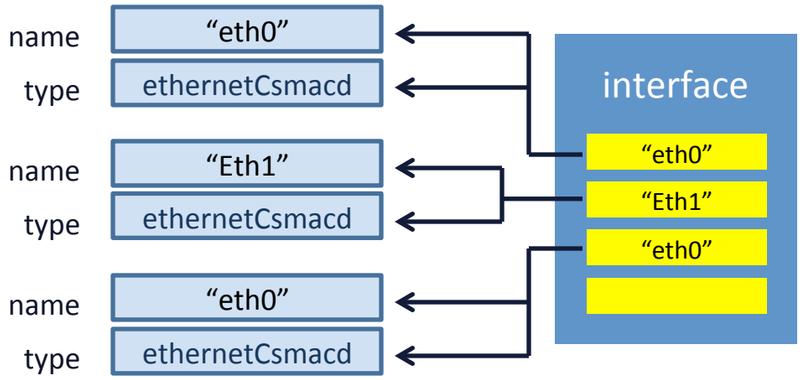
Abstract Types - Identityref

```
identity interface-type {
    description
       "Base identity from which specific
        interface types are derived.";
}

leaf type {
  type identityref {
    base interface-type;
  }
  mandatory true;
  description
    "The type of the interface....";
  reference
    "RFC 2863: The Interfaces Group MIB -
     ifType";
 }
```

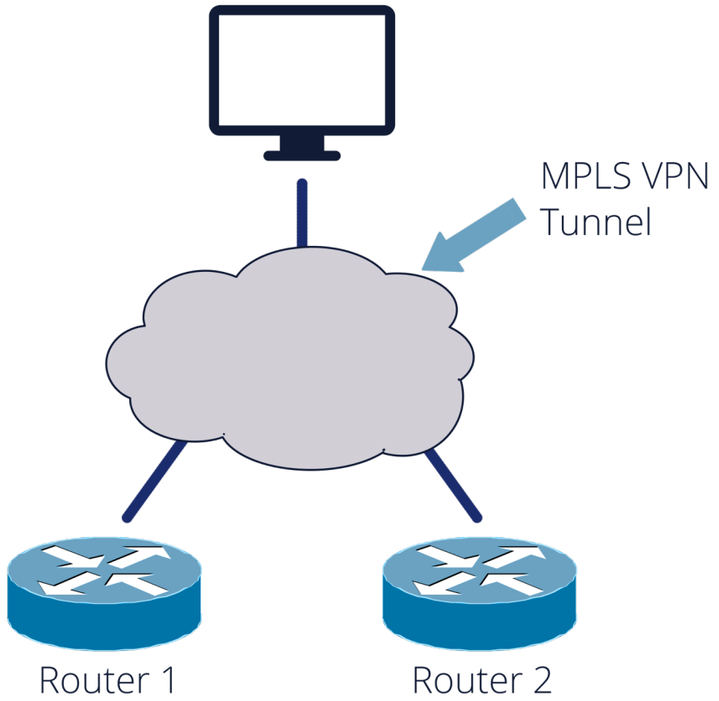
The Model



An Instance of the Model

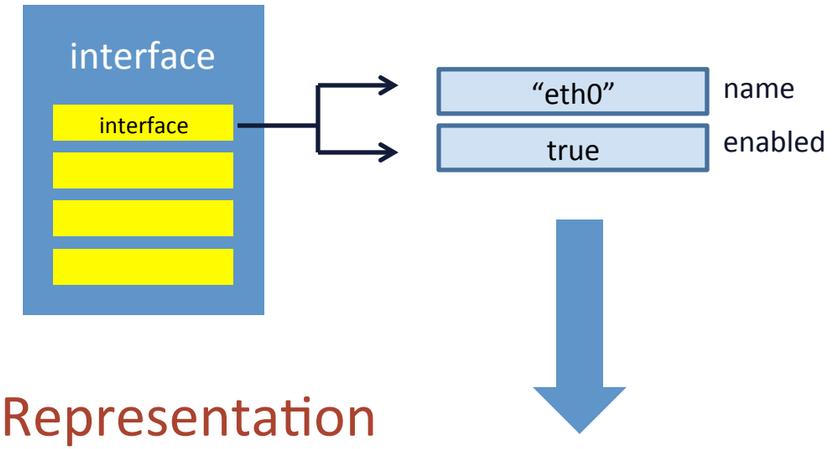


The Instance Data in XML



Router 1:
eth0: **2001:db8:c18:1::3/128**
Router 2:
eth0: **2001:db8:c18:1::2/128**

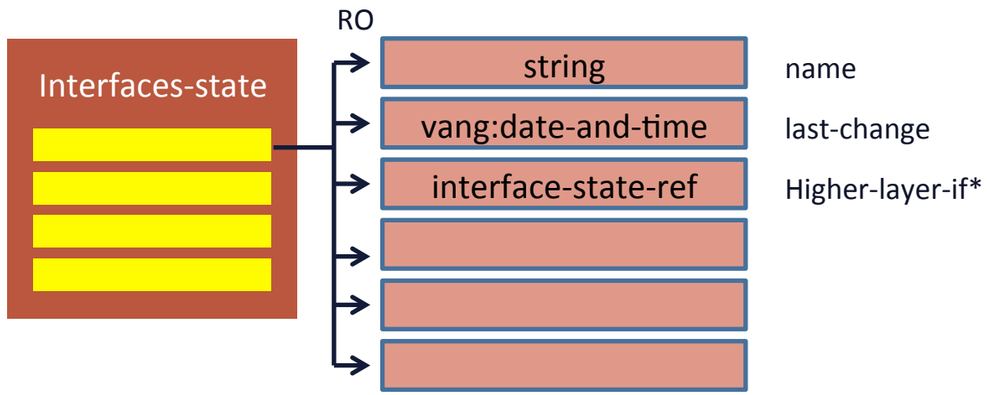
Instance



XML Representation

```
<interfaces>
    <interface>
        <name>eth0</name>
        <enabled>true</enabled>
    </interface>
</interfaces
```

Inspecting the Interfaces State Tree




```
+--ro interfaces-state
  +--ro interface* [name]
    +--ro name string
    +--ro type identityref
    +--ro admin-status enumeration
    +--ro oper-status enumeration
    +--ro last-change? yang:date-and-time
    +--ro if-index int32
    +--ro phys-address? yang:phys-address
    +--ro higher-layer-if* interface-state-ref
    +--ro lower-layer-if* interface-state-ref
    +--ro speed? yang:gauge64
    +--ro statistics
         +--ro discontinuity-time yang:date-and-
         time
         +--ro in-octets? yang:counter64
         +--ro in-unicast-pkts? yang:counter64
         +--ro in-broadcast-pkts? yang:counter64
         +--ro in-multicast-pkts? yang:counter64
         +--ro in-discards? yang:counter32
         +--ro in-errors? yang:counter32
         +--ro in-unknown-protos? yang:counter32
         …
```

Each entry in the interfaces-state list is a container representing the state of an interface

Imports and Includes

```
...
import ietf-yang-types {
    prefix yang;
}
...
```

YANG structures data models into modules and submodules.

- The `import` statement makes definitions from one module available inside another module or submodule
- The `include` statement is used to make content from a submodule available to that submodule's parent module, or to another submodule of that parent module.

Example Import

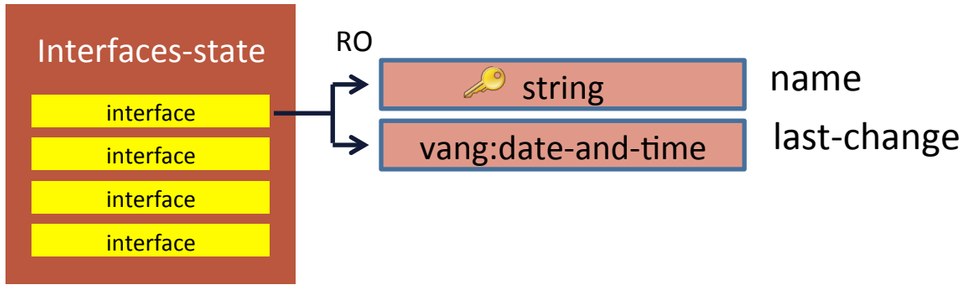
```
 import ietf-yang-types {
    prefix yang;
 }
...
leaf last-change {
   type yang:date-and-time;
      description
         "The time the interface entered its current operational
         state.  If the current state was entered prior to the
         last re-initialization of the local network management
         subsystem, then this node is not present.";
      reference
         "RFC 2863: The Interfaces Group MIB - ifLastChange";
}
```

ietf-yang-types.yang

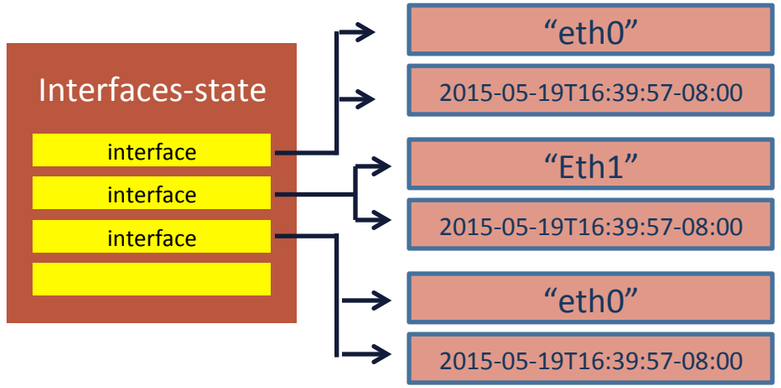
```
 typedef date-and-time {
    type string {
      pattern '\d{4}-\d{2}-\d{2}T\d{2}:\d{2}:\d{2}(\.
\d+)?'
            + '(Z|[\+\-]\d{2}:\d{2})';
    }
    description
     "The date-and-time type is a profile of the ISO
     8601 standard for representation of dates and
     times using the …
```

Example derived type

Model



Instance




```
typedef date-and-time {
   type string {
     pattern '\d{4}\d{2}\d{2}T\d{2}:\d{2}:\d{2}
      (\.\d+)?'+ '(Z|[\+\-]\d{2}:\d{2})';
   }
```

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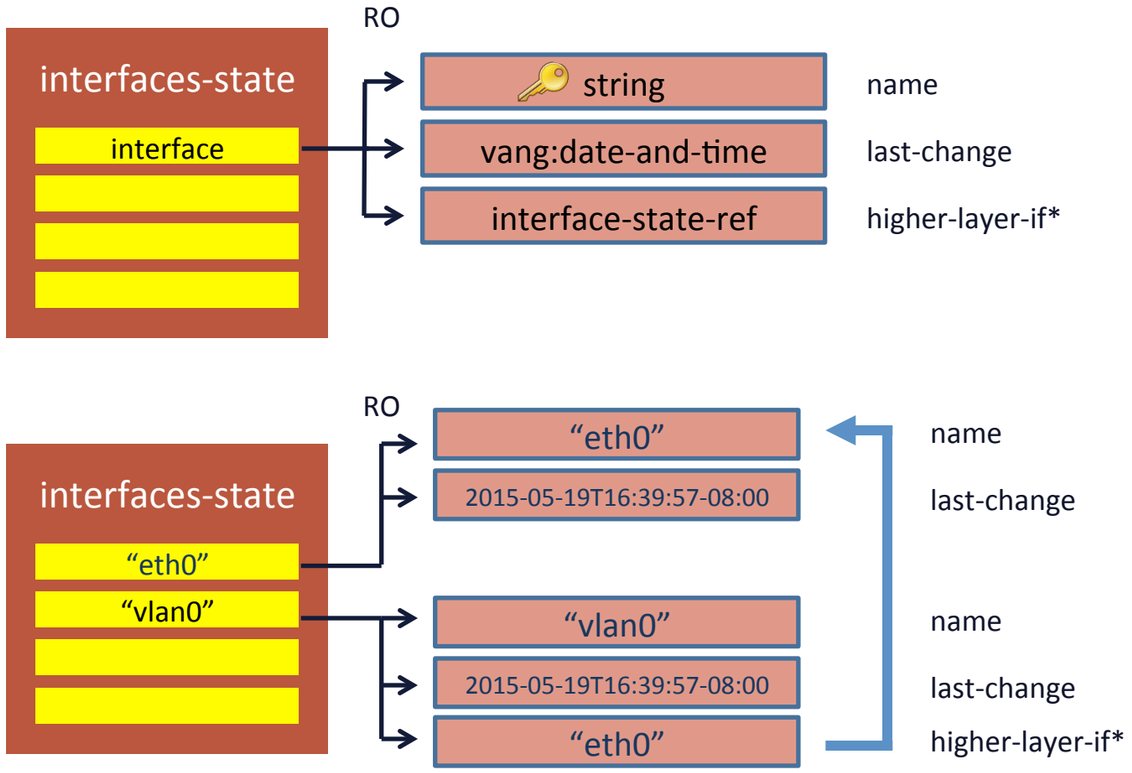
Referencing Another Leaf - leafref

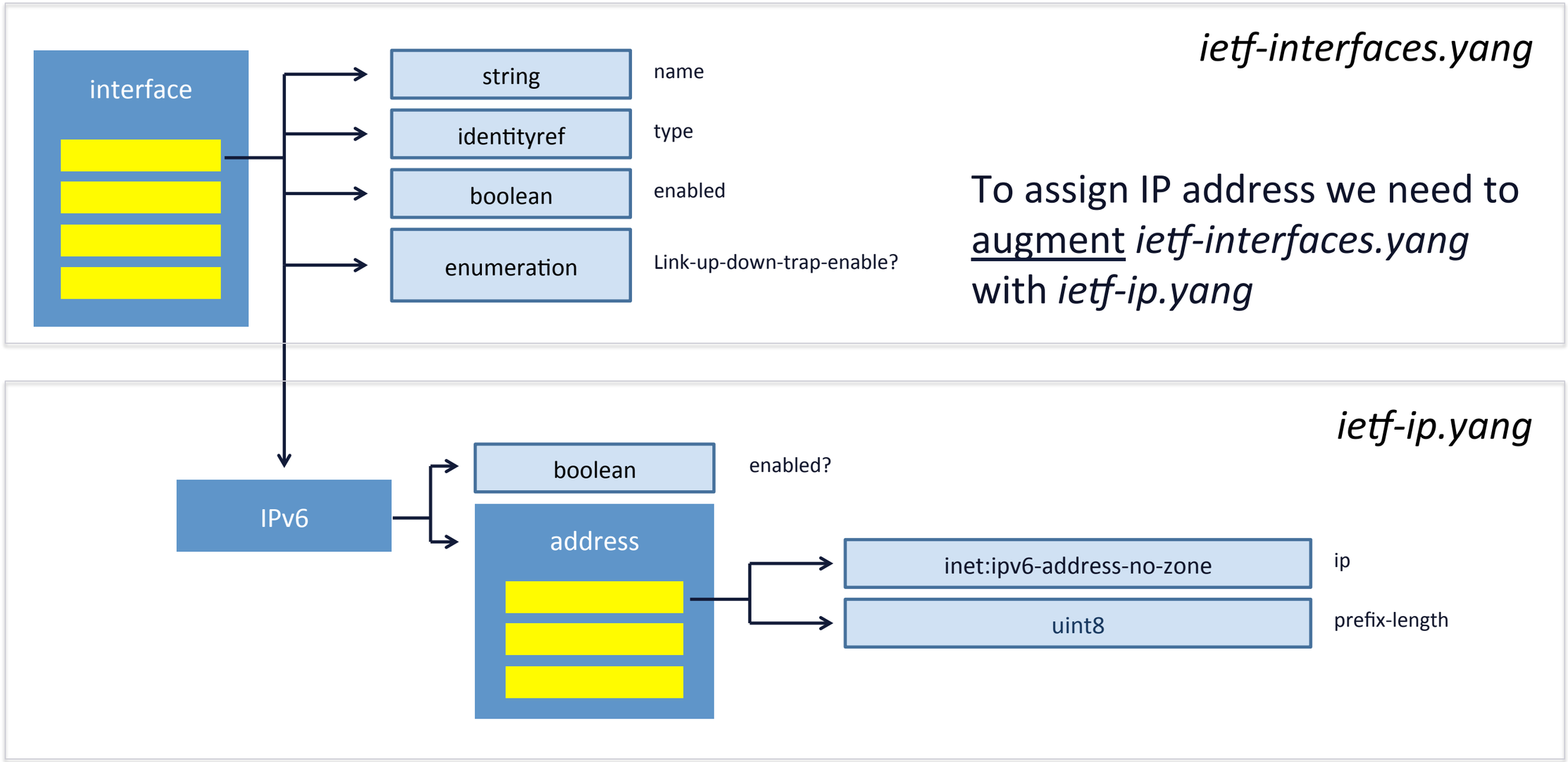
Use `leafref` to reference a particular leaf instance in the data tree

```
typedef interface-state-ref {
 type leafref {
 path "/if:interfaces-state/
if:interface/if:name";
 }
...
}

leaf-list lower-layer-if {
   type interface-state-ref;
…
}
```



Task #2: Assigning an IPv6 Address

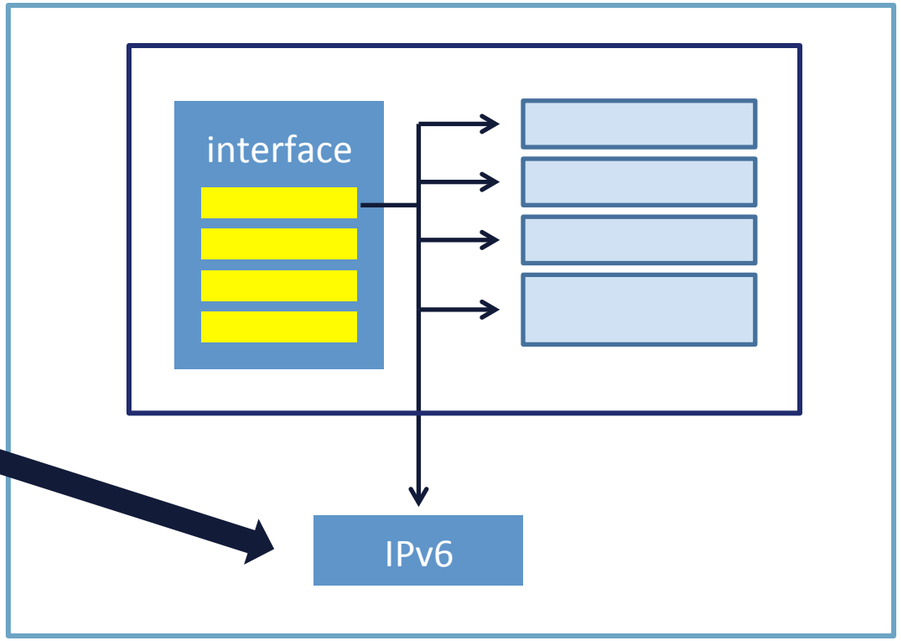


Augmenting the Interface Definition

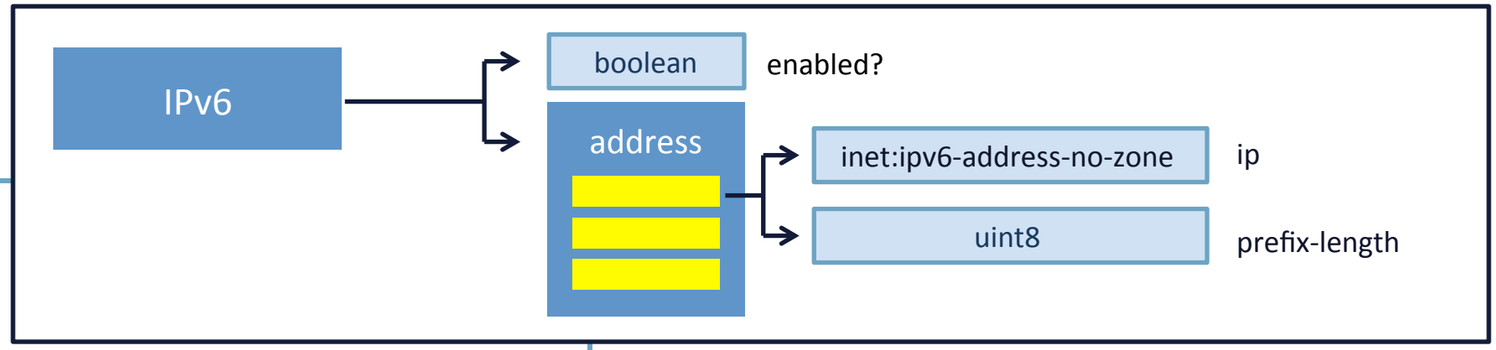
ietf-ip.yang

```
import ietf-interfaces {
    prefix if;
}
…

augment "/if:interfaces/if:interface" {
    description
        "Parameters for configuring IP on
interfaces...";
    container ipv6 {
        presence
            "Enables IPv6 unless the 'enabled' leaf
            (which defaults to 'true') is set to
'false'";
            description
            "Parameters for the IPv6 address
family.";
    }
}
```

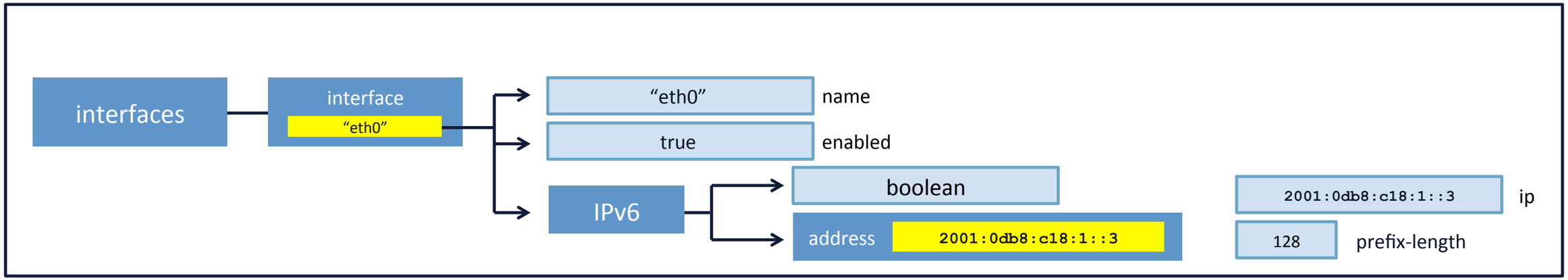


The IPv6 Model




```
container ipv6 {
   leaf enabled {
      type boolean;
      default true;
      description "Controls whether IPv6 is enabled or disabled...";
   }
   list address {
      key "ip";
      description "list of configured IPv6 addresses on interface.";
      leaf ip {
         type inet:ipv6-address-no-zone;
         description "The IPv6 address on the interface.";
      }
      leaf prefix-length {
         type uint8 { range "0..128"; }
         mandatory true;
         description "The length of the subnet prefix.";
      }
   }
)
```

The Instance Data in XML



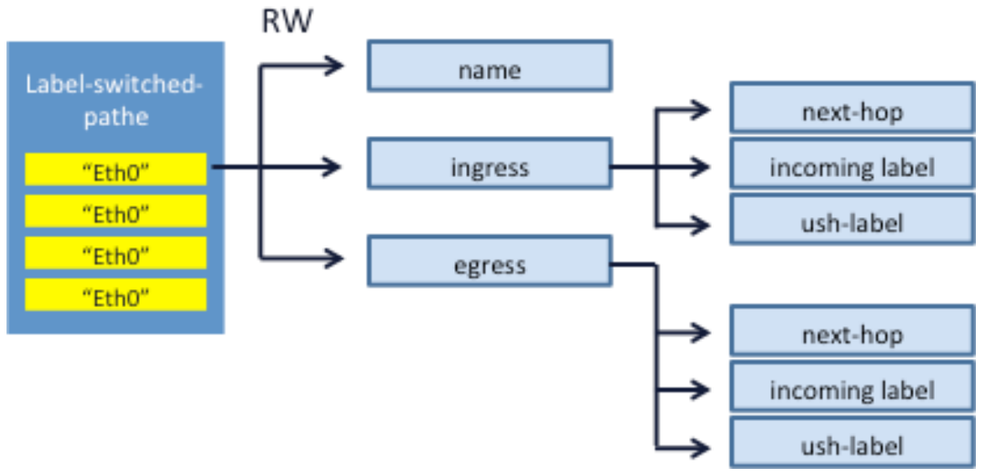
Router #1

```
<interfaces>
    <interface>
        <name>eth0</name>
        <enabled>true</enabled>
        <ipv6>
            <enabled>true</enabled>
            <address>
                <ip>2001:0db8:c18:1::2</ip>
                <prefix-length>128</prefix-length>
            </address>
        </ipv6>
    </interface>
</interfaces
```

Router #2

```
<interfaces>
    <interface>
        <name>eth0</name>
        <enabled>true</enabled>
        <ipv6>
            <enabled>true</enabled>
            <address>
                <ip>2001:0db8:c18:1::3</ip>
                <prefix-length>128</prefix-length>
            </address>
        </ipv6>
    </interface>
</interfaces
```

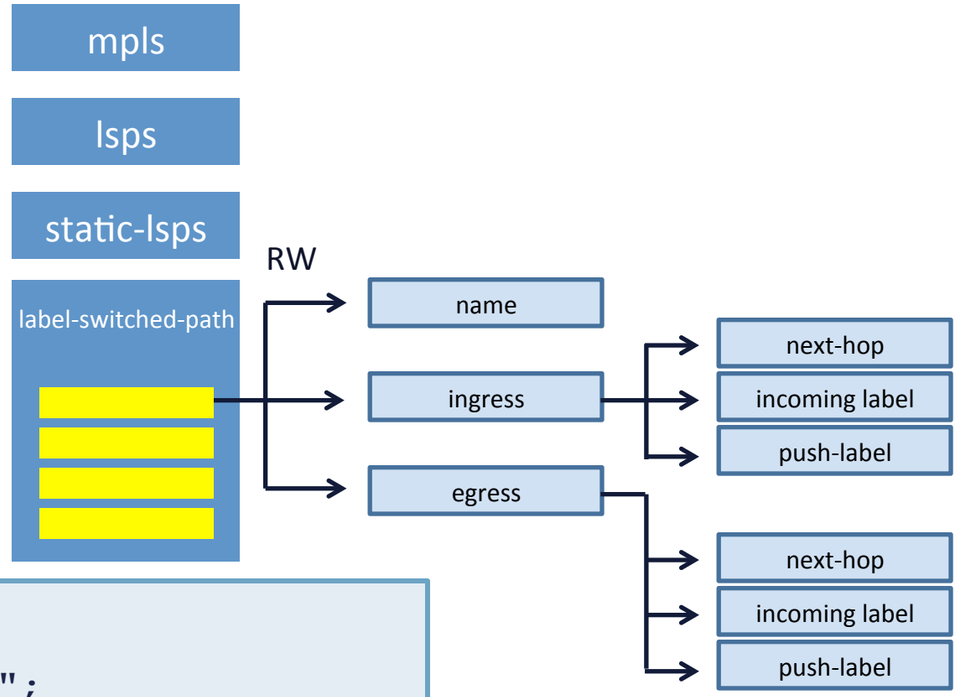
Task #3: Configure an LSP



Task #3: Configure LSPs

Container `static-lsps` will hold our configuration

Please note the `uses` statement below

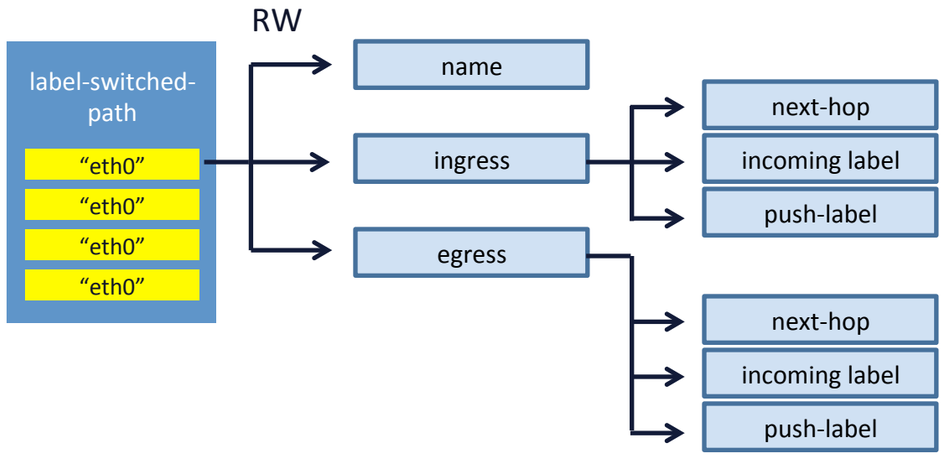



```
container mpls {
  presence "top-level container for MPLS config and state";
  ...
  container lsps {
    description "LSP definitions and configuration";
    container static-lsps {
      description "statically configured LSPs, without dynamic signaling";
      uses static-lsp-main;
    }
  }
}
```

Groupings

Groups of nodes can be assembled into reusable collections using the `grouping` statement.

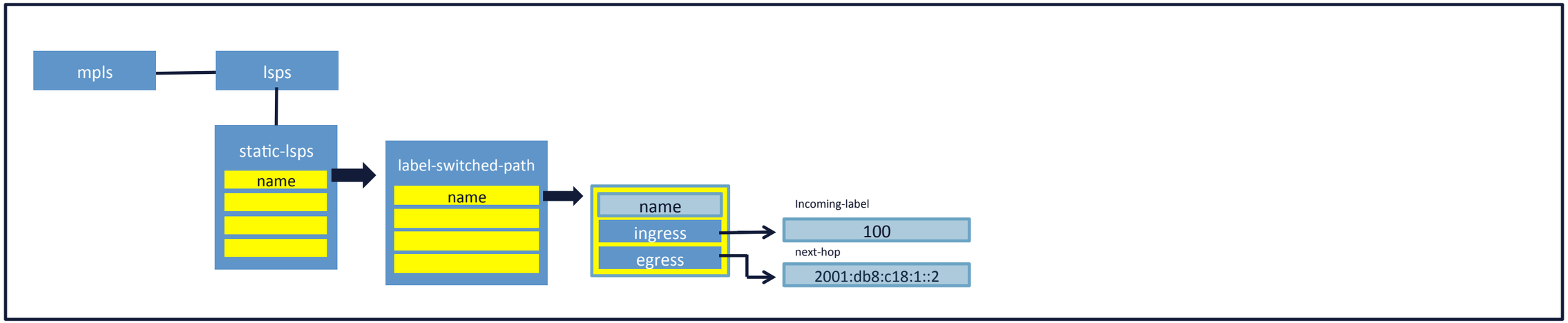
A grouping defines a set of nodes that are instantiated with the `uses` statement:




```
grouping static-lsp-main {
  list label-switched-path {
    key name;
    leaf name { type string; }
    container ingress { uses static-lsp-common; }
    container egress { uses static-lsp-common; }
  }
}
```

```
grouping static-lsp-common {
  leaf next-hop { type inet:ip-address; }
  leaf incoming-label { type mplst:mpls-label; }
  leaf push-label { type mplst:mpls-label; }
}
```

The Instance Data in XML



Router #1

```
<mpls>
  <lsps>
    <static-lsps>
      <label-switched-path>
        <name>lsp0</name>
        <ingress>
          <incoming-label>100</incoming-label>
        </ingress>
        <egress>
          <next-hop>2001:db8:c18:1::2</next-hop>
        </egress>
      </label-switched-path>
    </static-lsps>
  s</lsps>
</mpls>
```

Router #2

```
<mpls>
  <lsps>
    <static-lsps>
      <label-switched-path>
        <name>lsp0</name>
        <ingress>
          <incoming-label>100</incoming-label>
        </ingress>
        <egress>
          <next-hop>2001:db8:c18:1::3</next-hop>
        </egress>
      </label-switched-path>
    </static-lsps>
  s</lsps>
</mpls>
```

Summary

You should now be able to:

- Identify and describe common elements of a YANG model
- Examine a YANG model and create a valid configuration instance

Back Matter

- This material was originally developed by Charlie Justus and Carl Moberg with the support of Cisco Systems, special thanks to:
  - Kevin Serveau

Changelog

- 1.0 (2015-10-05) – Initial version
  Carl Moberg <camoberg@cisco.com>