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YANG Alarm Module
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Abstract

This document defines a YANG module for alarm management. It includes functions for alarm list management, alarm shelving and notifications to inform management systems. There are also RPCs to manage the operator state of an alarm and administrative alarm procedures. The module carefully maps to relevant alarm standards.

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1. Introduction

This document defines a YANG [[RFC7950](#)] module for alarm management. The purpose is to define a standardized alarm interface for network devices that can be easily integrated into management applications. The model is also applicable as a northbound alarm interface in the management applications.

Alarm monitoring is a fundamental part of monitoring the network. Raw alarms from devices do not always tell the status of the network services or necessarily point to the root cause. However, being able to feed alarms to the alarm management application in a standardized format is a starting point for performing higher level network assurance tasks.

The design of the module is based on experience from using and implementing available alarm standards from ITU [[X.733](#)], 3GPP [[ALARMIRP](#)] and ANSI [[ISA182](#)].

1.1. Terminology and Notation

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.

The following terms are defined in [[RFC7950](#)]:

- o action
- o client
- o data tree
- o RPC
- o server

The following terms are used within this document:

- o Alarm (the general concept): An alarm signifies an undesirable state in a resource that requires corrective action.

- o Alarm Type: An alarm type identifies a possible unique alarm state for a resource. Alarm types are names to identify the state like "link-alarm", "jitter-violation", "high-disk-utilization".
- o Resource: A fine-grained identification of the alarming resource, for example: an interface, a process.
- o Alarm Instance: The alarm state for a specific resource and alarm type. For example (GigabitEthernet0/15, link-alarm). An entry in the alarm list.
- o Alarm Inventory: A list of all possible alarm types on a system.
- o Alarm Shelving: Blocking alarms according to specific criteria.
- o Corrective Action: An action taken by an operator or automation routine in order to minimize the impact of the alarm or resolving the root cause.
- o Management System: The alarm management application that consumes the alarms, i.e., acts as a client.
- o System: The system that implements this YANG alarm module, i.e., acts as a server. This corresponds to a network device or a management application that provides a north-bound alarm interface.

Tree diagrams used in this document follow the notation defined in [\[RFC8340\]](#).

2. Objectives

The objectives for the design of the Alarm Module are:

- o Simple to use. If a system supports this module, it shall be straight-forward to integrate this into a YANG based alarm manager.
- o View alarms as states on resources and not as discrete notifications.
- o Clear definition of "alarm" in order to exclude general events that should not be forwarded as alarm notifications.
- o Clear and precise identification of alarm types and alarm instances.

- o A management system should be able to pull all available alarm types from a system, i.e., read the alarm inventory from a system. This makes it possible to prepare alarm operators with corresponding alarm instructions.
- o Address alarm usability requirements, see [Appendix G](#). While IETF has not really addressed alarm management, telecom standards has addressed it purely from a protocol perspective. The process industry has published several relevant standards addressing requirements for a useful alarm interface; [\[EEMUA\]](#), [\[ISA182\]](#). This alarm module defines usability requirements as well as a YANG data model.
- o Mapping to X.733, which is a requirement for some alarm systems. Still, keep some of the X.733 concepts out of the core model in order to make the model small and easy to understand.

3. Alarm Module Concepts

This section defines the fundamental concepts behind the data model. This section is rooted in the works of Vallin et. al [\[ALARMSEM\]](#).

3.1. Alarm Definition

An alarm signifies an undesirable state in a resource that requires corrective action.

There are two main things to remember from this definition:

1. the definition focuses on leaving out events and logging information in general. Alarms should only be used for undesired states that require action.
2. the definition also focus on alarms as a state on a resource, not the notifications that report the state changes.

See [Appendix F](#) for information how this definition relates to other alarm standards.

3.2. Alarm Type

This document defines an alarm type with an alarm type id and an alarm type qualifier.

The alarm type id is modeled as a YANG identity. With YANG identities, new alarm types can be defined in a distributed fashion. YANG identities are hierarchical, which means that an hierarchy of alarm types can be defined.

Standards and vendors should define their own alarm type identities based on this definition.

The use of YANG identities means that all possible alarms are identified at design time. This explicit declaration of alarm types makes it easier to allow for alarm qualification reviews and preparation of alarm actions and documentation.

There are occasions where the alarm types are not known at design time. For example, a system with digital inputs that allows users to connect detectors (e.g., smoke detector) to the inputs. In this case it is a configuration action that says that certain connectors are fire alarms for example.

In order to allow for dynamic addition of alarm types the alarm module allows for further qualification of the identity based alarm type using a string. A potential drawback of this is that there is a big risk that alarm operators will receive alarm types as a surprise, they do not know how to resolve the problem since a defined alarm procedure does not necessarily exist. To avoid this risk the system MUST publish all possible alarm types in the alarm inventory, see [Section 4.2](#).

A vendor or standard organization can define their own alarm-type hierarchy. The example below shows a hierarchy based on X.733 event types:

```
import ietf-alarms {
  prefix al;
}
identity vendor-alarms {
  base al:alarm-type;
}
identity communications-alarm {
  base vendor-alarms;
}
identity link-alarm {
  base communications-alarm;
}
```

Alarm types can be abstract. An abstract alarm type is used as a base for defining hierarchical alarm types. Concrete alarm types are used for alarm states and appear in the alarm inventory. There are two kinds of concrete alarm types:

1. The last subordinate identity in the "alarm-type-id" hierarchy is concrete, for example: "alarm-identity.environmental-alarm.smoke". In this example "alarm-identity" and

"environmental-alarm" are abstract YANG identities, whereas "smoke" is a concrete YANG identity.

2. The YANG identity hierarchy is abstract and the concrete alarm type is defined by the dynamic alarm qualifier string, for example: "alarm-identity.environmental-alarm.external-detector" with alarm-type-qualifier "smoke".

For example:

```
// Alternative 1: concrete alarm type identity
import ietf-alarms {
  prefix al;
}
identity environmental-alarm {
  base al:alarm-type;
  description "Abstract alarm type";
}
identity smoke {
  base environmental-alarm;
  description "Concrete alarm type";
}

// Alternative 2: concrete alarm type qualifier
import ietf-alarms {
  prefix al;
}
identity environmental-alarm {
  base al:alarm-type;
  description "Abstract alarm type";
}
identity external-detector {
  base environmental-alarm;
  description
    "Abstract alarm type, a run-time configuration
    procedure sets the type of alarm detected. This will
    be reported in the alarm-type-qualifier.";
}
```

A server SHOULD strive to minimize the number of dynamically defined alarm types.

3.3. Identifying the Alarming Resource

It is of vital importance to be able to refer to the alarming resource. This reference must be as fine-grained as possible. If the alarming resource exists in the data tree then an instance-identifier MUST be used with the full path to the object.

When the module is used in a controller/orchestrator/manager the original device resource identification can be modified to include the device in the path. The details depend on how devices are identified, and are out of scope for this specification.

Example:

```
The original device alarm might identify the resource as
"/dev:interfaces/dev:interface[dev:name='FastEthernet1/0']".
```

```
The resource identification in the manager could look something
like: "/mgr:devices/mgr:device[mgr:name='xyz123']/dev:interfaces/
dev:interface[dev:name='FastEthernet1/0']"
```

This module also allows for alternate naming of the alarming resource if it is not available in the data tree.

3.4. Identifying Alarm Instances

A primary goal of this alarm module is to remove any ambiguity in how alarm notifications are mapped to an update of an alarm instance. X.733 and especially 3GPP were not really clear on this point. This YANG alarm module states that the tuple (resource, alarm type identifier, alarm type qualifier) corresponds to a single alarm instance. This means that alarm notifications for the same resource and same alarm type are matched to update the same alarm instance. These three leafs are therefore used as the key in the alarm list:

```
list alarm {
  key "resource alarm-type-id alarm-type-qualifier";
  ...
}
```

3.5. Alarm Life-Cycle

The alarm model clearly separates the resource alarm life-cycle from the operator and administrative life-cycles of an alarm.

- o resource alarm life-cycle: the alarm instrumentation that controls alarm raise, clearance, and severity changes.
- o operator alarm life-cycle: operators acting upon alarms with actions like acknowledgment and closing. Closing an alarm implies that the operator considers the corrective action performed. Operators can also shelf (block/filter) alarms in order to avoid nuisance alarms.

- o administrative alarm life-cycle: purging (deleting) unwanted alarms and compressing the alarm status change list. This module exposes operations to manage the administrative life-cycle. The server may also perform these operations based on other policies, but how that is done is out of scope for this document.

A server SHOULD describe how long it retains cleared/closed alarms: until manually purged or if it has an automatic removal policy.

3.5.1. Resource Alarm Life-Cycle

From a resource perspective, an alarm can for example have the following life-cycle: raise, change severity, change severity, clear, being raised again etc. All of these status changes can have different alarm texts generated by the instrumentation. Two important things to note:

1. Alarms are not deleted when they are cleared. Deleting alarms is an administrative process. The alarm module defines an rpc "purge" that deletes alarms.
2. Alarms are not cleared by operators, only the underlying instrumentation can clear an alarm. Operators can close alarms.

The YANG tree representation below illustrates the resource oriented life-cycle:

```

+--ro alarm* [resource alarm-type-id alarm-type-qualifier]
  ...
  +--ro is-cleared                boolean
  +--ro last-changed              yang:date-and-time
  +--ro perceived-severity        severity
  +--ro alarm-text                alarm-text
  +--ro status-change* [time]
    +--ro time                    yang:date-and-time
    +--ro perceived-severity      severity-with-clear
    +--ro alarm-text              alarm-text

```

For every status change from the resource perspective a row is added to the "status-change" list. The last status values are also represented as leafs for the alarm. Note well that the alarm severity does not include "cleared", alarm clearance is a boolean flag.

An alarm can therefore look like this: ((GigabitEthernet0/25, link-alarm,""), false, T, major, "Interface GigabitEthernet0/25 down")

3.5.2. Operator Alarm Life-cycle

Operators can also act upon alarms using the set-operator-state action:

```

+--ro alarm* [resource alarm-type-id alarm-type-qualifier]
  ...
+--ro operator-state-change* [time] {operator-actions}?
|  +--ro time          yang:date-and-time
|  +--ro operator      string
|  +--ro state         operator-state
|  +--ro text?         string
+---x set-operator-state {operator-actions}?
  +---w input
    +---w state        writable-operator-state
    +---w text?       string

```

The operator state for an alarm can be: "none", "ack", "shelved", and "closed". Alarm deletion (using the rpc "purge-alarms"), can use this state as a criteria. A closed alarm is an alarm where the operator has performed any required corrective actions. Closed alarms are good candidates for being purged.

3.5.3. Administrative Alarm Life-Cycle

Deleting alarms from the alarm list is considered an administrative action. This is supported by the "purge-alarms" rpc. The "purge-alarms" rpc takes a filter as input. The filter selects alarms based on the operator and resource life-cycle such as "all closed cleared alarms older than a time specification". The server may also perform these operations based on other policies, but how that is done is out of scope for this document.

Alarms can be compressed. Compressing an alarm deletes all entries in the alarm's "status-change" list except for the last status change. A client can perform this using the "compress-alarms" rpc. The server may also perform these operations based on other policies, but how that is done is out of scope for this document.

3.6. Root Cause, Impacted Resources and Related Alarms

The general principle of this alarm module is to limit the amount of alarms. The alarm has two leaf-lists to identify possible impacted resources and possible root-cause resources. The system should not represent individual alarms for the possible root-cause resources and impacted resources. These serves as hints only. It is up to the client application to use this information to present the overall status.

A system should always strive to identify the resource that can be acted upon as the "resource" leaf. The "impacted-resource" leaf-list shall be used to identify any side-effects of the alarm. The impacted resources can not be acted upon to fix the problem. An example of this kind of alarm might be a disc full problem which impacts a number of databases.

In some occasions the system might not be capable of detecting the root cause, the resource that can be acted upon. The instrumentation in this case only monitors the side-effect and needs to represent an alarm that indicates a situation that needs acting upon. The instrumentation still might identify possible candidates for the root-cause resource. In this case the "root-cause-resource" leaf-list can be used to indicate the candidate root-cause resources. An example of this kind of alarm might be an active test tool that detects an SLA violation on a VPN connection and identifies the devices along the chain as candidate root causes.

The alarm module also supports a way to associate different alarms to each other with the "related-alarm" list. This list enables the server to inform the client that certain alarms are related to other alarms.

Note well that this module does not prescribe any dependencies or preference between the above alarm correlation mechanisms. Different systems have different capabilities and the above described mechanisms are available to support the instrumentation features.

[3.7.](#) Alarm Shelving

Alarm shelving is an important function in order for alarm management applications and operators to stop superfluous alarms. A shelved alarm implies that any alarms fulfilling this criteria are ignored (blocked/filtered). Shelved alarms appear in a dedicated shelved alarm list in order not to disturb the relevant alarms. Shelved alarms do not generate notifications.

[3.8.](#) Alarm Profiles

Alarm profiles are used to configure further information to an alarm type. This module supports configuring severity levels overriding the system default levels. This corresponds to the Alarm Assignment Profile, ASAP, functionality in M.3100 [[M.3100](#)] and M.3160 [[M.3160](#)]. Other standard or enterprise modules can augment this list with further alarm type information.

4. Alarm Data Model

The fundamental parts of the data model are the "alarm-list" with associated notifications and the "alarm-inventory" list of all possible alarm types. These MUST be implemented by a system. The rest of the data model are made conditional with YANG the features "operator-actions", "alarm-shelving", "alarm-history", "alarm-summary", "alarm-profile", and "severity-assignment".

The data model has the following overall structure:

```

+--rw control
| +--rw max-alarm-status-changes?      union
| +--rw (notify-status-changes)?
| |   ...
| +--rw alarm-shelving {alarm-shelving}?
|   ...
+--ro alarm-inventory
| +--ro alarm-type* [alarm-type-id alarm-type-qualifier]
|   ...
+--ro summary {alarm-summary}?
| +--ro alarm-summary* [severity]
| |   ...
| +--ro shelves-active?  empty {alarm-shelving}?
+--ro alarm-list
| +--ro number-of-alarms?  yang:gauge32
| +--ro last-changed?     yang:date-and-time
| +--ro alarm* [resource alarm-type-id alarm-type-qualifier]
|   ...
+--ro shelved-alarms {alarm-shelving}?
| +--ro number-of-shelved-alarms?  yang:gauge32
| +--ro alarm-shelf-last-changed?  yang:date-and-time
| +--ro shelved-alarm*
|   [resource alarm-type-id alarm-type-qualifier]
|   ...
+--rw alarm-profile*
|   [alarm-type-id alarm-type-qualifier-match resource]
|   {alarm-profile}?
+--rw alarm-type-id          al:alarm-type-id
+--rw alarm-type-qualifier-match  string
+--rw resource                al:resource-match
+--rw description             string
+--rw alarm-severity-assignment-profile
|   {severity-assignment}?
|   ...

```


4.1. Alarm Control

The `"/alarms/control/notify-status-changes"` choice controls if notifications are sent for all state changes, only raise and clear, or only notifications more severe than a configured level. This feature in combination with alarm shelving corresponds to the ITU Alarm Report Control functionality.

Every alarm has a list of status changes, this is a circular list. The length of this list is controlled by `"/alarms/control/max-alarm-status-changes"`.

4.1.1. Alarm Shelving

The shelving control tree is shown below:

```

+--rw control
  +--rw alarm-shelving {alarm-shelving}?
    +--rw shelf* [name]
      +--rw name                string
      +--rw resource*           resource-match
      +--rw alarm-type-id?      alarm-type-id
      +--rw alarm-type-qualifier-match? string
      +--rw description?        string

```

Shelved alarms are shown in a dedicated shelved alarm list. The instrumentation MUST move shelved alarms from the alarm list (`/alarms/alarm-list`) to the shelved alarm list (`/alarms/shelved-alarms/`). Shelved alarms do not generate any notifications. When the shelving criteria is removed or changed the alarm list MUST be updated to the correct actual state of the alarms.

Shelving and unshelving can only be performed by editing the shelf configuration. It cannot be performed on individual alarms. The server will add an operator state indicating that the alarm was shelved/unshelved.

A leaf (`/alarms/summary/shelfs-active`) in the alarm summary indicates if there are shelved alarms.

A system can select to not support the shelving feature.

4.2. Alarm Inventory

The alarm inventory represents all possible alarm types that may occur in the system. A management system may use this to build alarm procedures. The alarm inventory is relevant for several reasons:

The system might not instrument all defined alarm type identities, and some alarm identities are abstract.

The system has configured dynamic alarm types using the alarm qualifier. The inventory makes it possible for the management system to discover these.

Note that the mechanism whereby dynamic alarm types are added using the alarm type qualifier MUST populate this list.

The optional leaf-list "resource" in the alarm inventory enables the system to publish for which resources a given alarm type may appear.

A server MUST implement the alarm inventory in order to enable controlled alarm procedures in the client.

The alarm inventory tree is shown below:

```
+--ro alarm-inventory
  +--ro alarm-type* [alarm-type-id alarm-type-qualifier]
    +--ro alarm-type-id          alarm-type-id
    +--ro alarm-type-qualifier    alarm-type-qualifier
    +--ro resource*              resource-match
    +--ro has-clear              boolean
    +--ro severity-levels*       severity
    +--ro description            string
```

[4.3.](#) Alarm Summary

The alarm summary list summarizes alarms per severity; how many cleared, cleared and closed, and closed. It also gives an indication if there are shelved alarms.

The alarm summary tree is shown below:


```

+--ro summary {alarm-summary}?
  +--ro alarm-summary* [severity]
    | +-ro severity          severity
    | +-ro total?           yang:gauge32
    | +-ro cleared?        yang:gauge32
    | +-ro cleared-not-closed? yang:gauge32
    | |   {operator-actions}?
    | +-ro cleared-closed?  yang:gauge32
    | |   {operator-actions}?
    | +-ro not-cleared-closed? yang:gauge32
    | |   {operator-actions}?
    | +-ro not-cleared-not-closed? yang:gauge32
    |   {operator-actions}?
    +--ro shelves-active?  empty {alarm-shelving}?

```

[4.4.](#) The Alarm List

The alarm list (/alarms/alarm-list) is a function from (resource, alarm type, alarm type qualifier) to the current composite alarm state. The composite state includes states for the resource life-cycle such as severity, clearance flag and operator states such as acknowledgment.


```

+--ro alarm-list
  +--ro number-of-alarms?  yang:gauge32
  +--ro last-changed?     yang:date-and-time
  +--ro alarm* [resource alarm-type-id alarm-type-qualifier]
    +--ro resource          resource
    +--ro alarm-type-id     alarm-type-id
    +--ro alarm-type-qualifier alarm-type-qualifier
    +--ro alt-resource*     resource
    +--ro related-alarm*
      | [resource alarm-type-id alarm-type-qualifier]
      | +--ro resource
      | | -> /alarms/alarm-list/alarm/resource
      | +--ro alarm-type-id     leafref
      | +--ro alarm-type-qualifier leafref
    +--ro impacted-resource* resource
    +--ro root-cause-resource* resource
    +--ro time-created        yang:date-and-time
    +--ro is-cleared         boolean
    +--ro last-changed       yang:date-and-time
    +--ro perceived-severity severity
    +--ro alarm-text         alarm-text
    +--ro status-change* [time] {alarm-history}?
      | +--ro time              yang:date-and-time
      | +--ro perceived-severity severity-with-clear
      | +--ro alarm-text       alarm-text
    +--ro operator-state-change* [time] {operator-actions}?
      | +--ro time              yang:date-and-time
      | +--ro operator         string
      | +--ro state            operator-state
      | +--ro text?           string
    +---x set-operator-state {operator-actions}?
      | +---w input
      | +---w state            writable-operator-state
      | +---w text?          string
    +---n operator-action {operator-actions}?
      +-- time                yang:date-and-time
      +-- operator            string
      +-- state                operator-state
      +-- text?               string

```

Every alarm has three important states, the resource clearance state "is-cleared", the severity "perceived-severity" and the operator state available in the operator state change list.

In order to see the alarm history the resource state changes are available in the "status-change" list and the operator history is available in the "operator-state-change" list.

[4.5. The Shelved Alarms List](#)

The shelved alarm list has the same structure as the alarm list above. It shows all the alarms that matches the shelving criteria (/alarms/control/alarm-shelving).

[4.6. Alarm Profiles](#)

Alarm profiles (/alarms/alarm-profile/) is a list of configurable alarm types. The list supports configurable alarm severity levels in the container "alarm-severity-assignment-profile". If an alarm matches the configured alarm type it MUST use the configured severity level(s) instead of the system default. This configuration MUST also be represented in the alarm inventory.

```

+--rw alarm-profile*
   [alarm-type-id alarm-type-qualifier-match resource]
   {alarm-profile}?
  +--rw alarm-type-id           al:alarm-type-id
  +--rw alarm-type-qualifier-match string
  +--rw resource                 al:resource-match
  +--rw description              string
  +--rw alarm-severity-assignment-profile
     {severity-assignment}?
     +--rw severity-levels*    al:severity

```

[4.7. RPCs and Actions](#)

The alarm module supports rpcs and actions to manage the alarms:

"purge-alarms" (rpc): delete alarms according to specific criteria, for example all cleared alarms older then a specific date.

"compress-alarms" (rpc): compress the status-change list for the alarms.

"set-operator-state" (action): change the operator state for an alarm: for example acknowledge.

[4.8. Notifications](#)

The alarm module supports a general notification to report alarm state changes. It carries all relevant parameters for the alarm management application.

There is also a notification to report that an operator changed the operator state on an alarm, like acknowledge.

If the alarm inventory is changed, for example a new card type is inserted, a notification will tell the management application that new alarm types are available.

5. Alarm YANG Module

This YANG module references [[RFC6991](#)].

```
<CODE BEGINS> file "ietf-alarms@2018-10-09.yang"
module ietf-alarms {
  yang-version 1.1;
  namespace "urn:ietf:params:xml:ns:yang:ietf-alarms";
  prefix al;

  import ietf-yang-types {
    prefix yang;
    reference "RFC 6991: Common YANG Data Types.";
  }

  organization
    "IETF CCAMP Working Group";
  contact
    "WG Web: <http://tools.ietf.org/wg/ccamp>
    WG List: <mailto:ccamp@ietf.org>

    Editor: Stefan Vallin
           <mailto:stefan@wallan.se>

    Editor: Martin Bjorklund
           <mailto:mbj@tail-f.com>";
  description
    "This module defines an interface for managing alarms. Main
    inputs to the module design are the 3GPP Alarm IRP, ITU-T X.733
    and ANSI/ISA-18.2 alarm standards.

    Main features of this module include:

    * Alarm list:
      A list of all alarms. Cleared alarms stay in
      the list until explicitly purged.

    * Operator actions on alarms:
      Acknowledging and closing alarms.
```


- * Administrative actions on alarms:
Purging alarms from the list according to specific criteria.
- * Alarm inventory:
A management application can read all alarm types implemented by the system.
- * Alarm shelving:
Shelving (blocking) alarms according to specific criteria.
- * Alarm profiles:
A management system can attach further information to alarm types, for example overriding system default severity levels.

This module uses a stateful view on alarms. An alarm is a state for a specific resource (note that an alarm is not a notification). An alarm type is a possible alarm state for a resource. For example, the tuple:

```
('link-alarm', 'GigabitEthernet0/25')
```

is an alarm of type 'link-alarm' on the resource 'GigabitEthernet0/25'.

Alarm types are identified using YANG identities and an optional string-based qualifier. The string-based qualifier allows for dynamic extension of the statically defined alarm types. Alarm types identify a possible alarm state and not the individual notifications. For example, the traditional 'link-down' and 'link-up' notifications are two notifications referring to the same alarm type 'link-alarm'.

With this design there is no ambiguity about how alarm and alarm clear correlation should be performed: notifications that report the same resource and alarm type are considered updates of the same alarm, e.g., clearing an active alarm or changing the severity of an alarm.

The instrumentation can update 'severity' and 'alarm-text' on an existing alarm. The above alarm example can therefore look like:

```
((('link-alarm', 'GigabitEthernet0/25'),  
warning,
```



```
'interface down while interface admin state is up')
```

There is a clear separation between updates on the alarm from the underlying resource, like clear, and updates from an operator like acknowledge or closing an alarm:

```
(('link-alarm', 'GigabitEthernet0/25'),  
  warning,  
  'interface down while interface admin state is up',  
  cleared,  
  closed)
```

Administrative actions like removing closed alarms older than a given time is supported.

This alarm module does not define how the underlying instrumentation detects and clears the specific alarms. That belongs to the SDO or enterprise that owns that specific technology.

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The key words 'MUST', 'MUST NOT', 'REQUIRED', 'SHALL', 'SHALL NOT', 'SHOULD', 'SHOULD NOT', 'RECOMMENDED', 'MAY', and 'OPTIONAL' in the module text are to be interpreted as described in [RFC 2119](#) (<https://tools.ietf.org/html/rfc2119>).

This version of this YANG module is part of RFC XXXX (<https://tools.ietf.org/html/rfcXXXX>); see the RFC itself for full legal notices.";

```
revision 2018-10-09 {  
  description  
    "Initial revision."  
  reference "RFC XXXX: YANG Alarm Module";  
}  
  
/*  
 * Features  
*/
```



```
feature operator-actions {
  description
    "This feature indicates that the system supports operator
    states on alarms.";
}

feature alarm-shelving {
  description
    "This feature indicates that the system supports shelving
    (blocking) alarms.";
}

feature alarm-history {
  description
    "This feature indicates that server maintains a history of
    state changes for each alarm. For example, if an alarm
    toggles between cleared and active 10 times, these state
    changes are present in a separate list in the alarm.";
}

feature alarm-summary {
  description
    "This feature indicates that the server summarizes the number
    of alarms per severity and operator state.";
}

feature alarm-profile {
  description
    "The system supports clients to configure further information
    to each alarm type.";
}

feature severity-assignment {
  description
    "The system supports configurable alarm severity levels.";
  reference
    "M.3160/M.3100 Alarm Severity Assignment Profile, ASAP";
}

/*
 * Identities
 */

identity alarm-type-id {
  description
    "Base identity for alarm types. A unique identification of the
    alarm, not including the resource. Different resources can
    share alarm types. If the resource reports the same alarm
```


type, it is to be considered to be the same alarm. The alarm type is a simplification of the different X.733 and 3GPP alarm IRP alarm correlation mechanisms and it allows for hierarchical extensions.

A string-based qualifier can be used in addition to the identity in order to have different alarm types based on information not known at design-time, such as values in textual SNMP Notification var-binds.

Standards and vendors can define sub-identities to clearly identify specific alarm types.

This identity is abstract and MUST NOT be used for alarms.";

}

/*

* Common types

*/

typedef resource {

type union {

type instance-identifier {
require-instance false;

}

type yang:object-identifier;

type yang:uuid;

type string;

}

description

"This is an identification of the alarming resource, such as an interface. It should be as fine-grained as possible both to guide the operator and to guarantee uniqueness of the alarms.

If the alarming resource is modelled in YANG, this type will be an instance-identifier.

If the resource is an SNMP object, the type will be an object-identifier.

If the resource is anything else, for example a distinguished name or a CIM path, this type will be a string.

If the alarming object is identified by a UUID use the uuid type. Be cautious when using this type, since a UUID is hard to use for an operator.

If the server supports several models, the presedence should


```
    be in the order as given in the union definition.";
}
```

```
typedef resource-match {
  type union {
    type yang:xpath1.0;
    type yang:object-identifier;
    type string;
  }
}
```

description

"This type is used to match resources of type 'resource'. Since the type 'resource' is a union of different types, the 'resource-match' type is also a union of corresponding types.

If the type is given as an XPath 1.0 expression, a resource of type 'instance-identifier' matches if the instance is part of the node set that is the result of evaluating the XPath 1.0 expression. For example, the XPath 1.0 expression:

```
/if:interfaces/if:interface[if:type='ianaift:ethernetCsmacd']
```

would match the resource instance-identifier:

```
/if:interfaces/if:interface[if:name='eth1'],
```

assuming that the interface 'eth1' is of type 'ianaift:ethernetCsmacd'.

If the type is given as an object identifier, a resource of type 'object-identifier' matches if the match object identifier is a prefix of the resource's object identifier. For example, the value:

```
1.3.6.1.2.1.2.2
```

would match the resource object identifier:

```
1.3.6.1.2.1.2.2.1.1.5
```

If the type is given as an UUID or a string, it is interpreted as a W3C regular expression, which matches a resource of type 'yang:uuid' or 'string' if the given regular expression matches the resource string.

If the type is given as an XPath expression it is evaluated in the following XPath context:


```
o The set of namespace declarations are those in scope on
  the leaf element where this type is used.

o The set of variable bindings is empty.

o The function library is the core function library
  and the functions defined in Section 10 of RFC 7950.

o The function library is the core function library

o The context node is the root node in the data tree.";
}

typedef alarm-text {
  type string;
  description
    "The string used to inform operators about the alarm. This
    MUST contain enough information for an operator to be able
    to understand the problem and how to resolve it. If this
    string contains structure, this format should be clearly
    documented for programs to be able to parse that
    information.";
}

typedef severity {
  type enumeration {
    enum indeterminate {
      value 2;
      description
        "Indicates that the severity level could not be
        determined. This level SHOULD be avoided.";
    }
    enum minor {
      value 3;
      description
        "The 'minor' severity level indicates the existence of a
        non-service affecting fault condition and that corrective
        action should be taken in order to prevent a more serious
        (for example, service affecting) fault. Such a severity
        can be reported, for example, when the detected alarm
        condition is not currently degrading the capacity of the
        resource.";
    }
  }
  enum warning {
    value 4;
    description
      "The 'warning' severity level indicates the detection of a
      potential or impending service affecting fault, before any
```



```
        significant effects have been felt. Action should be
        taken to further diagnose (if necessary) and correct the
        problem in order to prevent it from becoming a more
        serious service affecting fault.";
    }
    enum major {
        value 5;
        description
            "The 'major' severity level indicates that a service
            affecting condition has developed and an urgent corrective
            action is required. Such a severity can be reported, for
            example, when there is a severe degradation in the
            capability of the resource and its full capability must be
            restored.";
    }
    enum critical {
        value 6;
        description
            "The 'critical' severity level indicates that a service
            affecting condition has occurred and an immediate
            corrective action is required. Such a severity can be
            reported, for example, when a resource becomes totally out
            of service and its capability must be restored.";
    }
}
description
    "The severity level of the alarm. Note well that value 'clear'
    is not included. If an alarm is cleared or not is a separate
    boolean flag.";
reference
    "ITU Recommendation X.733: Information Technology
    - Open Systems Interconnection
    - System Management: Alarm Reporting Function";
}

typedef severity-with-clear {
    type union {
        type enumeration {
            enum cleared {
                value 1;
                description
                    "The alarm is cleared by the instrumentation.";
            }
        }
    }
    type severity;
}
description
    "The severity level of the alarm including clear.
```



```
        This is used *only* in notifications reporting state changes
        for an alarm.";
    }

typedef writable-operator-state {
    type enumeration {
        enum none {
            value 1;
            description
                "The alarm is not being taken care of.";
        }
        enum ack {
            value 2;
            description
                "The alarm is being taken care of. Corrective action not
                taken yet, or failed";
        }
        enum closed {
            value 3;
            description
                "Corrective action taken successfully.";
        }
    }
}
description
    "Operator states on an alarm. The 'closed' state indicates
    that an operator considers the alarm being resolved. This
    is separate from the alarm's 'is-cleared' leaf.";
}

typedef operator-state {
    type union {
        type writable-operator-state;
        type enumeration {
            enum shelved {
                value 4;
                description
                    "The alarm is shelved. Alarms in /alarms/shelved-alarms/
                    MUST be assigned this operator state by the server as
                    the last entry in the operator-state-change list. The
                    text for that entry SHOULD include the shelf name.";
            }
            enum un-shelved {
                value 5;
                description
                    "The alarm is moved back to 'alarm-list' from a shelf.
                    Alarms that are moved from /alarms/shelved-alarms/ to
                    /alarms/alarm-list MUST be assigned this state by the
                    server as the last entry in the 'operator-state-change'
```



```
        list. The text for that entry SHOULD include the shelf
        name.";
    }
}
}
description
    "Operator states on an alarm. The 'closed' state indicates
    that an operator considers the alarm being resolved. This
    is separate from the alarm's 'is-cleared' leaf.";
}

/* Alarm type */

typedef alarm-type-id {
    type identityref {
        base alarm-type-id;
    }
    description
        "Identifies an alarm type. The description of the alarm type
        id MUST indicate if the alarm type is abstract or not. An
        abstract alarm type is used as a base for other alarm type ids
        and will not be used as a value for an alarm or be present in
        the alarm inventory.";
}

typedef alarm-type-qualifier {
    type string;
    description
        "If an alarm type can not be fully specified at design time by
        alarm-type-id, this string qualifier is used in addition to
        fully define a unique alarm type.

        The definition of alarm qualifiers is considered being part
        of the instrumentation and out of scope for this module.
        An empty string is used when this is part of a key.";
}

/*
 * Groupings
 */

grouping common-alarm-parameters {
    description
        "Common parameters for an alarm.

        This grouping is used both in the alarm list and in the
        notification representing an alarm state change.";
    leaf resource {
```



```
    type resource;
    mandatory true;
    description
      "The alarming resource.  See also 'alt-resource'.
      This could for example be a reference to the alarming
      interface";
  }
  leaf alarm-type-id {
    type alarm-type-id;
    mandatory true;
    description
      "This leaf and the leaf 'alarm-type-qualifier' together
      provides a unique identification of the alarm type.";
  }
  leaf alarm-type-qualifier {
    type alarm-type-qualifier;
    description
      "This leaf is used when the 'alarm-type-id' leaf cannot
      uniquely identify the alarm type.  Normally, this is not
      the case, and this leaf is the empty string.";
  }
  leaf-list alt-resource {
    type resource;
    description
      "Used if the alarming resource is available over other
      interfaces.  This field can contain SNMP OID's, CIM paths or
      3GPP Distinguished names for example.";
  }
  list related-alarm {
    key "resource alarm-type-id alarm-type-qualifier";
    description
      "References to related alarms.  Note that the related alarm
      might have been purged from the alarm list.";
    leaf resource {
      type leafref {
        path "/alarms/alarm-list/alarm/resource";
        require-instance false;
      }
      description
        "The alarming resource for the related alarm.";
    }
    leaf alarm-type-id {
      type leafref {
        path "/alarms/alarm-list/alarm"
          + "[resource=current()/../resource]"
          + "/alarm-type-id";
        require-instance false;
      }
    }
  }
}
```



```
    description
      "The alarm type identifier for the related alarm.";
  }
  leaf alarm-type-qualifier {
    type leafref {
      path "/alarms/alarm-list/alarm"
        + "[resource=current()/../resource]"
        + "[alarm-type-id=current()/../alarm-type-id]"
        + "/alarm-type-qualifier";
      require-instance false;
    }
    description
      "The alarm qualifier for the related alarm.";
  }
}
leaf-list impacted-resource {
  type resource;
  description
    "Resources that might be affected by this alarm.  If the
    system creates an alarm on a resource and also has a mapping
    to other resources that might be impacted, these resources
    can be listed in this leaf-list.  In this way the system can
    create one alarm instead of several.  For example, if an
    interface has an alarm, the 'impacted-resource' can
    reference the aggregated port channels.";
}
leaf-list root-cause-resource {
  type resource;
  description
    "Resources that are candidates for causing the alarm.  If the
    system has a mechanism to understand the candidate root
    causes of an alarm, this leaf-list can be used to list the
    root cause candidate resources.  In this way the system can
    create one alarm instead of several.  An example might be a
    logging system (alarm resource) that fails, the alarm can
    reference the file-system in the 'root-cause-resource'
    leaf-list.  Note that the intended use is not to also send an
    an alarm with the root-cause-resource as alarming resource.
    The root-cause-resource leaf list is a hint and should not
    also generate an alarm for the same problem.";
}
}
grouping alarm-state-change-parameters {
  description
    "Parameters for an alarm state change.

    This grouping is used both in the alarm list's
```



```
        status-change list and in the notification representing an
        alarm state change.";
leaf time {
    type yang:date-and-time;
    mandatory true;
    description
        "The time the status of the alarm changed. The value
        represents the time the real alarm state change appeared
        in the resource and not when it was added to the
        alarm list. The /alarm-list/alarm/last-changed MUST be
        set to the same value.";
}
leaf perceived-severity {
    type severity-with-clear;
    mandatory true;
    description
        "The severity of the alarm as defined by X.733. Note
        that this may not be the original severity since the alarm
        may have changed severity.";
    reference
        "ITU Recommendation X.733: Information Technology
        - Open Systems Interconnection
        - System Management: Alarm Reporting Function";
}
leaf alarm-text {
    type alarm-text;
    mandatory true;
    description
        "A user friendly text describing the alarm state change.";
    reference
        "ITU Recommendation X.733: Information Technology
        - Open Systems Interconnection
        - System Management: Alarm Reporting Function";
}
}
grouping operator-parameters {
    description
        "This grouping defines parameters that can be changed by an
        operator.";
    leaf time {
        type yang:date-and-time;
        mandatory true;
        description
            "Timestamp for operator action on alarm.";
    }
    leaf operator {
        type string;
    }
}
```



```
    mandatory true;
    description
      "The name of the operator that has acted on this
       alarm.";
  }
  leaf state {
    type operator-state;
    mandatory true;
    description
      "The operator's view of the alarm state.";
  }
  leaf text {
    type string;
    description
      "Additional optional textual information provided by
       the operator.";
  }
}

grouping resource-alarm-parameters {
  description
    "Alarm parameters that originates from the resource view.";
  leaf is-cleared {
    type boolean;
    mandatory true;
    description
      "Indicates the current clearance state of the alarm. An
       alarm might toggle from active alarm to cleared alarm and
       back to active again.";
  }
  leaf last-changed {
    type yang:date-and-time;
    mandatory true;
    description
      "A timestamp when the alarm status was last changed. Status
       changes are changes to 'is-cleared', 'perceived-severity',
       and 'alarm-text'.";
  }
  leaf perceived-severity {
    type severity;
    mandatory true;
    description
      "The last severity of the alarm.

       If an alarm was raised with severity 'warning', but later
       changed to 'major', this leaf will show 'major'.";
  }
  leaf alarm-text {
```



```
    type alarm-text;
    mandatory true;
    description
      "The last reported alarm text. This text should contain
      information for an operator to be able to understand
      the problem and how to resolve it.";
  }
  list status-change {
    if-feature "alarm-history";
    key "time";
    min-elements 1;
    description
      "A list of status change events for this alarm.

      The entry with latest time-stamp in this list MUST
      correspond to the leafs 'is-cleared', 'perceived-severity'
      and 'alarm-text' for the alarm. The time-stamp for that
      entry MUST be equal to the 'last-changed' leaf.

      This list is ordered according to the timestamps of
      alarm state changes. The last item corresponds to the
      latest state change.

      The following state changes creates an entry in this
      list:
      - changed severity (warning, minor, major, critical)
      - clearance status, this also updates the 'is-cleared'
        leaf
      - alarm text update";
    uses alarm-state-change-parameters;
  }
}

/*
 * The /alarms data tree
 */

container alarms {
  description
    "The top container for this module.";
  container control {
    description
      "Configuration to control the alarm behaviour.";
    leaf max-alarm-status-changes {
      type union {
        type uint16;
        type enumeration {
          enum infinite {
```



```
        description
            "The status change entries are accumulated
            infinitely.";
    }
}
}
default "32";
description
    "The status-change entries are kept in a circular list
    per alarm. When this number is exceeded, the oldest
    status change entry is automatically removed. If the
    value is 'infinite', the status change entries are
    accumulated infinitely.";
}
choice notify-status-changes {
    description
        "This leaf controls the notifications sent for alarm status
        updates. There are three options:
        1. notifications are sent for all updates, severity level
        changes and alarm text changes
        2. notifications are only sent for alarm raise and clear
        3. notifications are sent for status changes equal to or
        above the specified severity level. Clear notifications
        shall always be sent
        Notifications shall also be sent for state changes that
        makes an alarm less severe than the specified level.
        In option 3, assuming the severity level is set to major,
        and that the alarm has the following state changes
        [(Time, severity, clear)]:
        [(T1, major, -), (T2, minor, -), (T3, warning, -),
        (T4, minor, -), (T5, major, -), (T6, critical, -),
        (T7, major, -), (T8, major, clear)]
        In that case, notifications will be sent at
        T1, T2, T5, T6, T7 and T8.";
    leaf notify-all-state-changes {
        type empty;
        description
            "Send notifications for all status changes.";
    }
    leaf notify-raise-and-clear {
        type empty;
        description
            "Send notifications only for raise, clear, and re-raise.
            Notifications for severity level changes or alarm text
            changes are not sent.";
    }
    leaf notify-severity-level {
        type severity;
    }
}
```



```
    description
      "Only send notifications for alarm state changes
      crossing the specified level. Always send clear
      notifications.";
  }
}
container alarm-shelving {
  if-feature "alarm-shelving";
  description
    "The alarm-shelving/shelf list is used to shelve
    (block/filter) alarms. The server will move any alarms
    corresponding to the shelving criteria from the
    alarms/alarm-list/alarm list to the
    alarms/shelved-alarms/shelved-alarm list. It will also
    stop sending notifications for the shelved alarms. The
    conditions in the shelf criteria are logically ANDed.
    When the shelving criteria is deleted or changed, the
    non-matching alarms MUST appear in the
    alarms/alarm-list/alarm list according to the real state.
    This means that the instrumentation MUST maintain states
    for the shelved alarms. Alarms that match the criteria
    shall have an operator-state 'shelved'. When the shelf
    configuration will remove an alarm from the shelf the
    server shall add an operator state 'unshelved'.";
  list shelf {
    key "name";
    leaf name {
      type string;
      description
        "An arbitrary name for the alarm shelf.";
    }
    description
      "Each entry defines the criteria for shelving alarms.
      Criteria are ANDed. If no criteria are specified,
      all alarms will be shelved.";
    leaf-list resource {
      type resource-match;
      description
        "Shelve alarms for matching resources.";
    }
    leaf alarm-type-id {
      type alarm-type-id;
      description
        "Shelve all alarms that have an alarm-type-id that is
        equal to or derived from the given alarm-type-id.";
    }
    leaf alarm-type-qualifier-match {
      type string;
```



```
leaf-list resource {
  type resource-match;
  description
    "Optionally, specifies for which resources the alarm type
    is valid.";
}
leaf has-clear {
  type boolean;
  mandatory true;
  description
    "This leaf tells the operator if the alarm will be
    cleared when the correct corrective action has been
    taken. Implementations SHOULD strive for detecting the
    cleared state for all alarm types. If this leaf is
    true, the operator can monitor the alarm until it
    becomes cleared after the corrective action has been
    taken. If this leaf is false the operator needs to
    validate that the alarm is not longer active using other
    mechanisms. Alarms can lack a corresponding clear due
    to missing instrumentation or that there is no logical
    corresponding clear state.";
}
leaf-list severity-levels {
  type severity;
  description
    "This leaf-list indicates the possible severity levels of
    this alarm type. Note well that 'clear' is not part of
    the severity type. In general, the severity level should
    be defined by the instrumentation based on dynamic state
    and not defined statically by the alarm type in order to
    provide relevant severity level based on dynamic state
    and context. However most alarm types have a defined set
    of possible severity levels and this should be provided
    here.";
}
leaf description {
  type string;
  mandatory true;
  description
    "A description of the possible alarm. It SHOULD include
    information on possible underlying root causes and
    corrective actions.";
}
}
}
}
container summary {
  if-feature "alarm-summary";
  config false;
```



```
description
  "This container gives a summary of number of alarms.";
list alarm-summary {
  key "severity";
  description
    "A global summary of all alarms in the system. The summary
    does not include shelved alarms.";
  leaf severity {
    type severity;
    description
      "Alarm summary for this severity level.";
  }
  leaf total {
    type yang:gauge32;
    description
      "Total number of alarms of this severity level.";
  }
  leaf cleared {
    type yang:gauge32;
    description
      "For this severity level, the number of alarms that are
      cleared.";
  }
  leaf cleared-not-closed {
    if-feature "operator-actions";
    type yang:gauge32;
    description
      "For this severity level, the number of alarms that are
      cleared but not closed.";
  }
  leaf cleared-closed {
    if-feature "operator-actions";
    type yang:gauge32;
    description
      "For this severity level, the number of alarms that are
      cleared and closed.";
  }
  leaf not-cleared-closed {
    if-feature "operator-actions";
    type yang:gauge32;
    description
      "For this severity level, the number of alarms that are
      not cleared but closed.";
  }
  leaf not-cleared-not-closed {
    if-feature "operator-actions";
    type yang:gauge32;
    description
```



```
        "For this severity level, the number of alarms that are
          not cleared and not closed.";
    }
}
leaf shelves-active {
    if-feature "alarm-shelving";
    type empty;
    description
        "This is a hint to the operator that there are active
        alarm shelves. This leaf MUST exist if the
        alarms/shelved-alarms/number-of-shelved-alarms is > 0.";
}
}
container alarm-list {
    config false;
    description
        "The alarms in the system.";
    leaf number-of-alarms {
        type yang:gauge32;
        description
            "This object shows the total number of
            alarms in the system, i.e., the total number
            of entries in the alarm list.";
    }
    leaf last-changed {
        type yang:date-and-time;
        description
            "A timestamp when the alarm list was last
            changed. The value can be used by a manager to
            initiate an alarm resynchronization procedure.";
    }
}
list alarm {
    key "resource alarm-type-id alarm-type-qualifier";
    description
        "The list of alarms. Each entry in the list holds one
        alarm for a given alarm type and resource.
        An alarm can be updated from the underlying resource or
        by the user. The following leafs are maintained by the
        resource: is-cleared, last-change, perceived-severity,
        and alarm-text. An operator can change: operator-state
        and operator-text.
```

Entries appear in the alarm list the first time an alarm becomes active for a given alarm-type and resource. Entries do not get deleted when the alarm is cleared, this is a boolean state in the alarm.

Alarm entries are removed, purged, from the list by an


```
explicit purge action. For example, purge all alarms
that are cleared and in closed operator-state that are
older than 24 hours. Systems may also remove alarms based
on locally configured policies which is out of scope for
this module.";
uses common-alarm-parameters;
leaf time-created {
  type yang:date-and-time;
  mandatory true;
  description
    "The time-stamp when this alarm entry was created. This
    represents the first time the alarm appeared, it can
    also represent that the alarm re-appeared after a purge.
    Further state-changes of the same alarm does not change
    this leaf, these changes will update the 'last-changed'
    leaf.";
}
uses resource-alarm-parameters;
list operator-state-change {
  if-feature "operator-actions";
  key "time";
  description
    "This list is used by operators to indicate
    the state of human intervention on an alarm.
    For example, if an operator has seen an alarm,
    the operator can add a new item to this list indicating
    that the alarm is acknowledged.";
  uses operator-parameters;
}
action set-operator-state {
  if-feature "operator-actions";
  description
    "This is a means for the operator to indicate
    the level of human intervention on an alarm.";
  input {
    leaf state {
      type writable-operator-state;
      mandatory true;
      description
        "Set this operator state.";
    }
    leaf text {
      type string;
      description
        "Additional optional textual information.";
    }
  }
}
}
```



```
notification operator-action {
  if-feature "operator-actions";
  description
    "This notification is used to report that an operator
      acted upon an alarm.";
  uses operator-parameters;
}
}
}
container shelved-alarms {
  if-feature "alarm-shelving";
  config false;
  description
    "The shelved alarms. Alarms appear here if they match the
      criteria in /alarms/control/alarm-shelving. This list does
      not generate any notifications. The list represents alarms
      that are considered not relevant by the operator. Alarms in
      this list have an operator-state of 'shelved'. This can not
      be changed.";
  leaf number-of-shelved-alarms {
    type yang:gauge32;
    description
      "This object shows the total number of currently
        alarms, i.e., the total number of entries
        in the alarm list.";
  }
  leaf alarm-shelf-last-changed {
    type yang:date-and-time;
    description
      "A timestamp when the shelved alarm list was last
        changed. The value can be used by a manager to
        initiate an alarm resynchronization procedure.";
  }
  list shelved-alarm {
    key "resource alarm-type-id alarm-type-qualifier";
    description
      "The list of shelved alarms. Shelved alarms
        can only be updated from the underlying resource,
        no operator actions are supported.";
    uses common-alarm-parameters;
    leaf shelf-name {
      type leafref {
        path "/alarms/control/alarm-shelving/shelf/name";
        require-instance false;
      }
      description
        "The name of the shelf.";
    }
  }
}
```



```
    uses resource-alarm-parameters;
  list operator-state-change {
    if-feature "operator-actions";
    key "time";
    description
      "This list is used by operators to indicate
       the state of human intervention on an alarm.
       For shelved alarms, the system has set the list
       item in the list to 'shelved'.";
    uses operator-parameters;
  }
}
}
list alarm-profile {
  if-feature "alarm-profile";
  key "alarm-type-id alarm-type-qualifier-match resource";
  ordered-by user;
  description
    "This list is used to assign further information or
     configuration for each alarm type. This module supports
     a mechanism where the client can override the system
     default alarm severity levels. The alarm-profile is
     also a useful augmentation point for specific additions
     to alarm types.";
  leaf alarm-type-id {
    type al:alarm-type-id;
    description
      "The alarm type identifier to match.";
  }
  leaf alarm-type-qualifier-match {
    type string;
    description
      "A W3C regular expression that is used to
       match.";
  }
  leaf resource {
    type al:resource-match;
    description
      "Specifies which resources to match.";
  }
  leaf description {
    type string;
    mandatory true;
    description
      "A description of the alarm profile.";
  }
  container alarm-severity-assignment-profile {
    if-feature "severity-assignment";
```



```
description
  "The client can override the system default
  severity level.";
reference
  "ITU M.3100, ITU M.3160
  - Generic Network Information Model,
  Alarm Severity Assignment Profile";
leaf-list severity-levels {
  type al:severity;
  ordered-by user;
  description
    "Specifies the configured severity level(s) for the
    matching alarm.  If the alarm has several severity
    levels the leaf-list shall be given in rising severity
    order.  The original M3100/M3160 ASAP function only
    allows for a one-to-one mapping between alarm type and
    severity but since the IETF alarm module supports
    stateful alarms the mapping must allow for several
    severity levels.

    Assume a high-utilisation alarm type with two
    thresholds with the system default severity levels of
    threshold1 = warning and threshold2 = minor.  Setting
    this leaf-list to (minor, major) will assign the
    severity levels threshold1 = minor and
    threshold2 = major";
}
}
}
}
/*
 * Operations
 */

rpc compress-alarms {
  if-feature "alarm-history";
  description
    "This operation requests the server to compress entries in the
    alarm list by removing all but the latest state change for all
    alarms.  Conditions in the input are logically ANDed.  If no
    input condition is given, all alarms are compressed.";
  input {
    leaf resource {
      type leafref {
        path "/alarms/alarm-list/alarm/resource";
        require-instance false;
      }
    }
  }
}
```



```
    description
      "Compress the alarms with this resource.";
  }
  leaf alarm-type-id {
    type leafref {
      path "/alarms/alarm-list/alarm/alarm-type-id";
      require-instance false;
    }
    description
      "Compress alarms with this alarm-type-id.";
  }
  leaf alarm-type-qualifier {
    type leafref {
      path "/alarms/alarm-list/alarm/alarm-type-qualifier";
      require-instance false;
    }
    description
      "Compress the alarms with this alarm-type-qualifier.";
  }
}
output {
  leaf compressed-alarms {
    type uint32;
    description
      "Number of compressed alarm entries.";
  }
}
}
rpc compress-shelved-alarms {
  if-feature "alarm-history and alarm-shelving";
  description
    "This operation requests the server to compress entries in the
    shelved alarm list by removing all but the latest state change
    for all alarms. Conditions in the input are logically ANDed.
    If no input condition is given, all alarms are compressed.";
  input {
    leaf resource {
      type leafref {
        path "/alarms/shelved-alarms/shelved-alarm/resource";
        require-instance false;
      }
      description
        "Compress the alarms with this resource.";
    }
    leaf alarm-type-id {
      type leafref {
        path "/alarms/shelved-alarms/shelved-alarm/alarm-type-id";
        require-instance false;
      }
    }
  }
}
```



```
    }
    description
      "Compress alarms with this alarm-type-id.";
  }
  leaf alarm-type-qualifier {
    type leafref {
      path "/alarms/shelved-alarms/shelved-alarm"
        + "/alarm-type-qualifier";
      require-instance false;
    }
    description
      "Compress the alarms with this alarm-type-qualifier.";
  }
}
}
output {
  leaf compressed-alarms {
    type uint32;
    description
      "Number of compressed alarm entries.";
  }
}
}

grouping filter-input {
  description
    "Grouping to specify a filter construct on alarm information.";
  leaf alarm-status {
    type enumeration {
      enum any {
        description
          "Ignore alarm clearance status.";
      }
      enum cleared {
        description
          "Filter cleared alarms.";
      }
      enum not-cleared {
        description
          "Filter not cleared alarms.";
      }
    }
  }
  mandatory true;
  description
    "The clearance status of the alarm.";
}
container older-than {
  presence "Age specification";
  description
```



```
    "Matches the 'last-status-change' leaf in the alarm.";
  choice age-spec {
    description
      "Filter using date and time age.";
    case seconds {
      leaf seconds {
        type uint16;
        description
          "Seconds part";
      }
    }
    case minutes {
      leaf minutes {
        type uint16;
        description
          "Minute part";
      }
    }
    case hours {
      leaf hours {
        type uint16;
        description
          "Hours part.";
      }
    }
    case days {
      leaf days {
        type uint16;
        description
          "Day part";
      }
    }
    case weeks {
      leaf weeks {
        type uint16;
        description
          "Week part";
      }
    }
  }
}
container severity {
  presence "Severity filter";
  choice sev-spec {
    description
      "Filter based on severity level.";
    leaf below {
      type severity;
    }
  }
}
```



```
        description
            "Severity less than this leaf.";
    }
    leaf is {
        type severity;
        description
            "Severity level equal this leaf.";
    }
    leaf above {
        type severity;
        description
            "Severity level higher than this leaf.";
    }
}
description
    "Filter based on severity.";
}
container operator-state-filter {
    if-feature "operator-actions";
    presence "Operator state filter";
    leaf state {
        type operator-state;
        description
            "Filter on operator state.";
    }
    leaf user {
        type string;
        description
            "Filter based on which operator.";
    }
}
description
    "Filter based on operator state.";
}
}

rpc purge-alarms {
    description
        "This operation requests the server to delete entries from the
        alarm list or the shelved alarms list according to the
        supplied criteria. To purge alarms in the shelved alarms,
        set the operator-state filter input to 'shelved'.
        Typically it can be used to delete alarms that are
        in closed operator state and older than a specified time.
        In the shelved alarm list it makes sense to delete alarms that
        are not relevant anymore.
        The number of purged alarms is returned as an output
        parameter.";
    input {
```



```
    uses filter-input;
  }
  output {
    leaf purged-alarms {
      type uint32;
      description
        "Number of purged alarms.";
    }
  }
}

/*
 * Notifications
 */

notification alarm-notification {
  description
    "This notification is used to report a state change for an
    alarm. The same notification is used for reporting a newly
    raised alarm, a cleared alarm or changing the text and/or
    severity of an existing alarm.";
  uses common-alarm-parameters;
  uses alarm-state-change-parameters;
}
notification alarm-inventory-changed {
  description
    "This notification is used to report that the list of possible
    alarms has changed. This can happen when for example if a new
    software module is installed, or a new physical card is
    inserted.";
}
}

<CODE ENDS>
```

6. X.733 Extensions

Many alarm systems are based on the X.733, [\[X.733\]](#), and X.736 [\[X.736\]](#) alarm standards. This module augments the alarm inventory, the alarm lists and the alarm notification with X.733 and X.736 parameters.

The module also supports a feature whereby the alarm manager can configure the mapping from alarm types to X.733 event-type and probable-cause parameters. This might be needed when the default mapping provided by the system is in conflict with other management systems or not considered correct.

Note that the IETF Alarm Module term 'resource' is synonymous to the ITU term 'managed object'.

7. The X.733 Mapping Module

This YANG module references [[X.733](#)] and [[X.736](#)].

```
<CODE BEGINS> file "ietf-alarms-x733@2018-10-09.yang"
module ietf-alarms-x733 {
  yang-version 1.1;
  namespace "urn:ietf:params:xml:ns:yang:ietf-alarms-x733";
  prefix x733;

  import ietf-alarms {
    prefix al;
  }
  import ietf-yang-types {
    prefix yang;
    reference "RFC 6991: Common YANG Data Types";
  }

  organization
    "IETF CCAMP Working Group";
  contact
    "WG Web: <http://tools.ietf.org/wg/ccamp>
    WG List: <mailto:ccamp@ietf.org>

    Editor: Stefan Vallin
           <mailto:stefan@wallan.se>

    Editor: Martin Bjorklund
           <mailto:mbj@tail-f.com>";
  description
    "This module augments the ietf-alarms module with X.733 alarm
    parameters.
```

The following structures are augmented with X.733 event type and probable cause:

- 1) alarms/alarm-inventory: all possible alarm types
- 2) alarms/alarm-list: every alarm in the system
- 3) alarm-notification: notifications indicating alarm state changes

The module also optionally allows the alarm management system to configure the mapping from the IETF Alarm module alarm keys to the ITU tuple (event-type, probable-cause).

The mapping does not include a corresponding X.733 specific problem value. The recommendation is to use the 'alarm-type-qualifier' leaf which serves the same purpose.

The module uses an integer and a corresponding string for probable cause instead of a globally defined enumeration, in order to be able to manage conflicting enumeration definitions. A single globally defined enumeration is challenging to maintain.";

reference

```
"ITU Recommendation X.733: Information Technology
  - Open Systems Interconnection
  - System Management: Alarm Reporting Function";
```

```
revision 2018-10-09 {
  description
    "Initial revision.";
  reference "RFC XXXX: YANG Alarm Module";
}
```

```
/*
 * Features
 */
```

```
feature configure-x733-mapping {
  description
    "The system supports configurable X733 mapping from
    the IETF alarm module alarm-type to X733 event-type
    and probable-cause.";
}
```

```
/*
 * Typedefs
 */
```

```
typedef event-type {
  type enumeration {
    enum other {
      value 1;
      description
        "None of the below.";
    }
    enum communications-alarm {
      value 2;
      description
        "An alarm of this type is principally associated with the
        procedures and/or processes required to convey
        information from one point to another.";
    }
  }
}
```



```
}
enum quality-of-service-alarm {
  value 3;
  description
    "An alarm of this type is principally associated with a
    degradation in the quality of a service.";
}
enum processing-error-alarm {
  value 4;
  description
    "An alarm of this type is principally associated with a
    software or processing fault.";
}
enum equipment-alarm {
  value 5;
  description
    "An alarm of this type is principally associated with an
    equipment fault.";
}
enum environmental-alarm {
  value 6;
  description
    "An alarm of this type is principally associated with a
    condition relating to an enclosure in which the equipment
    resides.";
}
enum integrity-violation {
  value 7;
  description
    "An indication that information may have been illegally
    modified, inserted or deleted.";
}
enum operational-violation {
  value 8;
  description
    "An indication that the provision of the requested service
    was not possible due to the unavailability, malfunction or
    incorrect invocation of the service.";
}
enum physical-violation {
  value 9;
  description
    "An indication that a physical resource has been violated
    in a way that suggests a security attack.";
}
enum security-service-or-mechanism-violation {
  value 10;
  description
```



```
        "An indication that a security attack has been detected by
          a security service or mechanism.";
    }
    enum time-domain-violation {
        value 11;
        description
            "An indication that an event has occurred at an unexpected
            or prohibited time.";
    }
}
description
    "The event types as defined by X.733 and X.736.";
reference
    "ITU Recommendation X.733: Information Technology
    - Open Systems Interconnection
    - System Management: Alarm Reporting Function
    ITU Recommendation X.736: Information Technology
    - Open Systems Interconnection
    - System Management: Security Alarm Reporting Function";
}

typedef trend {
    type enumeration {
        enum less-severe {
            description
                "There is at least one outstanding alarm of a
                severity higher (more severe) than that in the
                current alarm.";
        }
        enum no-change {
            description
                "The Perceived severity reported in the current
                alarm is the same as the highest (most severe)
                of any of the outstanding alarms";
        }
        enum more-severe {
            description
                "The Perceived severity in the current alarm is
                higher (more severe) than that reported in any
                of the outstanding alarms.";
        }
    }
}
description
    "This type is used to describe the
    severity trend of the alarming resource";
reference "Module Attribute-ASN1Module (X.721:02/1992)";
}
```



```
typedef value-type {
  type union {
    type int64;
    type uint64;
    type decimal64 {
      fraction-digits 2;
    }
  }
  description
    "A generic union type to match ITU choice of integer
    and real.";
}

/*
 * Groupings
 */

grouping x733-alarm-parameters {
  description
    "Common X.733 parameters for alarms.";
  leaf event-type {
    type event-type;
    description
      "The X.733/X.736 event type for this alarm.";
  }
  leaf probable-cause {
    type uint32;
    description
      "The X.733 probable cause for this alarm.";
  }
  leaf probable-cause-string {
    type string;
    description
      "The user friendly string matching
      the probable cause integer value. The string
      SHOULD match the X.733 enumeration. For example,
      value 27 is 'localNodeTransmissionError'.";
  }
  container threshold-information {
    description
      "This parameter shall be present when the alarm
      is a result of crossing a threshold. ";
    leaf triggered-threshold {
      type string;
      description
        "The identifier of the threshold attribute that
        caused the notification.";
    }
  }
}
```



```
leaf observed-value {
  type value-type;
  description
    "The value of the gauge or counter which crossed
    the threshold. This may be different from the
    threshold value if, for example, the gauge may
    only take on discrete values.";
}
choice threshold-level {
  description
    "In the case of a gauge the threshold level specifies
    a pair of threshold values, the first being the value
    of the crossed threshold and the second, its corresponding
    hysteresis; in the case of a counter the threshold level
    specifies only the threshold value.";
  case up {
    leaf up-high {
      type value-type;
      description
        "The going up threshold for rising the alarm.";
    }
    leaf up-low {
      type value-type;
      description
        "The threshold level for clearing the alarm.
        This is used for hysteresis functions for gauges.";
    }
  }
  case down {
    leaf down-low {
      type value-type;
      description
        "The going down threshold for rising the alarm.";
    }
    leaf down-high {
      type value-type;
      description
        "The threshold level for clearing the alarm.
        This is used for hysteresis functions for gauges.";
    }
  }
}
leaf arm-time {
  type yang:date-and-time;
  description
    "For a gauge threshold, the time at which the threshold
    was last re-armed, namely the time after the previous
    threshold crossing at which the hysteresis value of the
```



```
        threshold was exceeded thus again permitting generation
        of notifications when the threshold is crossed.
        For a counter threshold, the later of the time at which
        the threshold offset was last applied, or the time at
        which the counter was last initialized (for resettable
        counters).";
    }
}
list monitored-attributes {
    uses attribute;
    key "id";
    description
        "The Monitored attributes parameter, when present, defines
        one or more attributes of the resource and their
        corresponding values at the time of the alarm.";
}
leaf-list proposed-repair-actions {
    type string;
    description
        "This parameter, when present, is used if the cause is
        known and the system being managed can suggest one or
        more solutions (such as switch in standby equipment,
        retry, replace media).";
}
leaf trend-indication {
    type trend;
    description
        "This parameter specifies the current
        severity trend of the resource. If present it
        indicates that there are one or more alarms
        ('outstanding alarms') which have not been cleared,
        and pertain to the same resource as that to which
        this alarm ('current alarm') pertains.
        The possible values are:

        more-severe: The Perceived severity in the current
            alarm is higher (more severe) than that reported in
            any of the outstanding alarms.

        no-change: The Perceived severity reported in the
            current alarm is the same as the highest (most severe)
            of any of the outstanding alarms.

        less-severe: There is at least one outstanding alarm
            of a severity higher (more severe) than that in the
            current alarm.";
}
leaf backedup-status {
```



```
type boolean;
description
  "This parameter, when present, specifies whether or not
  the object emitting the alarm has been backed-up, and
  services provided to the user have, therefore, not been
  disrupted. The use of this field in conjunction with the
  severity field provides information in an independent form
  to qualify the seriousness of the alarm and the ability of
  the system as a whole to continue to provide services.
  If the value of this parameter is true, it indicates that
  the object emitting the alarm has been backed-up; if false,
  the object has not been backed-up.";
}
leaf backup-object {
  type al:resource;
  description
    "This parameter shall be present when the Backed-up status
    parameter is present and has the value true. This parameter
    specifies the managed object instance that is providing
    back-up services for the managed object about which the
    notification pertains. This parameter is useful,
    for example, when the back-up object is from a pool of
    objects any of which may be dynamically allocated to
    replace a faulty object.";
}
list additional-information {
  key "identifier";
  description
    "This parameter allows the inclusion of a
    set of additional information in the alarm. It is
    a series of data structures each of which contains three
    items of information: an identifier, a significance
    indicator, and the problem information.";
  leaf identifier {
    type string;
    description
      "Identifies the data-type of the information parameter.";
  }
  leaf significant {
    type boolean;
    description
      "Set to true if the receiving system must be able to
      parse the contents of the information subparameter
      for the event report to be fully understood.";
  }
  leaf information {
    type string;
    description
```



```
        "Additional information about the alarm.";
    }
}
leaf security-alarm-detector {
    type al:resource;
    description
        "This parameter identifies the detector of the security
        alarm.";
}
leaf service-user {
    type al:resource;
    description
        "This parameter identifies the service-user whose request
        for service led to the generation of the security alarm.";
}
leaf service-provider {
    type al:resource;
    description
        "This parameter identifies the intended service-provider
        of the service that led to the generation of the security
        alarm.";
}
reference
    "ITU Recommendation X.733: Information Technology
    - Open Systems Interconnection
    - System Management: Alarm Reporting Function
    ITU Recommendation X.736: Information Technology
    - Open Systems Interconnection
    - System Management: Security Alarm Reporting Function";
}

grouping x733-alarm-definition-parameters {
    description
        "Common X.733 parameters for alarm definitions.
        This grouping is used to define those alarm
        attributes that can be mapped from the alarm-type
        mechanism in the ietf-alarm module.";
    leaf event-type {
        type event-type;
        description
            "The alarm type has this X.733/X.736 event type.";
    }
    leaf probable-cause {
        type uint32;
        description
            "The alarm type has this X.733 probable cause value.
            This module defines probable cause as an integer
            and not as an enumeration. The reason being that the
```



```
        primary use of probable cause is in the management
        application if it is based on the X.733 standard.
        However, most management applications have their own
        defined enum definitions and merging enums from
        different systems might create conflicts. By using
        a configurable uint32 the system can be configured
        to match the enum values in the management application.";
    }
    leaf probable-cause-string {
        type string;
        description
            "This string can be used to give a user friendly string
            to the probable cause value.";
    }
}

grouping attribute {
    description
        "A grouping to match the ITU generic reference to
        an attribute.";
    leaf id {
        type al:resource;
        description
            "The resource representing the attribute.";
    }
    leaf value {
        type string;
        description
            "The value represented as a string since it could
            be of any type.";
    }
    reference "Module Attribute-ASN1Module (X.721:02/1992)";
}

/*
 * Add X.733 parameters to the alarm definitions, alarms,
 * and notification.
 */

augment "/al:alarms/al:alarm-inventory/al:alarm-type" {
    description
        "Augment X.733 mapping information to the alarm inventory.";
    uses x733-alarm-definition-parameters;
}

/*
 * Add X.733 configurable mapping.
 */
```



```
augment "/al:alarms/al:control" {
  description
    "Add X.733 mapping capabilities. ";
  list x733-mapping {
    if-feature "configure-x733-mapping";
    key "alarm-type-id alarm-type-qualifier-match";
    description
      "This list allows a management application to control the
      X.733 mapping for all alarm types in the system. Any entry
      in this list will allow the alarm manager to over-ride the
      default X.733 mapping in the system and the final mapping
      will be shown in the alarm inventory.";
    leaf alarm-type-id {
      type al:alarm-type-id;
      description
        "Map the alarm type with this alarm type identifier.";
    }
    leaf alarm-type-qualifier-match {
      type string;
      description
        "A W3C regular expression that is used when mapping an
        alarm type and alarm-type-qualifier to X.733 parameters.";
    }
    uses x733-alarm-definition-parameters;
  }
}
augment "/al:alarms/al:alarm-list/al:alarm" {
  description
    "Augment X.733 information to the alarm.";
  uses x733-alarm-parameters;
}
augment "/al:alarms/al:shelved-alarms/al:shelved-alarm" {
  description
    "Augment X.733 information to the alarm.";
  uses x733-alarm-parameters;
}
augment "/al:alarm-notification" {
  description
    "Augment X.733 information to the alarm notification.";
  uses x733-alarm-parameters;
}
}
```

<CODE ENDS>

8. IANA Considerations

This document registers a URI in the IETF XML registry [[RFC3688](#)]. Following the format in [RFC 3688](#), the following registration is requested to be made.

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

Registrant Contact: The IESG.

XML: N/A, the requested URI is an XML namespace.

This document registers a YANG module in the YANG Module Names registry [[RFC6020](#)].

```
name:          ietf-alarms
namespace:    urn:ietf:params:xml:ns:yang:ietf-alarms
prefix:       al
reference:    RFC XXXX
```

9. 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 [[RFC5246](#)].

The NETCONF access control model [[RFC6536](#)] 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 this YANG module that are writable/creatable/deletable (i.e., config true, which is the default). These data nodes may be considered sensitive or vulnerable in some network environments. Write operations (e.g., edit-config) to these data nodes without proper protection can have a negative effect on network operations. These are the subtrees and data nodes and their sensitivity/vulnerability:

/alarms/control/notify-status-change: This leaf controls whether an alarm should notify only raise and clear or all severity level changes. Unauthorized access to leaf could have a negative impact on operational procedures relying on fine-grained alarm state change reporting.

/alarms/control/alarm-shelving/shelf: This list controls the shelving (blocking) of alarms. Unauthorized access to this list could jeopardize the alarm management procedures since these alarms will not be notified and not be part of the alarm list.

Some of the RPC operations in this YANG module may be considered sensitive or vulnerable in some network environments. It is thus important to control access to these operations. These are the operations and their sensitivity/vulnerability:

purge-alarms: This RPC deletes alarms from the alarm list. Unauthorized use of this RPC could jeopardize the alarm management procedures since the deleted alarms may be vital for the alarm management application.

10. Acknowledgements

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[Appendix A](#). Vendor-specific Alarm-Types Example

This example shows how to define alarm-types in a vendor-specific module. In this case the vendor "xyz" has chosen to define top level identities according to X.733 event types.


```
module example-xyz-alarms {
  namespace "urn:example:xyz-alarms";
  prefix xyz-al;

  import ietf-alarms {
    prefix al;
  }

  identity xyz-alarms {
    base al:alarm-type-id;
  }

  identity communications-alarm {
    base xyz-alarms;
  }
  identity quality-of-service-alarm {
    base xyz-alarms;
  }
  identity processing-error-alarm {
    base xyz-alarms;
  }
  identity equipment-alarm {
    base xyz-alarms;
  }
  identity environmental-alarm {
    base xyz-alarms;
  }

  // communications alarms
  identity link-alarm {
    base communications-alarm;
  }

  // QoS alarms
  identity high-jitter-alarm {
    base quality-of-service-alarm;
  }
}
```

[Appendix B](#). Alarm Inventory Example

This shows an alarm inventory, it shows one alarm type defined only with the identifier, and another dynamically configured. In the latter case a digital input has been connected to a smoke-detector, therefore the 'alarm-type-qualifier' is set to "smoke-detector" and the 'alarm-type-identity' to "environmental-alarm".


```

<alarms xmlns="urn:ietf:params:xml:ns:yang:ietf-alarms"
  xmlns:xyz-al="urn:example:xyz-alarms"
  xmlns:dev="urn:example:device">
  <alarm-inventory>
    <alarm-type>
      <alarm-type-id>xyz-al:link-alarm</alarm-type-id>
      <alarm-type-qualifier/>
      <resource>
        /dev:interfaces/dev:interface
      </resource>
      <has-clear>true</has-clear>
      <description>
        Link failure, operational state down but admin state up
      </description>
    </alarm-type>
    <alarm-type>
      <alarm-type-id>xyz-al:environmental-alarm</alarm-type-id>
      <alarm-type-qualifier>smoke-alarm</alarm-type-qualifier>
      <has-clear>true</has-clear>
      <description>
        Connected smoke detector to digital input
      </description>
    </alarm-type>
  </alarm-inventory>
</alarms>

```

[Appendix C](#). Alarm List Example

In this example we show an alarm that has toggled [major, clear, major]. An operator has acknowledged the alarm.

```

<alarms xmlns="urn:ietf:params:xml:ns:yang:ietf-alarms"
  xmlns:xyz-al="urn:example:xyz-alarms"
  xmlns:dev="urn:example:device">
  <alarm-list>
    <number-of-alarms>1</number-of-alarms>
    <last-changed>2015-04-08T08:39:50.00Z</last-changed>

    <alarm>
      <resource>
        /dev:interfaces/dev:interface[name='FastEthernet1/0']
      </resource>
      <alarm-type-id>xyz-al:link-alarm</alarm-type-id>
      <alarm-type-qualifier></alarm-type-qualifier>

      <time-created>2015-04-08T08:39:50.00Z</time-created>
      <is-cleared>>false</is-cleared>
    </alarm>
  </alarm-list>
</alarms>

```



```
<alt-resource>1.3.6.1.2.1.2.2.1.1.17</alt-resource>
<last-changed>2015-04-08T08:39:40.00Z</last-changed>
<perceived-severity>major</perceived-severity>
<alarm-text>
  Link operationally down but administratively up
</alarm-text>
<status-change>
  <time>2015-04-08T08:39:40.00Z</time>
  <perceived-severity>major</perceived-severity>
  <alarm-text>
    Link operationally down but administratively up
  </alarm-text>
</status-change>
<status-change>
  <time>2015-04-08T08:30:00.00+00:00</time>
  <perceived-severity>cleared</perceived-severity>
  <alarm-text>
    Link operationally up and administratively up
  </alarm-text>
</status-change>
<status-change>
  <time>2015-04-08T08:20:10.00+00:00</time>
  <perceived-severity>major</perceived-severity>
  <alarm-text>
    Link operationally down but administratively up
  </alarm-text>
</status-change>
<operator-state-change>
  <time>2015-04-08T08:39:50.00Z</time>
  <state>ack</state>
  <operator>joe</operator>
  <text>Will investigate, ticket TR764999</text>
</operator-state-change>
</alarm>
</alarm-list>
</alarms>
```

[Appendix D](#). Alarm Shelving Example

This example shows how to shelve alarms. We shelve alarms related to the smoke-detectors since they are being installed and tested. We also shelve all alarms from FastEthernet1/0.


```
<alarms xmlns="urn:ietf:params:xml:ns:yang:ietf-alarms"
  xmlns:xyz-al="urn:example:xyz-alarms"
  xmlns:dev="urn:example:device">
  <control>
    <alarm-shelving>
      <shelf>
        <name>FE10</name>
        <resource>
          /dev:interfaces/dev:interface[name='FastEthernet1/0']
        </resource>
      </shelf>
      <shelf>
        <name>detectortest</name>
        <alarm-type-id>xyz-al:environmental-alarm</alarm-type-id>
        <alarm-type-qualifier-match>
          smoke-alarm
        </alarm-type-qualifier-match>
      </shelf>
    </alarm-shelving>
  </control>
</alarms>
```

[Appendix E](#). X.733 Mapping Example

This example shows how to map a dynamic alarm type (alarm-type-identity=environmental-alarm, alarm-type-qualifier=smoke-alarm) to the corresponding X.733 event-type and probable cause parameters.

```
<alarms xmlns="urn:ietf:params:xml:ns:yang:ietf-alarms"
  xmlns:xyz-al="urn:example:xyz-alarms">
  <control>
    <x733-mapping
      xmlns="urn:ietf:params:xml:ns:yang:ietf-alarms-x733">
      <alarm-type-id>xyz-al:environmental-alarm</alarm-type-id>
      <alarm-type-qualifier-match>
        smoke-alarm
      </alarm-type-qualifier-match>
      <event-type>quality-of-service-alarm</event-type>
      <probable-cause>777</probable-cause>
    </x733-mapping>
  </control>
</alarms>
```


Appendix F. Relationships to other standards

This section briefly describes how this alarm module relates to other relevant standards.

F.1. Relationship to [RFC 8348](#)

[RFC 8348](#) [[RFC8348](#)] defines a YANG data model for the management of hardware. The "alarm-state" in [RFC 8348](#) (and EntityAlarmStatus in [RFC 4268](#) [[RFC4268](#)]) is a summary of the alarm severity levels that may be active on the specific hardware component. It does not say anything about how alarms are reported, and it doesn't provide any details of the alarms.

The mapping between the alarm YANG data-model and the alarm-state in [RFC 8348](#) are outlined below

- resource: corresponds to /hardware/component/
- is-cleared: no bit set in /hardware/component/state/alarm-state
- perceived-severity: corresponding bit set in /hardware/component/state/alarm-state
- operator-state-change/state: if the alarm is acknowledged by the operator it may correspond to under-repair

F.2. Relationship to other alarm standards

F.2.1. Alarm definition

The table below summarizes relevant definitions of the term "alarm" in other alarm standards.

Standard	Definition	Comment
X.733 [X.733]	error: A deviation of a system from normal operation. fault: The physical or algorithmic cause of a malfunction. Faults manifest themselves as errors. alarm: A notification, of the form defined by this function, of a specific event. An alarm may or	The X.733 alarm definition is focused on the notification as such and not the state. It also uses the basic criteria of deviation from normal condition. There is no requirement for an operation action to be required.

	may not represent an error.	
G.7710 [G.7710]	Alarms are indications that are automatically generated by an NE as a result of the declaration of a failure.	The G.7710 definition is close to the original X.733 definition.
Alarm MIB [RFC3877]	Alarm: Persistent indication of a fault. Fault: Lasting error or warning condition. Error: A deviation of a system from normal operation.	RFC 3877 defines alarm referring back to "a deviation from normal operation". This is problematic, since this might not require an operator action. The alarm MIB is state oriented rather than notification oriented, an alarm is a "lasting condition", not a discrete notification reporting about a condition state change.
ISA [ISA182]	Alarm: An audible and/or visible means of indicating to the operator an equipment malfunction, process deviation or abnormal condition requiring a response.	The ISA standard adds an important requirement to the "deviation from normal condition state"; requiring a response.
EEMUA [EEMUA]	An alarm is an event to which an operator must knowingly react, respond, and acknowledge - not simply acknowledge and ignore.	This is the foundation for the definition of alarm in this document. It focuses on the core criteria that an action is really needed.
3GPP Alarm IRP [ALARMIRP]	3GPP v15: An alarm signifies an undesired condition of a resource (e.g. network element, link) for which an operator action is required. It emphasizes a	The latest 3GPP Alarm IRP version uses literally the same alarm definition as this alarm module. It is worth noting that earlier versions used a

	key requirement that	definition not requiring	
	operators [...] should	an operator action and	
	not be informed about an	the more broad	
	undesired condition	definition of deviation	
	unless it requires	from normal condition.	
	operator action. 3GPP	The earlier version also	
	v12: alarm: abnormal	defined an alarm as a	
	network entity condition,	special case of "event".	
	which categorizes an		
	event as a fault. fault:		
	a deviation of a system		
	from normal operation,		
	which may result in the		
	loss of operational		
	capabilities [...]		
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+			

Table 1: Definition of alarm in standards

The evolution of the definition of alarm moves from focused on events reporting a deviation from normal operation towards a definition to a undesired *state* which *requires an operator action*.

F.2.2. Data model

This section describes how this YANG alarm module relates to other standard data models. Note well that we cover other data-models for alarm interfaces. Not other standards such as SDO specific alarms for example.

F.2.2.1. X.733

X.733 has acted as a base for several alarm data models over the year. The YANG alarm module differs in the following ways:

X.733 models the alarm list as a list of notifications. The YANG alarm module defines the alarm list as the current alarm states for the resources, which is generated from the state change reporting notifications.

In X.733 an alarm can have the severity level clear. In the YANG alarm module "clear" is not a severity level, it is a separate state of the alarm. An alarm can have the following states for example (major, cleared), (minor, not cleared)

X.733 uses a flat globally defined enumerated "probable cause" to identify alarm types. This alarm module uses a hierarchical YANG identity, alarm-type. This enables delegation of alarm types

within organizations. It also lets management reason about "abstract" alarm-types corresponding to base identities, see [Section 3.2](#).

The YANG alarm module has not included the majority of the X.733 alarm attributes. Rather these are defined in an augmenting module if "strict" X.733 compliance is needed.

[F.2.2.2.](#) [RFC 3877](#), the Alarm MIB

The MIB in [RFC 3877](#) takes a different approach, rather than defining a concrete data model for alarms, it defines a model to map existing SNMP managed objects and notifications into alarm states and alarm notifications. This was necessary since MIBs were already defined with both managed objects and notifications indicating alarms, for example linkUp and linkDown notifications in combination with ifAdminState and ifOperState. So [RFC 3877](#) can not really be compared to the alarm YANG module in that sense.

The Alarm MIB maps existing MIB definitions into alarms, alarmModelTable. The upside of that is that a SNMP Manager can at runtime read the possible alarm types. This corresponds to the alarmInventory in the alarm YANG module.

[F.2.2.3.](#) 3GPP Alarm IRP

The 3GPP Alarm IRP is an evolution of X.733. Main differences between the alarm YANG module and 3GPP are:

3GPP keeps the majority of the X.733 attributes, the alarm YANG module does not.

3GPP introduced overlapping and possibly conflicting keys for alarms, alarmId and (managed object, event type, probable cause, specific problem). (See Annex C in [[X.733](#)] Example 3). In the YANG alarm module the key for identifying an alarm instance is clearly defined by (resource, alarm-type, alarm-type-qualifier). See also [Section 3.4](#) for more information.

The alarm YANG module clearly separates the resource/instrumentation life cycle from the operator life cycle. 3GPP allows operators to set the alarm severity to clear, this is not allowed by this module, rather an operator closes an alarm which does not affect the severity.

F.2.2.4. G.7710

G.7710 is different than the previous referenced alarm standards. It does define a data-model for alarm reporting. It defines common equipment management function requirements including alarm instrumentation. The scope is transport networks.

The requirements in G.7710 corresponds to features in the alarm YANG module in the following way:

Alarm Severity Assignment Profile (ASAP): the alarm profile `"/alarms/alarm-profile/"`.

Alarm Reporting Control (ARC): alarm shelving `"/alarms/control/alarm-shelving/"` and the ability to control alarm notifications `"/alarms/control/notify-status-changes"`.

Appendix G. Alarm Usability Requirements

This section defines usability requirements for alarms. Alarm usability is important for an alarm interface. A data-model will help in defining the format but if the actual alarms are of low value we have not gained the goal of alarm management.

Common alarm problems and the cause of the problems are summarized in Table 2. This summary is adopted to networking based on the ISA [[ISA182](#)] and EEMUA [[EEMUA](#)] standards.

Problem	Cause	How this module address the cause
Alarms are generated but they are ignored by the operator.	"Nuisance" alarms (chattering alarms and fleeting alarms), faulty hardware, redundant alarms, cascading alarms, incorrect alarm settings, alarms have not been rationalized, the alarms represent log information rather than true alarms.	Strict definition of alarms requiring corrective response. Alarm requirements in Table 3.
When alarms occur, operators do not know how to respond.	Insufficient alarm response procedures and not well defined alarm types.	The alarm inventory lists all alarm types and corrective actions. Alarm requirements in Table 3.
The alarm display is full of alarms, even when there is nothing wrong.	Nuisance alarms, stale alarms, alarms from equipment not in service.	The alarm definition and alarm shelving.
During a failure, operators are flooded with so many alarms that they do not know which ones are the most important.	Incorrect prioritization of alarms. Not using advanced alarm techniques (e.g. state-based alarming).	State-based alarm model, alarm rate requirements in Table 4 and Table 5

Table 2: Alarm Problems and Causes

Based upon the above problems EEMUA gives the following definition of a good alarm:

Characteristic	Explanation
Relevant	Not spurious or of low operational value.
Unique	Not duplicating another alarm.
Timely	Not long before any response is needed or too late to do anything.
Prioritized	Indicating the importance that the operator deals with the problem.
Understandable	Having a message which is clear and easy to understand.
Diagnostic	Identifying the problem that has occurred.
Advisory	Indicative of the action to be taken.
Focusing	Drawing attention to the most important issues.

Table 3: Definition of a Good Alarm

Vendors SHOULD rationalize all alarms according to above. Another crucial requirement is acceptable alarm notification rates. Vendors SHOULD make sure that they do not exceed the recommendations from EEMUA below:

Long Term Alarm Rate in Steady Operation	Acceptability
More than one per minute	Very likely to be unacceptable.
One per 2 minutes	Likely to be over-demanding.
One per 5 minutes	Manageable.
Less than one per 10 minutes	Very likely to be acceptable.

Table 4: Acceptable Alarm Rates, Steady State

Number of alarms displayed in 10 minutes following a major network problem	Acceptability
More than 100	Definitely excessive and very likely to lead to the operator to abandon the use of the alarm system.
20-100	Hard to cope with.
Under 10	Should be manageable - but may be difficult if several of the alarms require a complex operator response.

Table 5: Acceptable Alarm Rates, Burst

The numbers in Table 4 and Table 5 are the sum of all alarms for a network being managed from one alarm console. So every individual system or NMS contributes to these numbers.

Vendors SHOULD make sure that the following rules are used in designing the alarm interface:

1. Rationalize the alarms in the system to ensure that every alarm is necessary, has a purpose, and follows the cardinal rule - that it requires an operator response. Adheres to the rules of Table 3
2. Audit the quality of the alarms. Talk with the operators about how well the alarm information support them. Do they know what to do in the event of an alarm? Are they able to quickly diagnose the problem and determine the corrective action? Does the alarm text adhere to the requirements in Table 3?
3. Analyze and benchmark the performance of the system and compare it to the recommended metrics in Table 4 and Table 5. Start by identifying nuisance alarms, standing alarms at normal state and startup.

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