

Internet Engineering Task Force (IETF)
Request for Comments: 7729
Category: Standards Track
ISSN: 2070-1721

B. Khasnabish
ZTE TX, Inc.
E. Haleplidis
University of Patras
J. Hadi Salim, Ed.
Mojatatu Networks
December 2015

Forwarding and Control Element Separation (ForCES)
Logical Functional Block (LFB) Subsidiary Management

Abstract

Deployment experience has demonstrated the value of using the Forwarding and Control Element Separation (ForCES) architecture to manage resources other than packet forwarding. In that spirit, the Forwarding Element Manager (FEM) is modeled by creating a Logical Functional Block (LFB) to represent its functionality. We refer to this LFB as the Subsidiary Mechanism (SM) LFB. A Control Element (CE) that controls a Forwarding Element's (FE) resources can also manage its configuration via the SM LFB. This document introduces the SM LFB class, an LFB class that specifies the configuration parameters of an FE. The configuration parameters include new LFB class loading and CE associations; they also provide manipulation of debug mechanisms along with a general purpose attribute definition to describe configuration information.

Status of This Memo

This is an Internet Standards Track document.

This document is a product of the Internet Engineering Task Force (IETF). It represents the consensus of the IETF community. It has received public review and has been approved for publication by the Internet Engineering Steering Group (IESG). Further information on Internet Standards is available in [Section 2 of RFC 5741](#).

Information about the current status of this document, any errata, and how to provide feedback on it may be obtained at <http://www.rfc-editor.org/info/rfc7729>.

Copyright Notice

Copyright (c) 2015 IETF Trust and the persons identified as the document authors. All rights reserved.

This document is subject to [BCP 78](#) and the IETF Trust's Legal Provisions Relating to IETF Documents (<http://trustee.ietf.org/license-info>) in effect on the date of publication of this document. Please review these documents carefully, as they describe your rights and restrictions with respect to this document. Code Components extracted from this document must include Simplified BSD License text as described in Section 4.e of the Trust Legal Provisions and are provided without warranty as described in the Simplified BSD License.

Table of Contents

1. Introduction	3
1.1. Requirements Language	5
1.2. Definitions	5
2. Use Cases	6
2.1. High Availability	6
2.2. Scalability	6
2.3. Adding New Resources to an NE	6
2.4. New LFB Class Installation	6
2.5. Logging Mechanism	7
2.6. General-Purpose Attribute Definition	7
3. Applicability Statement	8
3.1. FE Integrated	8
3.2. Virtual FEs	8
4. SM Library	8
4.1. Frame Definitions	8
4.2. Data Type Definitions	9
4.3. Metadata Definitions	9
4.4. SM	9
4.4.1. Data Handling	10
4.4.2. Components	10
4.4.3. Capabilities	10
4.4.4. Events	11
5. XML for SM LFB	11
6. Security Considerations	17
7. IANA Considerations	18
7.1. LFB Class Names and LFB Class Identifiers	18
8. References	18
8.1. Normative References	18
8.2. Informative References	19
Acknowledgments	20
Authors' Addresses	20

1. Introduction

Deployment experience has demonstrated the value of using the Forwarding and Control Element Separation (ForCES) architecture to manage resources other than packet forwarding. In that spirit, the Forwarding Element Manager (FEM) is modeled by creating a Logical Functional Block (LFB) to represent its functionality. We refer to this LFB as the Subsidiary Mechanism (SM) LFB. A Control Element (CE) that controls a Forwarding Element's (FE) resources can also manage its configuration via the SM LFB. This document introduces the SM LFB class, an LFB that specifies the configuration parameters of an FE.

On a running FE, a CE application may update an FE's runtime configuration via the SM LFB instance.

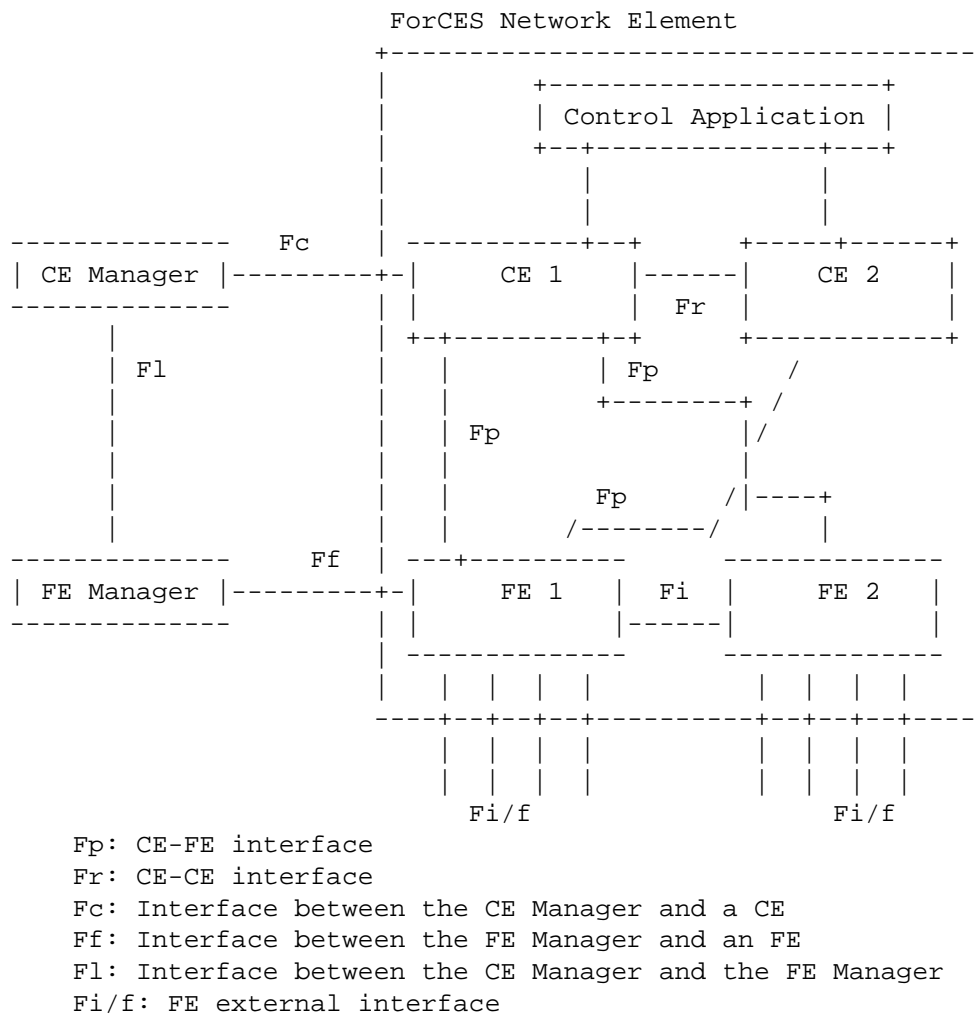


Figure 1: ForCES Architectural Diagram

Figure 1 shows a control application manipulating, at runtime, FE configuration via the SM LFB control. It would appear that this control application is playing the part of the FE Manager and thus appears as the messaging for Ff (FEM to FE interface) going via the standard Fp plane. However, the SM LFB describes a subset of the operations that can be performed over Ff; it does not suggest moving away from the Ff interface.

The SM LFB class describes the configuration parameters of an FE, namely the LFB classes it should load, the CEs it should be associated with, as well as the respective CE IP addresses. Additionally, the SM LFB provides a general purpose attribute

definition to describe configuration information, as well as the ability to manipulate the debug logging mechanism.

This document assumes that FEs are already booted. The FE's configuration can then be updated at runtime via the SM LFB for runtime configuration purposes. This document does not specify or standardize the FEM-FE (Ff) interface as depicted in [RFC3746]. This document describes a mechanism with which a CE can instruct the SM for FE management using ForCES.

This work item makes no assumption of whether FE resources are physical or virtual. In fact, the LFB library provided here is applicable to both. Thus, it can also be useful in addressing control of virtual FEs where individual FEMs can be addressed to control the creation, configuration, and resource assignment of such virtual FEs within a physical FE.

1.1. Requirements Language

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

1.2. Definitions

This document follows the terminology defined by [RFC3654], [RFC3746], [RFC5810], and [RFC5812]. In particular, the reader is expected to be familiar with the following terms:

- o Logical Functional Block (LFB)
- o Forwarding Element (FE)
- o Control Element (CE)
- o ForCES Network Element (NE)
- o FE Manager (FEM)
- o CE Manager
- o ForCES Protocol
- o ForCES Protocol Layer (ForCES PL)
- o ForCES Protocol Transport Mapping Layer (ForCES TML)

2. Use Cases

In this section, we present sample use cases to illustrate the need and usefulness of the SM LFB.

All use cases assume that an FE is already booted up and tied to at least one CE. A control application can delete a CE from an FE's table of CEs, which instructs the FE to terminate the connection with that removed CE. Likewise, the control application via the master CE instructs an FE to establish a ForCES association with a new CE by adding a particular CE to the FE's CEs table.

2.1. High Availability

Assume an FE associated to only one CE. At runtime, a CE management application may request, for redundancy reasons, that an FE be associated to another CE as a backup. To achieve this goal, the CE management application specifies the Control Element ID (CEID) of the new backup CE (to be uniquely identified within the NE) and the CE's IP address (IPv4 or IPv6).

2.2. Scalability

Assume an NE cluster that has FEs connected to multiple CEs, possibly in an active backup setup. Assume that system analytics discover that the CE is becoming a bottleneck. A new CE could be booted and some FEs moved to it. To achieve this goal, the CE management application will first ask an FE to connect to a new CE and would then instruct that FE to change its master to the new CE as described in [RFC7121].

2.3. Adding New Resources to an NE

Assume a resource pooling setup with multiple FEs belonging to a resource pool all connected to a dormant resource pool CE. An NE system manager by demand could move an FE from the resource pool to a working NE by asking it first to connect to a CE on the working NE and then asking it to disconnect from the resource pool manager CE.

2.4. New LFB Class Installation

A CE can learn, via the DynamicLFBLoading capability of the SM LFB, whether an FE is capable of loading new LFB classes. Provided that the FE supports new LFB class loading, the CE can request a new LFB to be installed and supported by the FE.

To load an LFB class on an FE, the CE will have to provide the following parameters:

- o LFB class - The LFB class ID
- o LFB version - The version of the LFB class
- o LFB class name - Optional, the LFB name
- o Parameters - Optional parameters. These parameters are implementation specific. For example, in one implementation they may contain the path where the LFB class implementation resides.

The parameters are fields that need to be described in documentation, depending on the implementation; one example is the location of the LFB class to be installed and/or mechanism to download it. The exact detail of the location semantics is implementation specific and out of scope of this document. However, this LFB library provides a placeholder, namely the SupportedParameters capability, which will host any standardized parameters.

This document does not standardize these parameters. It is expected that some future document will perform that task. These parameters are placeholders for future use, in order not to redefine the LFB class versions each time. They are simple strings that define the parameters supported by the LFB. The CE is expected to read this capability in order to understand the parameters it can use.

2.5. Logging Mechanism

The SM LFB class also provides a useful log-level manipulation. Experience has proven that the CE may be required to increase or decrease the debug levels of parts of the FE, whether that be LFBs, portions of LFBs, or generic processing code (all called "modules"). The module granularity is implementation specific and is not discussed in this document. The debug levels are derived from the "syslog Message Severities" registry <<http://www.iana.org/assignments/syslog-parameters>> defined in [RFC3164].

2.6. General-Purpose Attribute Definition

Experience has shown that a generic attribute name-value pair is useful for describing configuration information. This LFB class defines such a generic attribute name-value pair defined as a table of attribute name-value pair values. The attribute name-value pair is implementation specific and at the moment there is nothing to standardize. As an example, consider switches that have exactly the

same LFB classes and capabilities but need to be used in different roles. A good example would be a switch that could be used either as Spine or Top-of-Rack (ToR) in data-center setups. An attribute that defines the role could be retrieved from the FE, which will then dictate how it is controlled and configured. However, as in the case of LFB class loading parameters, this LFB class library provides a placeholder, namely the SupportedArguments capability, which will host any standardized arguments. This document does not standardize these parameters. The CE is expected to read the SupportedArguments capability in order to know what attributes it can use.

3. Applicability Statement

Examples of SM usage include, but are not limited to, the following two usage scenarios. These two scenarios are not implementation details, but rather depict how the SM class can be used to achieve the intended SM for manipulating the configuration of FEs.

3.1. FE Integrated

Only one instance of the SM LFB class can exist and is directly related to the FE.

3.2. Virtual FEs

In the case of the FE software that has hierarchical virtual FEs, multiple instances of the SM LFB class can exist, one per each virtual FE.

4. SM Library

4.1. Frame Definitions

This LFB class does not define any frames.

4.2. Data Type Definitions

This library defines the following data types.

Data Type Name	Type	Synopsis
loglevels	An enumerated char-based atomic data type.	The possible debug log levels. Derived from syslog.
LogRowType	A struct containing three components: the LogModule (string), the optional ModuleFilename (string), and the optional DebugLevel, which is one of the enumerated loglevels.	The logging module row.
CERow	A struct that contains three components: the address family of the CE IP (uchar), the CE's IPs (octetstring[16]), and the CE's ID (uint32).	A struct that defines the CE table row.
LCRowtype	A struct that contains four components: the LFB class ID (uint32), the LFB version (string[8]), the optional LFB Name (string), and the optional Parameters (string).	The LFB Class Configuration Definition.
NameVal	A struct that contains two components: an attribute name (string) and an attribute value (string).	Arbitrary Name Value struct.

FEM Data Types

4.3. Metadata Definitions

This LFB does not define any metadata definitions.

4.4. SM

The Subsidiary Mechanism LFB is an LFB that standardizes configuration of the FE parameters.

4.4.1. Data Handling

The SM LFB does not handle any packets. Its function is to provide the configuration parameters to the CE to be updated at runtime.

4.4.2. Components

This LFB class has four components specified.

The Debug component (ID 1) is a table to support changing of an FE's module debug levels. Changes in an FE's debug table rows will alter the debug level of the corresponding module.

The LFBLoad component (ID 2) is a table of LFB classes that the FE loads. Adding new rows in this table instructs the FE to load new LFB classes, and removing rows will unload them when possible. These two actions will, in effect, alter the SupportedLFBs capabilities table of FEObject LFB [RFC5812]. Each such row MUST provide (and is specified by this library) the LFB class ID. Optionally, the LFB class ID version may be specified, and the FE MUST assume that version 1.0 is used when the version is unspecified.

The AttributeValues component (ID 3) is the AttributeValues table, a generic attribute-value pair.

The CEs (ID 4) is the table of runtime CEs we are asking the FE to be able to connect with. By adding a row in this table, the CE instructs the FE to be able to connect with the specified CE. By doing a delete on this table, the CE instructs the FE to terminate any connection with that CE. How the FE interacts with the new CEs is dependent on the operations discussed in [RFC7121].

It is worth noting that the generic attribute-value pairs, the LFBload parameters, and the module information are all strings. To cope with string sizes, a CE application can extract that information from the component properties as defined in [RFC5812].

4.4.3. Capabilities

This LFB provides three capabilities. The first, DynamicLFBLoading, specifies whether this FE supports dynamic loading of new LFB classes. The second, SupportedParameters, is a placeholder and will store all the supported parameters for LFB class loading. The final, SupportedAttributes, is also a placeholder and will store all the supported attributes for the attribute-value pair table.

4.4.4. Events

This LFB has four events specified.

Two events reflect CE additions and report to the CE whether an entry of the CEs information has been added or deleted. In both cases, the event report constitutes the added or deleted row contents.

The other two events reflect LFB class loading and notify whether an entry of the LFBLoad table is added or deleted.

5. XML for SM LFB

```
<LFBLibrary xmlns="urn:ietf:params:xml:ns:forces:lfbmodel:1.1"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" provides="SM">
  <!-- XXX -->
  <dataTypeDefs>
    <dataTypeDef>
      <name>loglevels</name>
      <synopsis>The possible debug log levels. Derived from syslog.
      </synopsis>
      <atomic>
        <baseType>char</baseType>
        <specialValues>
          <specialValue value="-1">
            <name>DEB_OFF</name>
            <synopsis> The logs are totally turned off </synopsis>
          </specialValue>
          <specialValue value="0">
            <name>DEB_EMERG</name>
            <synopsis> Emergency level </synopsis>
          </specialValue>
          <specialValue value="1">
            <name>DEB_ALERT</name>
            <synopsis> Alert level </synopsis>
          </specialValue>
          <specialValue value="2">
            <name>DEB_CRIT</name>
            <synopsis> Critical level </synopsis>
          </specialValue>
          <specialValue value="3">
            <name>DEB_ERR</name>
            <synopsis> error level </synopsis>
          </specialValue>
          <specialValue value="4">
            <name>DEB_WARNING</name>
            <synopsis> warning level </synopsis>
          </specialValue>
        </specialValues>
      </atomic>
    </dataTypeDef>
  </dataTypeDefs>
</LFBLibrary>
```

```

    <specialValue value="5">
      <name>DEB_NOTICE</name>
      <synopsis>Notice level </synopsis>
    </specialValue>
    <specialValue value="6">
      <name>DEB_INFO</name>
      <synopsis>Info level </synopsis>
    </specialValue>
    <specialValue value="7">
      <name>DEB_DEBUG</name>
      <synopsis>Debug level </synopsis>
    </specialValue>
  </specialValues>
</atomic>
</dataTypeDef>
<dataTypeDef>
  <name>LogRowtype</name>
  <synopsis>The logging module row</synopsis>
  <struct>
    <component componentID="1">
      <name>lmodule</name>
      <synopsis>The LOG Module Name</synopsis>
      <typeRef>string</typeRef>
    </component>
    <component componentID="2">
      <name>filename</name>
      <synopsis>The Module File Name</synopsis>
      <optional/>
      <typeRef>string</typeRef>
    </component>
    <component componentID="3">
      <name>deblvl</name>
      <synopsis>debug level</synopsis>
      <optional/>
      <typeRef>loglevels</typeRef>
    </component>
  </struct>
</dataTypeDef>
<dataTypeDef>
  <name>CERow</name>
  <synopsis>The CE Table Row</synopsis>
  <struct>
    <component componentID="1">
      <name>AddressFamily</name>
      <synopsis>The address family</synopsis>
      <atomic>
        <baseType>uchar</baseType>
        <specialValues>

```

```

        <specialValue value="2">
            <name>IFA_AF_INET</name>
            <synopsis>IPv4</synopsis>
        </specialValue>
        <specialValue value="10">
            <name>IFA_AF_INET6</name>
            <synopsis>IPv6</synopsis>
        </specialValue>
    </specialValues>
</atomic>
</component>
<component componentID="2">
    <name>CEIP</name>
    <synopsis>CE ip v4 or v6(selected by family)</synopsis>
    <typeRef>octetstring[16]</typeRef>
</component>
<component componentID="3">
    <name>CEID</name>
    <synopsis>The CE ID</synopsis>
    <optional/>
    <typeRef>uint32</typeRef>
</component>
</struct>
</dataTypeDef>
<dataTypeDef>
    <name>LCRowtype</name>
    <synopsis>The LFB Class Configuration Definition</synopsis>
    <struct>
        <component componentID="1">
            <name>LFBClassID</name>
            <synopsis>The LFB Class ID</synopsis>
            <typeRef>uint32</typeRef>
        </component>
        <component componentID="2">
            <name>LFBVersion</name>
            <synopsis>The LFB Class Version</synopsis>
            <optional/>
            <typeRef>string</typeRef>
        </component>
        <component componentID="3">
            <name>LFBName</name>
            <synopsis>The LFB Class Name</synopsis>
            <optional/>
            <typeRef>string</typeRef>
        </component>
        <component componentID="4">
            <name>Parameters</name>
            <synopsis>Optional parameters such as where the LFB is

```

```

        located</synopsis>
        <optional/>
        <typeRef>string</typeRef>
    </component>
</struct>
</dataTypeDef>
<dataTypeDef>
    <name>NameVal</name>
    <synopsis>Arbitrary Name Value struct</synopsis>
    <struct>
        <component componentID="1">
            <name>AttrName</name>
            <synopsis>The Attribute Name</synopsis>
            <typeRef>string</typeRef>
        </component>
        <component componentID="2">
            <name>AttrVal</name>
            <synopsis>The Attribute Value</synopsis>
            <typeRef>string</typeRef>
        </component>
    </struct>
</dataTypeDef>
</dataTypeDefs>
<LFBClassDefs>
    <LFBClassDef LFBClassID="19">
        <name>SM</name>
        <synopsis>
            The Subsidiary Management LFB
        </synopsis>
        <version>1.0</version>
        <components>
            <component componentID="1" access="read-write">
                <name>Debug</name>
                <synopsis>A table to support changing of all debug levels
            </synopsis>
                <array type="variable-size">
                    <typeRef>LogRowtype</typeRef>
                </array>
            </component>
            <component componentID="2" access="write-only">
                <name>LFBLoad</name>
                <synopsis>An LFB Class to Load</synopsis>
                <array type="variable-size">
                    <typeRef>LCRowtype</typeRef>
                </array>
            </component>
            <component componentID="3" access="read-write">
                <name>AttributeValues</name>

```

```

    <synopsis>Table of general purpose SM attribute Values
  </synopsis>
  <array type="variable-size">
    <typeRef>NameVal</typeRef>
  </array>
</component>
<component componentID="4" access="write-only">
  <name>CEs</name>
  <synopsis>Table of CEs we are asking the FE to associate
    with</synopsis>
  <array type="variable-size">
    <typeRef>CERow</typeRef>
  </array>
</component>
</components>
<!-->
<capabilities>
  <capability componentID="10">
    <name>DynamicLFBLoading</name>
    <synopsis>This capability specifies whether this FE supports
      dynamic loading of new LFBs</synopsis>
    <typeRef>boolean</typeRef>
  </capability>
  <capability componentID="11">
    <name>SupportedParameters</name>
    <synopsis>This capability contains all the supported
      parameters</synopsis>
    <array type="variable-size">
      <typeRef>string</typeRef>
    </array>
  </capability>
  <capability componentID="12">
    <name>SupportedAttributes</name>
    <synopsis>This capability contains all the supported
      attributes names</synopsis>
    <array type="variable-size">
      <typeRef>string</typeRef>
    </array>
  </capability>
</capabilities>
<events baseID="20">
  <event eventID="1">
    <name>CEAdded</name>
    <synopsis>An CE has been added</synopsis>
    <eventTarget>
      <eventField>CEs</eventField>
    </eventTarget>
    <eventCreated/>
  </event>
</events>

```

```
<eventReports>
  <eventReport>
    <eventField>CEs</eventField>
    <eventSubscript>_CEIDsrowid_</eventSubscript>
  </eventReport>
</eventReports>
</event>
<event eventID="2">
  <name>CEDeleted</name>
  <synopsis>An CE has been deleted</synopsis>
  <eventTarget>
    <eventField>CEs</eventField>
    <eventSubscript>_CEIDsrowid_</eventSubscript>
  </eventTarget>
  <eventDeleted/>
  <eventReports>
    <eventReport>
      <eventField>CEs</eventField>
      <eventSubscript>_CEIDsrowid_</eventSubscript>
    </eventReport>
  </eventReports>
</event>
<event eventID="3">
  <name>LFBLoaded</name>
  <synopsis>An LFB has been loaded</synopsis>
  <eventTarget>
    <eventField>LFBLoad</eventField>
  </eventTarget>
  <eventCreated/>
  <eventReports>
    <eventReport>
      <eventField>LFBLoad</eventField>
      <eventSubscript>_LFBLoadrowid_</eventSubscript>
    </eventReport>
  </eventReports>
</event>
<event eventID="4">
  <name>LFBUnloaded</name>
  <synopsis>An CE has been unloaded</synopsis>
  <eventTarget>
    <eventField>LFBLoad</eventField>
    <eventSubscript>_LFBLoadrowid_</eventSubscript>
  </eventTarget>
  <eventDeleted/>
  <eventReports>
    <eventReport>
      <eventField>LFBLoad</eventField>
      <eventSubscript>_LFBLoadrowid_</eventSubscript>
    </eventReport>
  </eventReports>
</event>
```



```
        </eventReport>
      </eventReports>
    </event>
  </events>
</LFBClassDef>
</LFBClassDefs>
</LFBLibrary>
```

Figure 2: FEM XML LFB Library

6. Security Considerations

This document does not alter the ForCES model [RFC5812] or the ForCES protocol [RFC5810]. As such, it has no impact on their security considerations. This document simply defines the operational parameters and capabilities of an LFB that manage the SM for loading LFBs and create new connections between FEs and CEs.

On the issue of trust, a designer should take into account that the CE that creates new connections to CEs is either:

- o The FE manager that is responsible for managing the FEs, or
- o An already associated CE

In both of these cases, the entity making the connections should already be trusted to perform such activities. If the entity making the connections is faulty, rogue, or hacked, there is no way for the FE to know this, and it will perform any action that the CE requests. Therefore, this document does not attempt to analyze the security issues that may arise from misuse of the SM LFB. Any such issues, if they exist, and mitigation strategies are for the designers of the particular SM implementation, not the general mechanism.

The reader is also referred to the ForCES framework [RFC3746] document, particularly [Section 8](#), for an analysis of potential threats introduced by ForCES and how the ForCES architecture addresses them.

7. IANA Considerations

7.1. LFB Class Names and LFB Class Identifiers

LFB classes defined by this document belong to LFBs defined by Standards Track RFCs. The registration procedure is Standards Action for the range 0 to 65535 and First Come First Served with any publicly available specification for identifiers over 65535 [RFC5226]. This specification registers the following LFB class name and LFB class identifier in the "Logical Functional Block (LFB) Class Names and Class Identifiers" registry:

LFB Class Identifier	LFB Class Name	LFB Version	Description	Reference
19	SM	1.0	An SM LFB to standardize subsidiary management for ForCES Network Elements	RFC 7729 (this document)

Logical Functional Block (LFB) Class Name and Class Identifier

8. References

8.1. Normative References

- [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", [BCP 14](#), [RFC 2119](#), DOI 10.17487/RFC2119, March 1997, <<http://www.rfc-editor.org/info/rfc2119>>.
- [RFC5810] Doria, A., Ed., Hadi Salim, J., Ed., Haas, R., Ed., Khosravi, H., Ed., Wang, W., Ed., Dong, L., Gopal, R., and J. Halpern, "Forwarding and Control Element Separation (ForCES) Protocol Specification", [RFC 5810](#), DOI 10.17487/RFC5810, March 2010, <<http://www.rfc-editor.org/info/rfc5810>>.
- [RFC5812] Halpern, J. and J. Hadi Salim, "Forwarding and Control Element Separation (ForCES) Forwarding Element Model", [RFC 5812](#), DOI 10.17487/RFC5812, March 2010, <<http://www.rfc-editor.org/info/rfc5812>>.

- [RFC7121] Ogawa, K., Wang, W., Haleplidis, E., and J. Hadi Salim, "High Availability within a Forwarding and Control Element Separation (ForCES) Network Element", [RFC 7121](#), DOI 10.17487/RFC7121, February 2014, <<http://www.rfc-editor.org/info/rfc7121>>.

8.2. Informative References

- [RFC3164] Lonvick, C., "The BSD Syslog Protocol", [RFC 3164](#), DOI 10.17487/RFC3164, August 2001, <<http://www.rfc-editor.org/info/rfc3164>>.
- [RFC3654] Khosravi, H., Ed. and T. Anderson, Ed., "Requirements for Separation of IP Control and Forwarding", [RFC 3654](#), DOI 10.17487/RFC3654, November 2003, <<http://www.rfc-editor.org/info/rfc3654>>.
- [RFC3746] Yang, L., Dantu, R., Anderson, T., and R. Gopal, "Forwarding and Control Element Separation (ForCES) Framework", [RFC 3746](#), DOI 10.17487/RFC3746, April 2004, <<http://www.rfc-editor.org/info/rfc3746>>.
- [RFC5226] Narten, T. and H. Alvestrand, "Guidelines for Writing an IANA Considerations Section in RFCs", [BCP 26](#), [RFC 5226](#), DOI 10.17487/RFC5226, May 2008, <<http://www.rfc-editor.org/info/rfc5226>>.

Acknowledgments

The authors would like to thank Damascene Joachimpillai, Joel Halpern, Chuanhuang Li, and many others for their discussions and support.

The authors are grateful to Joel Halpern for shepherding this document. The authors would also like to thank Alia Atlas for taking on the role of sponsoring this document. Finally, thanks to Juergen Schoenwaelder for his operational directorate's review and Alexey Melnikov for his security review.

Authors' Addresses

Bhumip Khasnabish
ZTE TX, Inc.
55 Madison Avenue, Suite 160
Morristown, New Jersey 07960
United States

Phone: +001-781-752-8003
Email: vumipl@gmail.com, bhumip.khasnabish@ztetx.com
URI: <http://tinyurl.com/bhumip/>

Evangelos Haleplidis
University of Patras
Department of Electrical and Computer Engineering
Patras 26500
Greece

Email: ehalep@ece.upatras.gr

Jamal Hadi Salim (editor)
Mojatatu Networks
Suite 200, 15 Fitzgerald Road
Ottawa, Ontario K2H 9G1
Canada

Email: hadi@mojatatu.com