Forwarding and Control Element Separation (ForCES)
Applicability Statement

Abstract

   The Forwarding and Control Element Separation (ForCES) protocol
   defines a standard framework and mechanism for the interconnection
   between control elements and forwarding elements in IP routers and
   similar devices. In this document we describe the applicability of
   the ForCES model and protocol. We provide example deployment
   scenarios and functionality, as well as document applications that
   would be inappropriate for ForCES.

Status of This Memo

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1. Introduction

   The Forwarding and Control Element Separation (ForCES) protocol
   defines a standard framework and mechanism for the exchange of
   information between the logically separate functionality of the
   control and data forwarding planes of IP routers and similar devices.
   It focuses on the communication necessary for separation of control
   plane functionality such as routing protocols, signaling protocols,
   and admission control from data forwarding plane per-packet
   activities such as packet forwarding, queuing, and header editing.

This document defines the applicability of the ForCES mechanisms. It
describes types of configurations and settings where ForCES is most
appropriately applied. This document also describes scenarios and
configurations where ForCES would not be appropriate for use.

2. Purpose

The purpose of the ForCES Applicability Statement is to capture the
intent of the ForCES protocol [RFC5810] designers as to how the
protocol could be used in conjunction with the ForCES model [RFC5812]
and a Transport Mapping Layer [RFC5811].

3. Terminology

A set of concepts associated with ForCES was introduced in
"Requirements for Separation of IP Control and Forwarding" [RFC3654]
and in "Forwarding and Control Element Separation (ForCES) Framework"
[RFC3746]. The terminology associated with these concepts and with
the protocol elements in ForCES is defined in the "Forwarding and
Control Element Separation (ForCES) Protocol Specification"
[RFC5810].

The reader is directed to these documents for the conceptual
introduction and for definitions, including the following acronyms:

o CE: control element

o CEM: CE Manager

o FE: forwarding element

o FEM: FE Manager

o ForCES: Forwarding and Control Element Separation protocol

o LFB: Logical Function Block

o NE: ForCES network element

o TML: Transport Mapping Layer

4. Applicability to IP Networks

This section lists the areas of ForCES applicability in IP network
devices. Some relatively low-end routing systems may be implemented
on simple hardware that performs both control and packet forwarding
functionality. ForCES may not be useful for such devices.

Higher-end routing systems typically distribute work amongst several
interface-processing elements, and these devices (FEs) therefore need
to communicate with the control element(s) to perform their job. A
higher-end router may also distribute control processing amongst
several processing elements (CEs). ForCES provides a standard way to
do this communication. ForCES also provides support for high-
availability configurations that include a primary CE and one or more
secondary CEs.

The remainder of this section lists the applicable services that
ForCES may support, applicable FE functionality, applicable CE-FE
link scenarios, and applicable topologies in which ForCES may be
deployed.

4.1. Applicable Services

In this section we describe the applicability of ForCES for the
following control-forwarding-plane services:

o Association, Capability Discovery, and Information Exchange

o Topology Information Exchange

o Configuration

o Routing Exchange

o Quality of Service (QoS) Exchange

o Security Exchange

o Filtering Exchange

o Encapsulation/Tunneling Exchange

o NAT and Application-Level Gateways

o Measurement and Accounting

o Diagnostics

o CE Redundancy or CE Failover

4.1.1. Association, Capability Discovery, and Information Exchange

Association is the first step of the ForCES protocol exchange in
which capability discovery and exchange happens between one or more
CEs and the FEs. ForCES assumes that CEs and FEs already have

sufficient information to begin communication in a secure manner.
The ForCES protocol is only applicable after CEs and FEs have
discovered each other. ForCES makes no assumption about whether
discovery was performed using a dynamic protocol or merely static
configuration. Some discussion about how this can occur can be found
in Section 6.4 of this document.

During the association phase, CEs and FEs exchange capability
information with each other. For example, the FEs express the number
of interface ports they provide, as well as the static and
configurable attributes of each port.

In addition to initial configuration, the CEs and FEs also exchange
dynamic configuration changes using ForCES. For example, FEs
asynchronously inform the CEs of an increase/decrease in available
resources or capabilities on the FE.

4.1.2. Topology Information Exchange

In this context, topology information relates to how the FEs are
interconnected with each other with respect to packet forwarding.
Topology discovery is outside the scope of the ForCES protocol. An
implementation can choose its own method of topology discovery (for
example, it can use a standard topology discovery protocol or apply a
static topology configuration policy). Once the topology is
established, the ForCES protocol may be used to transmit the
resulting information to the CEs.

4.1.3. Configuration

ForCES is used to perform FE configuration. For example, CEs set
configurable FE attributes such as IP addresses, etc. for their
interfaces.

4.1.4. Routing Exchange

ForCES may be used to deliver packet forwarding information resulting
from CE routing calculations. For example, CEs may send forwarding
table updates to the FEs, so that they can make forwarding decisions.
FEs may inform the CEs in the event of a forwarding table miss.
ForCES may also be used to configure Equal Cost Multi-Path (ECMP)
capability.

4.1.5. QoS Capabilities Exchange and Configuration

   ForCES may be used to exchange QoS capabilities between CEs and FEs.
   For example, an FE may express QoS capabilities to the CE. Such
   capabilities might include metering, policing, shaping, and queuing
   functions. The CE may use ForCES to configure these capabilities.

4.1.6. Security Exchange

   ForCES may be used to exchange security information between a CE and
   the FEs it controls. For example, the FE may use ForCES to express
   the types of encryption that it is capable of using in an IP Security
   (IPsec) tunnel. The CE may use ForCES to configure such a tunnel.
   The CEs would be responsible for the NE dynamic key exchanges and
   updates.

4.1.7. Filtering Exchange and Firewalls

   ForCES may be used to exchange filtering information. For example,
   FEs may use ForCES to express the filtering functions, such as
   classification and action, that they can perform, and the CE may
   configure these capabilities.

4.1.8. Encapsulation/Tunneling Exchange

   ForCES may be used to exchange encapsulation capabilities of an FE,
   such as tunneling, and the configuration of such capabilities.

4.1.9. NAT and Application-Level Gateways

   ForCES may be used to exchange configuration information for Network
   Address Translators. Whilst ForCES is not specifically designed for
   the configuration of application-level gateway functionality, this
   may be in scope for some types of application-level gateways.

4.1.10. Measurement and Accounting

   ForCES may be used to exchange configuration information regarding
   traffic measurement and accounting functionality. In this area,
   ForCES may overlap somewhat with functionality provided by network
   management mechanisms such as the Simple Network Management Protocol
   (SNMP). In some cases, ForCES may be used to convey information to
   the CE to be reported externally using SNMP. A further discussion of
   this capability is covered in Section 6 of this document.

4.1.11. Diagnostics

   ForCES may be used for CEs and FEs to exchange diagnostic
   information. For example, an FE can send self-test results to a CE.

4.1.12. Redundancy and Failover

   The ForCES architecture includes mechanisms that allow for multiple
   redundant CEs and FEs in a ForCES NE. The ForCES-model LFB
   definitions provide sufficient component details via component
   identifiers to be universally unique within an NE. The ForCES
   protocol includes mechanisms to facilitate transactions as well as
   atomicity across the NE.

   Given the above, it is possible to deploy redundant CEs and FEs that
   incorporate failover.

4.2. CE-FE Link Capability

   When using ForCES, the bandwidth of the CE-FE link is a
   consideration, and cannot be ignored. For example, sending a full
   routing table is reasonable over a high-bandwidth link, but could be
   non-trivial over a lower-bandwidth link. ForCES should be
   sufficiently future-proof to be applicable in scenarios where routing
   tables grow to several orders of magnitude greater than their current
   size. However, we also note that not all IP routers need full
   routing tables.

4.3. CE/FE Locality

   ForCES is intended for environments where one of the following
   applies:

   o The control interconnect is some form of local bus, switch, or
      LAN, where reliability is high, closely controlled, and not
      susceptible to external disruption that does not also affect the
      CEs and/or FEs.

   o The control interconnect shares its fate with the FE's forwarding
      function. Typically this is because the control connection is
      also the FE's primary packet forwarding connection, and so if that
      link goes down, the FE cannot forward packets anyway.

   The key guideline is that the reliability of the device should not be
   significantly reduced by the separation of control and forwarding
   functionality.

Taking this into account, ForCES is applicable in the following CE/FE
localities:

Single Box NE:
    chassis with multiple CEs and FEs set up. ForCES is applicable in
    localities consisting of control and forwarding elements that are
    components in the same physical box.

    Example: a network element with a single control blade, and one or
    more forwarding blades, all present in the same chassis and
    sharing an interconnect such as Ethernet or Peripheral Component
    Interconnect (PCI). In this locality, the majority of the data
    traffic being forwarded typically does not traverse the same links
    as the ForCES control traffic.

Multiple Box NE:
    separated CE and FE, where physical locality could be the same
    rack, room, or building; or long distances that could span across
    continents and oceans. ForCES is applicable in localities
    consisting of control and forwarding elements that are separated
    by a single hop or multiple hops in the network.

5. Security Considerations

    The ForCES protocol allows for a variety of security levels
    [RFC5810]. When operating under a secured physical environment, or
    for other operational concerns (in some cases, performance issues),
    the operator may turn off all the security functions between CEs and
    FEs. When the operator makes a decision to secure the path between
    the FEs and CEs, then the operator chooses from one of the options
    provided by the TML. Security choices provided by the TML take
    effect during the pre-association phase of the ForCES protocol. An
    operator may choose to use all, some, or none of the security
    services provided by the TML in a CE-FE connection. A ForCES NE is
    required to provide CE/FE node authentication services, and may
    provide message integrity and confidentiality services. The NE may
    provide these services by employing IPsec or Transport Layer Security
    (TLS), depending on the choice of TML used in the deployment of
    the NE.

6. ForCES Manageability

    From the architectural perspective, the ForCES NE is a single network
    element. As an example, if the ForCES NE is specifically a router
    that needs to be managed, then it should be managed in essentially
    the same way any router should be managed. From another perspective,
    element management could directly view the individual entities and
    interfaces that make up a ForCES NE. However, any element management

   updates made directly on these entities and interfaces may compromise
   the control relationship between the CEs and the FEs, unless the
   update mechanism has been accounted for in the model used by the NE.

6.1. The NE as an Atomic Element

   From the ForCES Requirements [RFC3654], Section 4, point 4:

      A NE MUST support the appearance of a single functional device.

   As a single functional device, a ForCES NE runs protocols, and each
   of the protocols has its own existing manageability aspects that are
   documented elsewhere. As an example, a router would also have a
   configuration interface. When viewed in this manner, the NE is
   controlled as a single routing entity, and no new management beyond
   what is already available for routers and routing protocols would be
   required for a ForCES NE. Management commands on a management
   interface to the NE will arrive at the CE and may require ForCES
   interactions between the CE and FEs to complete. This may impact the
   atomicity of such commands and may require careful implementation by
   the CE.

6.2. The NE as Composed of Manageable Elements

   When viewed as a decomposed set of elements from the management
   perspective, the ForCES NE is divided into a set of one of more
   control elements, forwarding elements, and the interfaces between
   them. The interface functionality between the CE and the FE is
   provided by the ForCES protocol. A MIB module is provided for the
   purpose of gaining management information on the operation of the
   protocol described in Section 6.3 of this document.

   Additionally, the architecture makes provisions for configuration
   control of the individual CEs and FEs. This is handled by elements
   called the FE Manager (FEM) and the CE Manager (CEM). Specifically,
   from the ForCES Requirements RFC [RFC3654], Section 4, point 4:

      However, external entities (e.g., FE Managers and CE Managers) MAY
      have direct access to individual ForCES protocol elements for
      providing information to transition them from the pre-association
      to the post-association phase.

6.3. ForCES Protocol MIB

   The ForCES MIB [RFC5813] defines a primarily read-only MIB module
   that captures information related to the ForCES protocol. This
   includes state information about the associations between CE(s) and
   FE(s) in the NE.

The ForCES MIB does not include information that is specified in
other MIB modules, such as packet counters for interfaces, etc.

More specifically, the information in the ForCES MIB module relative
to associations includes:

o identifiers of the elements in the association

o state of the association

o configuration parameters of the association

o statistics of the association

6.3.1. MIB Management of an FE

While it is possible to manage an FE from an element manager, several
requirements relating to this have been included in the ForCES
Requirements.

From the ForCES Requirements [RFC3654], Section 4, point 14:

   1. The ability for a management tool (e.g., SNMP) to be used to
      read (but not change) the state of FE SHOULD NOT be precluded.

   2. It MUST NOT be possible for management tools (e.g., SNMP, etc)
      to change the state of a FE in a manner that affects overall NE
      behavior without the CE being notified.

The ForCES Framework [RFC3746], Section 5.7, goes further in
discussing the manner in which FEs should handle management requests
that are specifically directed to the FE:

   (For a ForCES NE that is an IP router,) RFC 1812 [RFC1812] also
   dictates that "Routers must be manageable by SNMP". In general,
   for the post-association phase, most external management tasks
   (including SNMP) should be done through interaction with the CE in
   order to support the appearance of a single functional device.
   Therefore, it is recommended that an SNMP agent be implemented by
   CEs and that the SNMP messages received by FEs be redirected to
   their CEs. AgentX framework defined in RFC 2741 [RFC2741]) may be
   applied here such that CEs act in the role of master agent to
   process SNMP messages while FEs act in the role of subagent to
   provide access to the MIB objects residing on FEs. AgentX
   protocol messages between the master agent (CE) and the subagent
   (FE) are encapsulated and transported via ForCES, just like data
   packets from any other application layer protocols.

6.4. The FEM and CEM

   Though out of scope for the initial ForCES specification effort, the
   ForCES architecture includes two entities: the CE Manager (CEM) and
   the FE Manager (FEM). From the ForCES Protocol Specification
   [RFC5810]:

   CE Manager (CEM):
      A logical entity responsible for generic CE management tasks. It
      is particularly used during the pre-association phase to determine
      with which FE(s) a CE should communicate.

   FE Manager (FEM):
      A logical entity responsible for generic FE management tasks. It
      is used during the pre-association phase to determine with which
      CE(s) an FE should communicate.

7. Contributors

   Mark Handley was an initial author involved in the earlier versions
   of this document.

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Authors' Addresses

   Alan Crouch
   Intel
   2111 NE 25th Avenue
   Hillsboro, OR 97124
   USA

   Phone: +1 503 264 2196
   EMail: alan.crouch@intel.com

   Hormuzd Khosravi
   Intel
   2111 NE 25th Avenue
   Hillsboro, OR 97124
   USA

   Phone: 1-503-264-0334
   EMail: hormuzd.m.khosravi@intel.com

   Avri Doria (editor)
   LTU
   Lulea University of Technology
   Sweden

   Phone: +46 73 277 1788
   EMail: avri@acm.org

   Xin-ping Wang
   Huawei
   Beijing
   China

   Phone: +86 10 82836067
   EMail: carly.wang@huawei.com

   Kentaro Ogawa
   NTT Corporation
   3-9-11 Midori-cho
   Musashino-shi, Tokyo 180-8585
   Japan

   EMail: ogawa.kentaro@lab.ntt.co.jp