Network Working Group
Internet-Draft
Intended status: Informational
Expires: August 25, 2013

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February 21, 2013

Interface to the Routing System Problem Statement
draft-atlas-i2rs-problem-statement-01

Abstract

As modern networks grow in scale and complexity, the need for rapid and dynamic control increases. With scale, the need to automate even the simplest operations is important, but even more critical is the ability to quickly interact with more complex operations such as policy-based controls.

In order to enable applications to have access to and control over information in the Internet's routing system, we need a publicly documented interface specification. The interface needs to support real-time, transaction-based interactions using data models and encodings that are efficient and potentially different from those available today. Furthermore, the interface must be tailored to support a variety of use cases.

This document expands upon these statements of requirements to provide a detailed problem statement for an Interface to the Internet Routing System (I2RS).

Status of this Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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This Internet-Draft will expire on August 25, 2013.

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1. Introduction

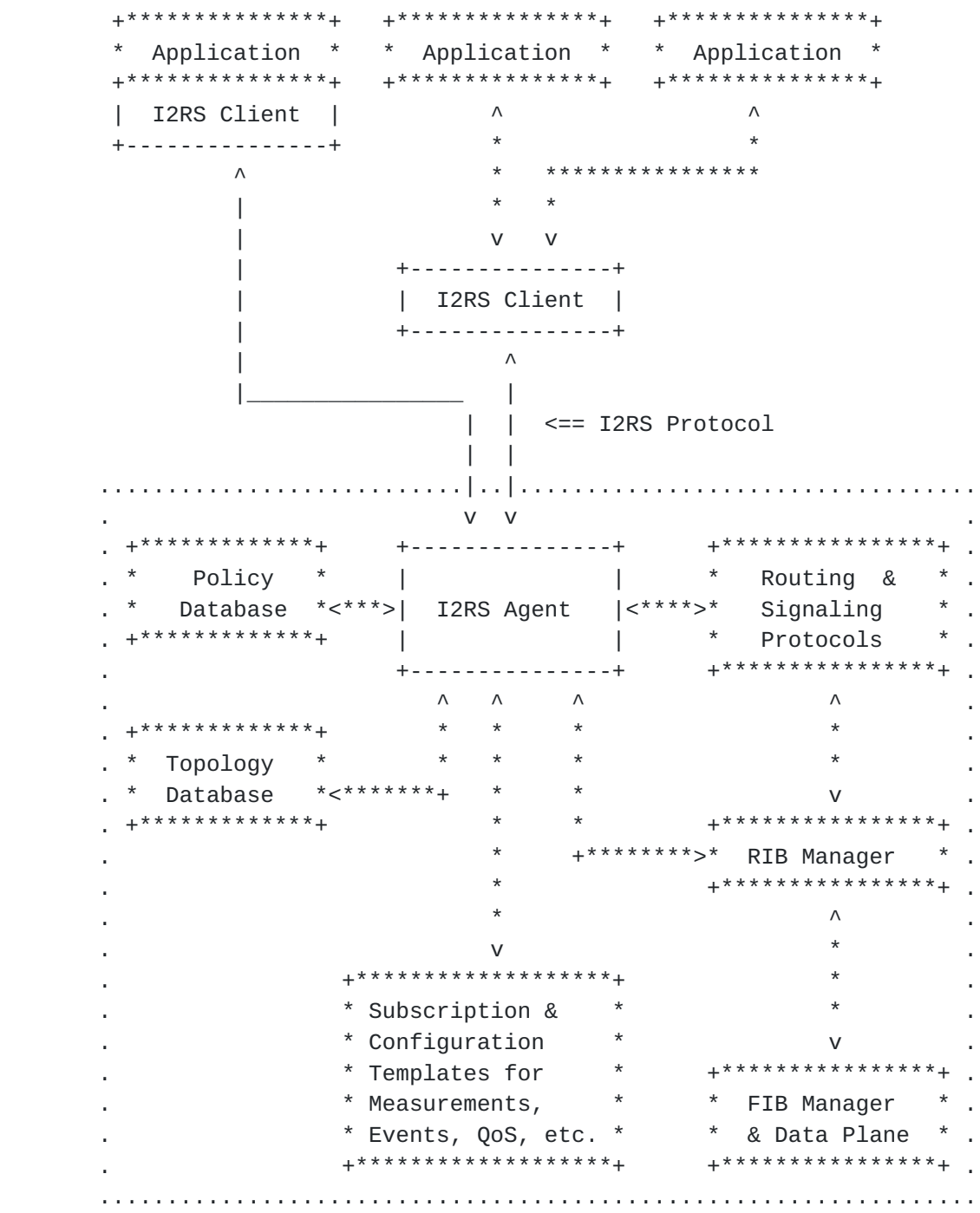
As modern networks grow in scale and complexity, the need for rapid and dynamic control increases. With scale, the need to automate even the simplest operations is important, but even more critical is the ability to quickly interact with more complex operations such as policy-based controls.

With complexity comes the need for more sophisticated automated applications and orchestration software that can process large quantities of data, run complex algorithms, and adjust the routing state as required in order to support the applications, their calculations and their policies. Changes made to the routing state of a network by external applications must be verifiable by those applications to ensure that the correct state has been installed in the right places.

Mechanisms to support the requirements outlined above have been developed piecemeal as proprietary solutions to specific situations and needs. A standard protocol, clearly defined operations that an application can initiate with that protocol, and data-models to support such actions would facilitate wide-scale deployment of interoperable applications and routing systems. That a protocol designed to facilitate rapid, isolated, secure, and dynamic routing changes is needed motivates the creation of an Interface to The Routing System (I2RS).

2. I2RS Model and Problem Area for The IETF

Managing a network of deployed devices running a variety of routing protocols involves interactions among multiple different components that exist within the network. Some of these components are virtual while some are physical; all should be made available to be managed and manipulated by applications, given that appropriate access, authentication, and policy hurdles have been crossed. The management of only some of these components requires standardization, as others have already been standardized. The I2RS model is intended to incorporate existing mechanisms where appropriate, and to build extensions and new protocols where needed. The I2RS model and problem area proposed for IETF work is illustrated in Figure 1. The I2RS Agent is associated with a routing element, which may or may not be co-located with a data-plane. The I2RS Client is used and controlled by a network application; they may be co-located or the I2RS Client might be part of a separate application, such as an orchestrator or controller.



<--> interfaces inside the scope of I2RS
+--+ objects inside the scope of I2RS

<**> interfaces NOT within the scope of I2RS
+**+ objects NOT within the scope of I2RS

.... boundary of a router participating in the I2RS

Figure 1: I2RS model and Problem Area

A critical aspect of I2RS is defining a suitable protocol or protocols to carry messages between the I2RS Clients and the I2RS Agent, and defining the encapsulation of data within those messages. This should provide a clear transfer syntax that is straightforward for applications to use (e.g., a Web Services design paradigm), and should provide the key features specified in Section 5.

The second critical aspect is semantic-aware data-models for information in the routing system and in a topology database. The data-models should be separable across different features of the managed components, versioned, and combine to provide a network data-model.

3. Standard Data-Models of Routing State for Installation

There is a need to be able to precisely control routing and signaling state based upon policy or external measures. This can range from simple static routes to policy-based routing to static multicast replication and routing state. This means that, to usefully model next-hops, the data model employed needs to handle indirection as well as different types of tunneling and encapsulation. The relevant MIB modules (for example [RFC4292]) lack the necessary generality and flexibility. In addition, by having I2RS focus initially on interfaces to the RIB layer (e.g. RIB, LFIB, multicast RIB, policy-based routing), the ability to use routing indirection allows flexibility and functionality that can't be as easily obtained at the forwarding layer.

Efforts to provide this level of control have focused on standardizing data models that describe the forwarding plane (e.g. ForCES [RFC3746]). I2RS posits that the routing system and a router's OS provide useful mechanisms that applications could usefully harness to accomplish application-level goals.

In addition to interfaces to the RIB layer, there is a need to configure the various routing and signaling protocols with differing dynamic state based upon application-level policy decisions. The range desired is not available via MIBs at the present time.

4. Learning Router Information

A router has information that applications may require so that they can understand the network, verify that programmed state is installed in the forwarding plane, measure the behavior of various flows, and

understand the existing configuration and state of the router. I2RS provides a framework for applications to register for asynchronous notifications and for them to make specific requests for information.

Although there are efforts to extend the topological information available, even the best of these (e.g., BGP-LS [I-D.gredler-idr-ls-distribution]) still provides only the current active state as seen at the IGP layer and above. Detailed topological state that provides more information than the current functional status is needed by applications; only the active paths or links are known versus those potentially available or unknown to the routing topology.

For applications to have a feedback loop that includes awareness of the relevant traffic, an application must be able to request the measurement and timely, scalable reporting of data. While a mechanism such as IPFIX [RFC5470] may be the facilitator for delivering the data, the need for an application to be able to dynamically request that measurements be taken and data delivered is critical.

There are a wide range of events that applications could use for either verification of router state before other network state is changed (e.g. that a route has been installed), to act upon changes to relevant routes by others, or upon router events (e.g. link up/down). While a few of these (e.g. link up/down) may be available via MIB Notifications today, the full range is not - nor is there the standardized ability to set up the router to trigger different actions upon an event's occurrence.

5. Desired Aspects of a Protocol for I2RS

This section describes required aspects of a protocol that could support I2RS. Whether such a protocol is built upon extending existing mechanisms or requires a new mechanism requires further investigation.

The key aspects needed in an interface to the routing system are:

Multiple Simultaneous Asynchronous Operations: A single application should be able to send multiple operations to I2RS without needing to wait for each to complete before sending the next.

Very Fine Granularity of Data Locking for Writing: When an I2RS operation is processed, it is required that the data locked for writing is very granular (e.g. a particular prefix and route) rather than extremely coarse, as is done for writing

configuration. This should improve the number of concurrent I2RS operations that are feasible and reduce blocking delays.

Multi-Headed Control: Multiple applications may communicate to the same I2RS agent in a minimally coordinated fashion. It is necessary that the I2RS agent can handle multiple conflicting requests in a well-known policy-based fashion. Data written can be owned by different I2RS clients.

Duplex: Communications can be established by either the router or the application. Similarly, events, acknowledgements, failures, operations, etc. can be sent at any time by both the router and the application. The I2RS is not a pure pull-model where only the application queries to pull responses.

High-Throughput: At a minimum, the I2RS Agent and associated router should be able to handle hundreds of simple operations per second.

Responsive: It should be possible to complete simple operations within a sub-second time-scale.

Multi-Channel: It should be possible for information to be communicated via the interface from different components in the router without requiring going through a single channel. For example, for scaling, some exported data or events may be better sent directly from the forwarding plane, while other interactions may come from the control-plane. Thus a single TCP session would not be a good match.

Temporal State for Installation and Expiration: The ability to have state installed with different lifetimes and different start-times is very valuable. In particular, the ability of an I2RS client to request that a pre-sent operation be started based upon a dynamic event would provide a powerful functionality.

Scalable, Filterable Information Access: To extract information in a scalable fashion that is more easily used by applications, the ability to specify filtering constructs in an operation requesting data or requesting an asynchronous notification is very valuable.

6. Existing Management Interfaces

This section discusses as a single entity the combination of the abstract data models, their representation in a data language, and the transfer protocol commonly used with them. While other combinations are possible, the ways described are those that have significant deployment.

There are three basic ways that routers are managed. The most popular is the command line interface (CLI), which allows both configuration and learning of device state. This is a proprietary interface resembling a UNIX shell that allows for very customized control and observation of a device, and, specifically of interest in this case, its routing system. Some form of this interface exists on almost every device (virtual or otherwise). Processing of information returned to the CLI (called "screen scraping") is a burdensome activity because the data is normally formatted for use by a human operator, and because the layout of the data can vary from device to device, and between different software versions. Despite its ubiquity, this interface has never been standardized and is unlikely to ever be standardized. I2RS does not involve CLI standardization.

The second most popular interface for interrogation of a device's state, statistics, and configuration is The Simple Network Management Protocol (SNMP) and a set of relevant standards-based and proprietary Management Information Base (MIB) modules. SNMP has a strong history of being used by network managers to gather statistical and state information about devices, including their routing systems. However, SNMP is very rarely used to configure a device or any of its systems for reasons that vary depending upon the network operator. Some example reasons include complexity, the lack of desired configuration semantics (e.g., configuration "roll-back", "sandboxing" or configuration versioning), and the difficulty of using the semantics (or lack thereof) as defined in the MIB modules to configure device features. Therefore, SNMP is not considered as a candidate solution for the problems motivating I2RS.

Finally, the IETF's Network Configuration (or NetConf) protocol has made many strides at overcoming most of the limitations around configuration that were just described. However, the lack of standard data models have hampered the adoption of NetConf. Naturally, I2RS may help define needed information and data models. Additional extensions to handle multi-headed control and time-based state installation and expiration may need to be added to NetConf and/or appropriate data models.

7. Acknowledgements

The authors would like to thank Ken Gray for his suggestions and review.

8. IANA Considerations

This document includes no request to IANA.

9. Security Considerations

Security is a key aspect of any protocol that allows state installation and extracting of detailed router state. More investigation remains to fully define the security requirements, such as authorization and authentication levels.

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