Internet Engineering Task Force (IETF)
Request for Comments: 6909
Category: Standards Track
ISSN: 2070-1721

S. Gundavelli, Ed.
Cisco
X. Zhou
ZTE Corporation
J. Korhonen
Renesas Mobile
G. Feige
R. Koodli
Cisco

April 2013

IPv4 Traffic Offload Selector Option for Proxy Mobile IPv6

Abstract

This specification defines a new mobility option, the IPv4 Traffic Offload Selector option, for Proxy Mobile IPv6. This option can be used by the local mobility anchor and the mobile access gateway for negotiating IPv4 traffic offload policy for a mobility session. Based on the negotiated IPv4 traffic offload policy, a mobile access gateway can selectively offload some of the IPv4 traffic flows in the access network instead of tunneling back to the local mobility anchor in the home network.

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/rfc6909.

Copyright Notice

Table of Contents

1. Introduction

Mobile operators are expanding their network coverage by integrating various access technology domains (e.g., Wireless LAN, CDMA, and Long-Term Evolution (LTE)) into a common IP mobility core. The Third Generation Partnership Project (3GPP) S2a Proxy Mobile IPv6 [TS23402] reference point, specified by the 3GPP system architecture, defines the protocol interworking for building such integrated multi-access networks. In this scenario, the mobile node's IP traffic is always tunneled back from the mobile access gateway [RFC5213] in the access network to the local mobility anchor in the home network. Currently, there is no mechanism for allowing some of the subscriber's IP flows to be offloaded in the access network.

With the exponential growth in mobile data traffic, mobile operators are exploring new ways to offload some of the IP traffic flows at the nearest access edge. The offload is intended either for local service access in the access network or for Internet offload through the access network when there is an Internet peering point. Not all IP traffic flows need to be routed back to the home network; the traffic that does not require IP mobility support can be offloaded at the mobile access gateway in the access network. This approach allows efficient usage of the mobile packet core, which helps in lowering transport costs. To identify the IP flows that need to be offloaded, the local mobility anchor in the home network can deliver the IP flow policy to the mobile access gateway in the access network. It is up to an operator’s discretion to classify the traffic for offload. One operator might choose to offload everything except traffic (such as Voice over IP) that requires QoS services. Another might choose to offload only HTTP traffic. This specification is only concerned with matching IP traffic against a given flow selector and classification of IP traffic for offloading purposes. This approach has one limitation with respect to identifying encrypted traffic: IPsec-encrypted traffic with no visibility into the application payload cannot be selected for offload.

This document defines a new mobility option, the IPv4 Traffic Offload Selector option (see Section 3.1), for Proxy Mobile IPv6 (PMIPv6). This option can be used by the local mobility anchor and the mobile access gateway for negotiating IPv4 traffic offload policy for a mobility session. This IPv4 traffic offload policy identifies the flow selectors that can be used for selecting the flows that can be offloaded at the access edge. Since the mobile node’s IP address topologically belongs to the home network, the offloaded IPv4 traffic flows may need to be NAT [RFC2663] translated. These offloaded flows will not have mobility support as the NAT becomes the anchor point for those flows. However, when the traffic is offloaded for local service access as opposed to Internet offload, NAT translation may not be needed if the mobile access gateway is in the path for the return traffic. The decision on when to apply NAT translation can be based on local configuration on the mobile access gateway. There are better ways to address the offload problem for IPv6, and with the goal not to create a NAT66 requirement, this specification therefore does not address traffic offload support for IPv6 flows.

2. Conventions and Terminology

2.1. Conventions

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 RFC 2119 [RFC2119].

2.2. Terminology

All the mobility-related terms used in this document are to be interpreted as defined in the base Proxy Mobile IPv6 specifications [RFC5213] [RFC5844]. Additionally, this document uses the following terms:

IP Flow

> IP flow [RFC5101] represents a set of IP packets that match a traffic selector (TS). The selector is typically based on the source IP address, destination IP address, source port, destination port, and other fields in upper-layer headers.

IP Traffic Offload

> IP traffic offload is the approach of selecting specific IP flows and routing them through the access network instead of tunneling them to the home network. Offload can also be between two access networks (e.g., moving some of the traffic from LTE access to WLAN access).

3. Solution Overview

Figure 1 illustrates the scenario where the mobile access gateway in an access network has enabled IPv4 traffic offload support for a mobility session. The offload decision is based on the IPv4 traffic offload policy that it negotiated with the local mobility anchor in the home network. For example, all the HTTP flows may be offloaded at the mobile access gateway, and all the other flows for that mobility session are tunneled back to the local mobility anchor. The offloaded flows typically have to be NAT translated, and this specification does not impose any restrictions on the location of the NAT function. It is possible for the NAT function to be co-located with the mobile access gateway or located somewhere at the edge of the access network. When the NAT function is not co-located with the mobile access gateway, offloaded traffic flows must be delivered through the local access network between the mobile access gateway and the NAT function, for example, through a VLAN or a point-to-point link. The exact means for this delivery are outside the scope of this document. If the offloaded IPv4 flows are for local service access and reverse traffic from the local service device can be routed to the mobile node through the mobile access gateway, the offloaded flows may be delivered directly to a local service device.

The traffic selectors in the IPv4 traffic offload policy are used to classify the traffic, so it can be offloaded at the access network. These parameters include source IP address, destination IP address, TCP/UDP port numbers, and other fields. The format of the IPv4 binary traffic selector is specified in Section 3.1 of [RFC6088].

```
                                      _----_
                                    _(      )_
                 :-----------------( Internet )---------------:
                 |                  (_      _)                |
                 |                    '----'                  |
                 |                                            |
                 :                                            |
      (IPv4 Traffic Offload Point)                            |
                 :                                            |
                 |                                            |
      ........................................................|....
                 |                              |             |
      +--------+ |                   +---------------------+  |
      |  Local | |                   | Services requiring  |  |
      |Services| |                   | mobility, or service|  |
      +--------+ |                   | treatment           |  |
           |     |                   +---------------------+  |
           |   +---+                            |             |
           |   |NAT|                            |             |
           |   +---+                            |             |
           +-----|            _----_            |             |
              +-----+       _(      )_       +-----+          |
      [MN]----| MAG |======(    IP    )======| LMA |----------
              +-----+       (_      _)       +-----+  Internet
                              '----'
                                 .
                                 .
          [Access Network]       .        [Home Network]
      ..........................................................
```

Figure 1: IPv4 Traffic Offload Support at the MAG

Figure 2 explains the operational sequence of the Proxy Mobile IPv6 protocol signaling message exchange between the mobile access gateway (MAG) and the local mobility anchor (LMA) for negotiating the IPv4 traffic offload selectors. The details related to DHCP transactions or Router Advertisements on the access link are not shown here as that is not the key focus of this specification. The use of IPv4 Traffic Selector option in the Proxy Binding Update is for allowing the MAG to request the LMA for the IPv4 traffic offload policy.

```
      MN    MAG(NAT)   LMA
      |------>|        |    1.  Mobile Node Attach
      |       |------->|    2.  Proxy Binding Update (IPv4TS)
      |       |<-------|    3.  Proxy Binding Acknowledgement (IPv4TS)
      |       |========|    4.  Tunnel/Route Setup
      |       +        |    5.  Installing the traffic offload rules
      |------>|        |    6.  IPv4 packet from mobile node
      |       +        |    7.  Offload rule applied (Tunnel/offload)
      |       |        |
```

Figure 2: Exchange of IPv4 Traffic Offload Selectors

3.1. IPv4 Traffic Offload Selector Option

A new mobility option, the IPv4 Traffic Offload Selector option (53), is defined for use in Proxy Binding Update (PBU) and Proxy Binding Acknowledgement (PBA) messages exchanged between a mobile access gateway and a local mobility anchor. This option is used for carrying the IPv4 traffic offload policy. This policy identifies the IPv4 traffic flow selectors that can be used by the mobile access gateway for enforcing the offload policy.

The alignment requirement for this option is 4n.

```
   0                   1                   2                   3
   0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
                                   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                                   |      Type     |   Length      |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |M|                         Reserved                            |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                  Traffic Selector Sub-option   ...
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 3: IPv4 Traffic Offload Selector Option

Type
   53

Length
   8-bit unsigned integer indicating the length in octets of the option, excluding the type and length fields.

Offload Mode (M) Flag

This field indicates the offload mode.

If the (M) flag value is set to a value of (0), it is an indication that the IPv4 flow(s) that match the traffic selectors in the Traffic Selector sub-option [RFC6089] and that are associated to that mobility session have to be offloaded at the mobile access gateway. All the other IPv4 flows associated with that mobility session and not matching the traffic selectors have to be tunneled to the local mobility anchor.

If the (M) flag value is set to a value of (1), it is an indication that all the IPv4 flows associated to that mobility session except the IPv4 flow(s) matching the traffic selectors in the Traffic Selector sub-option have to be offloaded at the mobile access gateway. All the IPv4 flows associated with that mobility session and matching the traffic selectors have to be tunneled back to the local mobility anchor.

Reserved

This field is unused for now. The value MUST be initialized to 0 by the sender and MUST be ignored by the receiver.

Traffic Selector Sub-option

The Traffic Selector sub-option includes the parameters used to match packets for a specific flow binding. This is an optional sub-option when the IPv4 Traffic Selector option is carried in a Proxy Binding Update message but is a mandatory sub-option when the IPv4 Traffic Selector option is carried in a Proxy Binding Acknowledgement message. The format of the Traffic Selector sub-option is defined in Section 4.2.1.4 of [RFC6089]. This sub-option includes a TS Format field, which identifies the format of the flow specification included in that sub-option. The values for that field are defined in Section 3 of [RFC6088] and are repeated here for completeness. When the value of the TS Format field is set to (1), the format that follows is the IPv4 binary traffic selector specified in Section 3.1 of [RFC6088], and that support is mandatory for this specification. The text specified in this section takes precedence over what is specified in [RFC6088] and [RFC6089].

1: IPv4 binary traffic selector

2: IPv6 binary traffic selector (not used by this specification)

3.2. MAG Considerations

- If the mobile access gateway is configured to enable IPv4 traffic offload support, then it includes the IPv4 Traffic Offload Selector option (Section 3.1) in the Proxy Binding Update message that it sends to the local mobility anchor. Optionally, the mobile access gateway can also propose a specific offload policy.

  * The mobile access gateway MAY choose not to propose any specific IPv4 traffic offload policy but request the local mobility anchor for the offload policy. In this scenario, the IPv4 Traffic Offload Selector option that is carried in the Proxy Binding Update message does not include the Traffic Selector sub-option (see Section 3.1), and the (M) flag (see Section 3.1) in the option MUST be set to a value of (0). Including the IPv4 Traffic Offload Selector option in the Proxy Binding Update without the Traffic Selector sub-option serves as an indication that the mobile access gateway is not proposing any specific offload policy for that mobility session, but rather it makes a request to the local mobility anchor to provide the offload policy.

  * The mobile access gateway MAY choose to propose a specific IPv4 traffic offload policy by including the Traffic Selector sub-option in the IPv4 Traffic Offload Selector option (see Section 3.1). The specific details on how the mobile access gateway obtains the mobile node’s IPv4 traffic offload policy are outside the scope of this document. When this offload policy is included in the Proxy Binding Update message, it serves as a proposal to the local mobility anchor. The local mobility anchor can override with its own offload policy, or it can agree to the proposed policy. The offload policy has to be translated to a set of selectors that can be used to match the mobile node’s IP flows, and these selectors have to be carried in the Traffic Selector sub-option. The Traffic Selector sub-option MUST be constructed as specified in Section 4.2.1.4 of [RFC6089]. This sub-option includes a TS Format field, which identifies the format of the flow specification included in the sub-option. The values for that field and the corresponding message format are defined in Section 3.1 of [RFC6088]. Considerations from Section 3.1 apply with respect to setting the Offload Mode (M) flag.

- When sending a Proxy Binding Update either for Binding Lifetime Extension or for Binding De-Registration, the mobile access gateway SHOULD copy the IPv4 Traffic Offload Selector option from the initial Proxy Binding Update message. Considerations from Sections 6.9.1.3 and 6.9.1.4 of [RFC5213] MUST be applied.

- If the mobile access gateway is not configured to support IPv4 traffic offload support as specified in this specification, but if the received Proxy Binding Acknowledgement message has the IPv4 Traffic Offload Selector option, then the mobile access gateway MUST ignore the option and process the rest of the message as per [RFC5213].

- If there is no IPv4 Traffic Offload Selector option in the Proxy Binding Acknowledgement message received from the local mobility anchor, it is an indication that the local mobility anchor did not enable IPv4 traffic offload support for that mobility session. Upon accepting the Proxy Binding Acknowledgement message, the mobile access gateway SHOULD NOT enable IPv4 traffic offload support for that mobility session.

- If there is an IPv4 Traffic Offload Selector option in the Proxy Binding Acknowledgement message, then the mobile access gateway SHOULD enable IPv4 traffic offload support for that mobility session. The mobility access gateway has to provision the data plane using the flow selectors present in the Traffic Selector sub-option. The IPv4 flows matching the flow selectors have to be offloaded or tunneled back based to the local mobility anchor based on the value of the Offload Mode (M) flag (see Section 3.1).

3.3. LMA Considerations

- If the received Proxy Binding Update message does not include the IPv4 Traffic Offload Selector option (Section 3.1), then the local mobility anchor MUST NOT enable IPv4 traffic offload support for that mobility session, and the Proxy Binding Acknowledgement message that will be sent in response MUST NOT contain the IPv4 Traffic Offload Selector option.

- If the Proxy Binding Update message includes the IPv4 Traffic Offload Selector option, but the local mobility anchor is not configured to support IPv4 traffic offload support, then the local mobility anchor will ignore the option and process the rest of the message as per [RFC5213]. This would have no effect on the operation of the rest of the protocol.

- If the Proxy Binding Update message has the IPv4 Traffic Offload Selector option and if the local mobility anchor is configured to support IPv4 traffic offload support, then the local mobility anchor MUST enable IPv4 traffic offload support for that mobility session. The Proxy Binding Acknowledgement message that will be sent in response MUST include the IPv4 Traffic Offload Selector option. The following considerations apply with respect to constructing the IPv4 Traffic Offload Selector option.

* The local mobility anchor can obtain the offload policy from the local configuration store or from a network function such as AAA (Authentication, Authorization, and Accounting) or PCRF (Policy and Charging Rule Function). The offload policy has to be translated to a set of selectors that can be used to match the mobile node's IP flows, and these selectors have to be carried in the Traffic Selector sub-option. The Traffic Selector sub-option MUST be constructed as specified in Section 4.2.1.4 of [RFC6089]. Considerations from Section 3.1 apply with respect to the Offload Mode (M) flag setting.

* If the Proxy Binding Update message includes a specific IPv4 traffic offload policy proposal in the form of the Traffic Selector sub-option [RFC6089], then the local mobility anchor MAY choose to agree to that request by including the same IPv4 traffic offload policy in the Proxy Binding Acknowledgement message. This implies the local mobility anchor has agreed to the IPv4 traffic offload policy provided by the mobile access gateway. The local mobility anchor MAY also choose to override the request by including a different IPv4 traffic offload policy that it wants the mobile access gateway to enforce for that mobility session. This is entirely based on the policy configuration on the local mobility anchor.

* The IPv4 traffic offload policy that is sent to the mobile access gateway has to be specific to the mobility session identified using the Mobile Node Identifier option [RFC5213]. The offload policy MUST be specific to a mobile node's application traffic. The traffic selectors have to match only the mobile node's application traffic and MUST NOT match any other mobile node's IP traffic. Furthermore, control-plane traffic such as DHCP, Neighbor Discovery (ND), or any other IP traffic that is used for IP address configuration, mobility management, or other control-plane functions MUST NOT be subject to offload.

* The local mobility anchor MUST NOT make any changes to the mobile node's offload policy during the middle of a mobility session, as long as the mobile node continues to attach to the mobile access gateway that negotiated the offload policy. However, when the mobile node performs an inter-MAG handover, the new mobile access gateway may not be capable of supporting IP Traffic offload and in this scenario, the offload policy may change. Therefore, the IPv4 Traffic Selector option with the Traffic Selector sub-option that is delivered during the initial mobility signaling MUST be the same as the one that is delivered as part of the mobility signaling related to lifetime extension from the same mobile access gateway.

4. Protocol Configuration Variables

This specification defines the following configuration variable that controls the IPv4 traffic offload support feature. This configuration variable is internal to the system and has no bearing on interoperability across different implementations.

The mobility entities, local mobility anchor, and the mobile access gateway have to allow these variables to be configured by the system management. The configured values for these protocol variables have to survive server reboots and service restarts.

EnableIPv4TrafficOffloadSupport

This flag indicates whether or not IPv4 traffic offload support needs to be enabled. This configuration variable is available at both the mobile access gateway and the local mobility anchor. The default value for this flag is set to (0), indicating that IPv4 traffic offload support is disabled.

When this flag on the mobile access gateway is set to a value of (1), the mobile access gateway has to enable IPv4 traffic offload support for all mobility sessions, by specifically requesting the IPv4 traffic offload policy from the local mobility anchor by including the IPv4 Traffic Offload Selector option in the Proxy Binding Update message. If the flag is set to a value of (0), the mobile access gateway has to disable IPv4 traffic offload support for all mobility sessions.

Similarly, when this flag on the local mobility anchor is set to a value of (1), the local mobility anchor has to enable IPv4 traffic offload support. If the local mobility anchor chooses to enable IPv4 traffic offload support when there is an offload policy specified for a mobile node, it has to deliver the IPv4 traffic offload policy to the mobile access gateway by including the IPv4 Traffic Offload Selector option in the Proxy Binding Acknowledgement message.

5. IANA Considerations

Per this specification, IANA has assigned a new mobility option: the IPv4 Traffic Offload Selector option (53). This option is described in Section 3.1. The Type value for this option has been assigned from the same numbering space as allocated for the other mobility options [RFC6275].

6. Security Considerations

The IPv4 Traffic Offload Selector option defined in this specification is for use in Proxy Binding Update and Proxy Binding Acknowledgement messages. This option is carried like any other mobility header option as specified in [RFC5213]. Therefore, it inherits from [RFC5213] its security guidelines and does not require any additional security considerations. Carrying IPv4 traffic offload selectors does not introduce any new security vulnerabilities.

When IPv4 traffic offload support is enabled for a mobile node, the mobile access gateway selectively offloads some of the mobile node’s IPv4 traffic flows to the access network. Typically, these offloaded flows get NAT translated, which essentially introduces certain vulnerabilities that are common to any NAT deployment. These vulnerabilities and the related considerations have been well documented in the NAT specification [RFC2663]. There are no additional considerations above and beyond what has already been documented by the NAT specifications and that are unique to the approach specified in this document.

The mobile node’s home network may be equipped with firewall and other security devices to guard against any security threats. When IPv4 traffic offload support is enabled, it potentially exposes the mobile node to some security risks in the access network. This threat can be mitigated by deploying the security features both in the access network and in the home network.

When IPv4 traffic offload support is enabled for a mobile node, some of the IP flows are sent through the home network, and some other IP flows are routed through the access network. This potentially introduces some complexity with respect to enabling diagnostics or monitoring on the user traffic. The tools that are used for such diagnostics have to be aware of the offload policy that in enabled in the network.

7. Acknowledgements

The authors would like to thank Ahmad Muhanna, Basavaraj Patil, Carlos Bernardos, Eric Voit, Frank Brockners, Hidetoshi Yokota, Marco Liebsch, Mark Grayson, Pierrick Seite, Ryuji Wakikawa, Steve Wood, Barry Leiba, Sean Turner, Pete Resnick, Wesley Eddy, Mary Barnes, Vincent Roca, Ralph Droms, Scott Bradner, Stephen Farrell, Adrian Farrel, Benoit Claise, and Brian Haberman for all the reviews and discussions related to the topic of IPv4 traffic offload.

8. References

8.1. Normative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997.

[RFC5213] Gundavelli, S., Leung, K., Devarapalli, V., Chowdhury, K., and B. Patil, "Proxy Mobile IPv6", RFC 5213, August 2008.

[RFC5844] Wakikawa, R. and S. Gundavelli, "IPv4 Support for Proxy Mobile IPv6", RFC 5844, May 2010.

[RFC6088] Tsirtsis, G., Giarreta, G., Soliman, H., and N. Montavont, "Traffic Selectors for Flow Bindings", RFC 6088, January 2011.

[RFC6089] Tsirtsis, G., Soliman, H., Montavont, N., Giaretta, G., and K. Kuladinithi, "Flow Bindings in Mobile IPv6 and Network Mobility (NEMO) Basic Support", RFC 6089, January 2011.

[RFC6275] Perkins, C., Johnson, D., and J. Arkko, "Mobility Support in IPv6", RFC 6275, July 2011.

8.2. Informative References

[RFC2663] Srisuresh, P. and M. Holdrege, "IP Network Address Translator (NAT) Terminology and Considerations", RFC 2663, August 1999.

[RFC5101] Claise, B., "Specification of the IP Flow Information Export (IPFIX) Protocol for the Exchange of IP Traffic Flow Information", RFC 5101, January 2008.

[TS23402] 3GPP, "Architecture enhancements for non-3GPP accesses", 2010.

Authors' Addresses

Sri Gundavelli (editor)
Cisco
170 West Tasman Drive
San Jose, CA 95134
USA

EMail: sgundave@cisco.com

Xingyue Zhou
ZTE Corporation
No.68 Zijinghua Rd
Nanjing
China

EMail: zhou.xingyue@zte.com.cn

Jouni Korhonen
Renesas Mobile
Porkkalankatu 24
Helsinki FIN-00180
Finland

EMail: jouni.nospam@gmail.com

Gaetan Feige
Cisco
France

EMail: gfeige@cisco.com

Rajeev Koodli
Cisco
3650 Cisco Way
San Jose, CA 95134
USA

EMail: rkoodli@cisco.com