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Essential correction for IPv6 ABNF and URI comparison in RFC3261
DOCNAME

Abstract

This document corrects the Augmented Backus-Naur Form (ABNF) production rule associated with generating IPv6 literals in RFC3261. It also clarifies the rule for Uniform Resource Identifier (URI) comparison when the URIs contain textual representation of IP addresses.

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1. Terminology

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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 (Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels," March 1997.) [2].

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2. Problem statement

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2.1. Extra colon in IPv4-mapped IPv6 address

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The ABNF [4] (Crocker, D. and P. Overell, "Augmented BNF for Syntax Specifications: ABNF," January 2008.) for generating IPv6 literals in RFC3261 [1] (Rosenberg, J., Schulzrinne, H., Camarillo, G., Johnston,

A., Peterson, J., Sparks, R., Handley, M., and E. Schooler, "SIP: Session Initiation Protocol," June 2002.) is incorrect. When generating IPv4-mapped IPv6 addresses, the production rule may actually generate the following construct:
[2001:db8:::192.0.2.1] - Note the extra colon before the IPv4 address. The correct construct, of course, would only include two colons before the IPv4 address.

> Historically, the ABNF pertaining to IPv6 references in RFC3261 was derived from Appendix B of RFC 2373 [7] (Hinden, R. and S. Deering, "IP Version 6 Addressing Architecture," July 1998.), which was flawed to begin with (see also RFC2373 errata at http://www.rfc-editor.org/cgi-bin/errataSearch.pl?rfc=2373.) RFC2373 has been subsequently obsoleted by RFC 4291 [6] (Hinden, R. and S. Deering, "IP Version 6 Addressing Architecture," February 2006.).

The ABNF for IPv6 reference is reproduced from RFC3261 below:

```
IPv6reference  =  "[" IPv6address "]"
IPv6address    =  hexpart [ ":" IPv4address ]
IPv4address    =  1*3DIGIT "." 1*3DIGIT "." 1*3DIGIT "." 1*3DIGIT
hexpart        =  hexseq / hexseq "::" [ hexseq ] / "::" [ hexseq ]
hexseq         =  hex4 *( ":" hex4)
hex4           =  1*4HEXDIG
```

Note that the ambiguity occurs in the <IPv6address> production rule where the <IPv4address> non-terminal is prefixed by the ":" token. Because the <hexpart> production rule is defined such that two of its alternatives already include the "::" token, this may yield to the faulty construction of an IPv6-mapped IPv4 address with an extra colon when expanding those alternatives.

2.2. Comparing URIs with textual representation of IP addresses

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In SIP, URIs are compared for a variety of reasons. Registrars compare URIs when they receive a binding update request, for instance. Section 19.1.4 of RFC3261 [1] (Rosenberg, J., Schulzrinne, H., Camarillo, G., Johnston, A., Peterson, J., Sparks, R., Handley, M., and E. Schooler, "SIP: Session Initiation Protocol," June 2002.) provides the rules for comparing URIs. Among other rules, it states that:

> For two URIs to be equal, the user, password, host, and port components must match.

Does the above rule then imply that the following URIs are equal:

> sip:bob@[::ffff:192.0.2.128] = sip:bob@[::ffff:c000:280]?
>
> sip:bob@[2001:db8::9:1] = sip:bob@[2001:db8::9:01]?
>
> sip:bob@[0:0:0:0:0:FFFF:129.144.52.38] = sip:bob@[::FFFF:
> 129.144.52.38]?

In all of the above examples, the textual representation of the IPv6 address is different, but these addresses are binary equivalent (implementers are also urged to consult Section 4 (Generating a Canonical IPv6 Textual Representation) of this document for recommendations on IPv6 address text representations.) Section 19.1.4 of RFC3261 does not provide any rule for URIs containing different textual representations of IPv6 addresses that all correspond to the same binary equivalent.

> Note that the same ambiguity occurs for IPv4 addresses, i.e., is 192.0.2.128 = 192.00.02.128? However, IPv6, with its compressed notation and the need to represent hybrid addresses (like IPv4-mapped IPv6 addresses) makes the representation issue more acute. The resolution discussed in Section 3.2 (Clarification for comparison of URIs with textual representation of IP addresses) applies to textual representations of both IPv6 and IPv4 addresses.

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3. Resolution

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3.1. Resolution for extra colon in IPv4-mapped IPv6 address

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The resolution to this ambiguity is simply to use the correct ABNF for the <IPv6address> production rule from Appendix A of RFC3986 [3] (Berners-Lee, T., Fielding, R., and L. Masinter, “Uniform Resource Identifier (URI): Generic Syntax,” January 2005.). For the sake of completeness, it is reproduced below:

```
IPv6address   =                            6( h16 ":" ) ls32
               /                       "::" 5( h16 ":" ) ls32
               / [               h16 ] "::" 4( h16 ":" ) ls32
               / [ *1( h16 ":" ) h16 ] "::" 3( h16 ":" ) ls32
               / [ *2( h16 ":" ) h16 ] "::" 2( h16 ":" ) ls32
               / [ *3( h16 ":" ) h16 ] "::"    h16 ":"   ls32
               / [ *4( h16 ":" ) h16 ] "::"              ls32
               / [ *5( h16 ":" ) h16 ] "::"              h16
               / [ *6( h16 ":" ) h16 ] "::"

 h16           = 1*4HEXDIG
 ls32          = ( h16 ":" h16 ) / IPv4address
 IPv4address   = dec-octet "." dec-octet "." dec-octet "." dec-octet
 dec-octet     = DIGIT                 ; 0-9
               / %x31-39 DIGIT         ; 10-99
               / "1" 2DIGIT            ; 100-199
               / "2" %x30-34 DIGIT     ; 200-249
               / "25" %x30-35          ; 250-255
```

Accordingly, this document updates RFC3261 as follows: the <IPv6address> and <IPv4address> production rules MUST be deleted from RFC3261 and MUST be replaced with the production rules of the same name in RFC3986 (and reproduced above.) These changes, when made to RFC3261, will make <hexpart>, <hexseq>, and <hex4> production rules obsolete. Thus this document also mandates that the <hexpart>, <hexseq>, and <hex4> production rules MUST be deleted from the ABNF of RFC3261.

3.2. Clarification for comparison of URIs with textual representation of IP addresses

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The resolution to this ambiguity is a simple clarification acknowledging that the textual representation of an IP addresses varies, but it is the binary equivalence of the IP address that must be taken into consideration when comparing two URIs that contain varying textual representations of an IP address.
Accordingly, the existing rule from the bulleted list in Section 19.1.4 of RFC3261 MUST be modified as follows:
OLD:

> *For two URIs to be equal, the user, password, host, and port components must match.

NEW:

> *For two URIs to be equal, the user, password, host, and port components must match. If the host component contains a textual representation of IP addresses, then the representation of those IP addresses may vary. If so, the host components are considered to match if the different textual representations yield the same binary IP address.

In addition, the text in the following paragraph MUST be added to the existing list of examples in Section 19.1.4 of RFC3261 in order to demonstrate the intent of the modified rule:
The following URIs are equivalent because the underlying binary representation of the IP addresses are the same although their textual representations vary:

```
sip:bob@[::ffff:192.0.2.128]
sip:bob@[::ffff:c000:280]

sip:bob@[2001:db8::9:1]
sip:bob@[2001:db8::9:01]

sip:bob@[0:0:0:0:0:FFFF:129.144.52.38]
sip:bob@[::FFFF:129.144.52.38]
```

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4. Generating a Canonical IPv6 Textual Representation

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Implementers SHOULD generate IPv6 text representation as defined in [5] (Kawamura, S. and M. Kawashima, “A Recommendation for IPv6 Address Text Representation,” February 2010.).

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5. Security Considerations

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This document does not introduce any new security considerations.

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6. IANA Considerations

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This document does not include any IANA considerations.

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7. Acknowledgments

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The ABNF for IPv6 was developed by Roy T. Fielding and Andrew Main and published in RFC3986.
Jeroen van Bemmel, Peter Blatherwick, Gonzalo Camarillo, Paul Kyzivat, Jonathan Rosenberg, Michael Thomas, and Dale Worley provided invaluable discussion points on the SIP WG mailing list on the URI equivalency problem. Alfred Hoenes urged the use of angle brackets (as specified in Section 2.1 of [4] (Crocker, D. and P. Overell, "Augmented BNF for Syntax Specifications: ABNF," January 2008.)) to denote productions.

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8.1. Normative References

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[1]	Rosenberg, J., Schulzrinne, H., Camarillo, G., Johnston, A., Peterson, J., Sparks, R., Handley, M., and E. Schooler, "SIP: Session Initiation Protocol," RFC 3261, June 2002 (TXT).
[2]	Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels," BCP 14, RFC 2119, March 1997 (TXT, HTML, XML).
[3]	Berners-Lee, T., Fielding, R., and L. Masinter, "Uniform Resource Identifier (URI): Generic Syntax," STD 66, RFC 3986, January 2005 (TXT, HTML, XML).
[4]	Crocker, D. and P. Overell, "Augmented BNF for Syntax Specifications: ABNF," STD 68, RFC 5234, January 2008 (TXT).
[5]	Kawamura, S. and M. Kawashima, "A Recommendation for IPv6 Address Text Representation," draft-ietf-6man-text-addr-representation-07 (work in progress), February 2010 (TXT).

8.2. Informative References

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[6]	Hinden, R. and S. Deering, "IP Version 6 Addressing Architecture," RFC 4291, February 2006 (TXT).
[7]	Hinden, R. and S. Deering, "IP Version 6 Addressing Architecture," RFC 2373, July 1998 (TXT, HTML, XML).

Authors' Addresses

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	Vijay K. Gurbani (editor)

	Bell Laboratories, Alcatel-Lucent
	1960 Lucent Lane
	Room 9C-533
	Naperville, IL 60563
	USA
Phone:	+1 630 224-0216
Email:	vkg@bell-labs.com
	Brian E. Carpenter (editor)
	Department of Computer Science
	University of Auckland
	PB 92019
	Auckland, 1142
	New Zealand
Email:	brian.e.carpenter@gmail.com
	Brett Tate (editor)
	BroadSoft
Email:	brett@broadsoft.com