MMUSIC
Internet-Draft
Intended status: Standards Track
Expires: January 7, 2008

J. Lennox
Layered Media
J. Ott
Helsinki University of Technology
T. Schierl
Fraunhofer HHI

July 6, 2007

Source-Specific Media Attributes in the Session Description Protocol (SDP)

draft-lennox-mmusic-sdp-source-attributes-01

Status of this Memo

Copyright Notice

Abstract

The Session Description Protocol provides mechanisms to describe attributes of multimedia sessions and of individual media streams (e.g., Real-time Transport Protocol (RTP) sessions) within a multimedia session, but does not provide any mechanism to describe

individual media sources within a media stream. This document defines a mechanism to describe RTP media sources, identified by their Synchronization Source Identifiers (SSRCs), in SDP, associate attributes with these sources, and express relationships among sources. It also defines several source-level attributes which can be used to describe properties of media sources.

Table of Contents

1. Introduction

The Session Description Protocol (SDP) [RFC4566] provides mechanisms to describe attributes of multimedia sessions and of media streams (e.g., Real-time Transport Protocol (RTP) [RFC3550] sessions) within a multimedia session, but does not provide any mechanism to describe individual media sources within a media stream.

Several recently-proposed protocols, notably RTP Single-Source Multicast [I-D.ietf-avt-rtcpssm] have found it useful to describe specific media sources in SDP messages. Single-source multicast, in particular, needs to ensure that receivers' RTP Syncronization Source Identifiers (SSRCs) do not collide with those of media senders, as the RTP specification [RFC3550] requires that colliding sources change their SSRC values after a collision has been detected. Earlier work has used mechanisms specific to each protocol to describe the individual sources of an RTP session.

Moreover, whereas the Real-Time Transport Protocol (RTP) [RFC3550] is defined as allowing multiple sources in an RTP session (for example, if a user has more than one camera), SDP has no existing mechanism for an endpoint to indicate that it will be using multiple sources, or to describe their characteristics individually.

To address all these problems, this document defines a mechanism to describe RTP sources, identified by their Synchronization Sources Identifiers (SSRCs), in SDP, associate attributes with these sources, and express relationships among individual sources. It also defines a number of new SDP attributes that apply to individual sources ("source-level" attributes); describes how a number of existing media stream ("media-level") attributes can also be applied at the source level; and establishes an IANA repository for source-level attributes.

During the still-ongoing discussion in the AVT and MMUSIC working groups on the transport [I-D.ietf-avt-rtp-svc] and signaling [I-D.schierl-mmusic-layered-codec] of the Scalable Video Coding (SVC) Extensions of H.264, SSRC multiplexing of layered video was considered as an appropriate multiplexing technique, if the use case strongly requires this. It was considered that a compelling use case exists for identifying RTP packet streams carrying different layers of a single SVC media stream. One use case was pointed out, which is the adaptation of an SRTP encrypted SVC stream by a middle-box not being in the security context. Since the authentication and integrity mechanism of SRTP still requires the middle-boy being in the security context, the authors of [I-D.ietf-avt-rtp-svc] and [I-D.schierl-mmusic-layered-codec] currently do not consider SSRC multiplexing. Since the process for both memos is still going on,

however, a requirement for SSRC multiplexing for SVC may come up again. SSRC multiplexing would anyway make an easy identification of layers of a scalable media stream in a middle-box possible, without the need of parsing into RTP payload headers. A potential use case is shown in Section 7, the examples section.

2. Terminology

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] and indicate requirement levels for compliant implementations.

3. Overview

In the Real-Time Transport Protocol (RTP) [RFC3550], an association among a group of communicating participants is known as an RTP Session. An RTP session is typically associated with a single transport address (in the case of multicast) or communication flow (in the case of unicast), though RTP translators and single-source multicast [I-D.ietf-avt-rtcpssm] can make the situation more complex. RTP topologies are discussed in more detail in [I-D.ietf-avt-topologies].

Within an RTP session, the source of a single stream of RTP packets is known as a synchronization source (SSRC). Every synchronization source is identified by a 32-bit numeric identifier. In addition, receivers (who may never send RTP packets) also have source identifiers, which are used to identify their RTP Control Protocol (RTCP) receiver reports and other feedback messages.

Messages of the Session Description Protocol (SDP) [RFC4566], known as Session Descriptions, describe Multimedia Sessions. A multimedia session is a set of multimedia senders and receivers, and the data streams flowing from senders to receivers. A multimedia session contains a number of Media Streams, which are the individual RTP sessions or other media paths over which one type of multimedia data is carried. Information that applies to an entire multimedia session is called Session-Level information, while information pertaining to one media stream is called Media-Level information. The collection of all the information describing a media stream is known as a Media Description. (Media descriptions are also sometimes known informally as SDP "m"-lines, after the SDP syntax that begins a media description.) Several standard information elements are defined at both the session level and the media level. Extended information can be included at both levels through the use of attributes.

(The term "Media Stream" does not appear in the SDP specification itself, but is used by a number of SDP extensions, for instance Interactive Connectivity Establishment (ICE) [I-D.ietf-mmusic-ice], to denote the object described by an SDP media description. This term is unfortunately rather confusing, as the RTP specification [RFC3550] uses the term "media stream" to refer to an individual media source or RTP packet stream, identified by an SSRC, whereas an SDP media stream describes an entire RTP session, which can contain any number of RTP sources. In this document, the term "media stream" means an SDP media stream, i.e. the thing described by an SDP media description, whereas "media source" is used for a single source of media packets, i.e. an RTP media stream.)

The core SDP specification does not have any way of describing individual media sources, in particular RTP synchronization sources, within a media stream. To address this problem, in this document we introduce a third level of information, called Source-Level information. Syntactically, source-level information is described by a new SDP media-level attribute "ssrc", which identifies specific synchronization sources within an RTP session, and acts as a meta-attribute mapping source-level attribute information to these sources.

This document also defines an SDP media-level attribute "ssrc-group", which can represent relationships among media sources within an RTP session, in much the same way as the "group" attribute [RFC3388] represents relationships among media streams within a multimedia session.

4. Media Attributes

This section defines two media-level attributes, "ssrc" and "ssrc-group".

4.1. The "ssrc" Media Attribute

```
a=ssrc:<ssrc-id> <attribute>
a=ssrc:<ssrc-id> <attribute>:<value>
```

The SDP media attribute "ssrc" indicates a property (known as a "source-level attribute") of a media source (RTP stream) within an RTP session. <ssrc-id> is the synchronizaton source ID (SSRC) of the source being described, interpreted as a 32-bit unsigned integer in network byte order and represented in decimal. <attribute> or <attribute>:<value> represent the source-level attribute specific to

the given media source. The source-level attribute follows the syntax of the SDP "a=" line. It thus consists either of a single attribute name (a flag), or an attribute name and value, e.g. "cname:user@example.com". No attributes of the former type are defined by this document.

Within a media stream, ssrc attributes with the same value of <ssrc-id> describe different attributes of the same media sources. Across media streams, <ssrc-id> values are not correlated (unless correlation is indicated by media-stream grouping or some other mechanism) and MAY be repeated.

For each source mentioned in SDP, the source-level attribute "cname", defined in Section 6.1, MUST be provided. Any number of other source-level attributes for the source MAY also be provided.

The "ssrc" media attribute MAY be used for any RTP-based media transport. It is not defined for other transports.

Though the source-level attributes specified by the ssrc property follow the same syntax as session-level and media-level attributes, they are defined independently. All source-level attributes MUST be registered with IANA, using the registry defined in Section 12.

Figure 10 in Section 10 gives a formal Augmented Backus-Naur Form (ABNF) [RFC4234] grammar for the ssrc attribute.

4.2. The "ssrc-group" Media Attribute

```
a=ssrc-group:<semantics> <ssrc-id> ...
```

The SDP media attribute "ssrc-group" expresses a relationship among several sources of an RTP session. It is analogous to the "group" session-level attribute [RFC3388], which expresses a relationship among media streams in an SDP multimedia session (i.e., a relationship among several logically related RTP sessions). As sources are already identified by their SSRC IDs, no analogous property to the "mid" attribute is necessary; groups of sources are identified by their SSRC IDs directly.

The <semantics> parameter is taken from the specification of the "group" attribute [RFC3388]. Its potential parameters are defined by IANA in "Semantics for the 'group' SDP Attribute" under "SDP Parameters". The semantics defined for the ssrc-group attribute are FID (Flow Identification) [RFC3388] and FEC (Forward Error Correction) [RFC4756]. In each case, the relationship among the

grouped sources is the same as the relationship among corresponding sources in media streams grouped using the SDP "group" attribute.

(None of the other "group" semantics registered with IANA as of this writing are useful for source grouping. LS (Lip Synchronization) [RFC3388] is redundant for sources within a media stream, as RTP sources with the same CNAME are implicitly synchronized in RTP. SRF (Single Reservation Flow) [RFC3524] and ANAT (Alternative Network Address Types) [RFC4091] refer specifically to the media stream's transport characteristics. CS (Composite Session) [I-D.mehta-rmt-flute-sdp] is used to group FLUTE sessions, and so is not applicable to RTP.)

The ssrc-group attribute indicates the sources in a group by listing the <ssrc-id>s of the sources in the group. It MUST list at least one <ssrc-id> for a group, and MAY list any number of additional ones. Every <ssrc-id> listed in an ssrc-group attribute MUST be defined by a corresponding "ssrc:" line in the same media description.

Figure 11 in Section 10 gives a formal Augmented Backus-Naur Form (ABNF) [RFC4234] grammar for the ssrc-group attribute.

5. Usage of Identified Source Identifiers in RTP

The synchronization source identifiers used in an RTP session are chosen randomly and independently by endpoints. As such, it is possible for two RTP endpoints to choose the same SSRC identifier. Though the probability of this is low, the RTP specification [RFC3550] requires that all RTP endpoints MUST be prepared to detect and resolve collisions.

As a result, all endpoints MUST be prepared for the fact that information about specific sources identified in a media stream might be out of date. The actual binding between SSRCs and source CNAMEs can only be identified by the source description (SDES) RTCP packets transmitted on the RTP session.

When endpoints are choosing their own local SSRC values for media streams for which source-level attributes have been specified, they MUST NOT use for themselves any SSRC identifiers mentioned in media descriptions they have received for the media stream.

However, sources identified by SDP source-level attributes do not otherwise affect RTP transport logic. Specifically, sources which are only known through SDP, for which neither RTP nor RTCP packets have been received, MUST NOT be counted for RTP group size

estimation, and report blocks MUST NOT be sent for them in SR or RR RTCP messages.

Endpoints MUST NOT assume that only the sources mentioned in SDP will be present in an RTP session; additional sources, with previously unmentioned SSRC IDs, can be added at any time, and endpoints MUST be prepared to receive packets from these sources. (How endpoints handle such packets is not specified here; they SHOULD be handled in the same manner as packets from additional sources would be handled had the endpoint not received any a=ssrc: attributes at all.)

An endpoint that observes an SSRC collision between its explicitly-signaled source and another entity that has not explicitly signaled an SSRC MAY delay its RTP collision-resolution actions [RFC3550] by 5*1.5*Td, with Td being the deterministic calculated reporting interval for receivers, to see whether the conflict still exists. (This gives precedence to explicitly-signaled sources, and places the burden of collision resolution on non-signaled sources.) SSRC collisions between multiple explicitly-signaled sources, however, MUST be acted upon immediately.

If, following RTP's collision-resolution procedures [RFC3550], a source identified by source-level attributes has been forced to change its SSRC identifier, the author of the SDP containing the source-level attributes for these sources SHOULD send out an updated SDP session description with the new SSRC, if the mechanism by which SDP is being distributed for the multimedia session has a mechanism to distribute updated SDP. This updated SDP MUST include a previous-ssrc source-level attribute, described in Section 6.2, listing the source's previous SSRC ID. (If only a single source with a given CNAME has collided, the other RTP session members can infer a correspondence between the source's old and new SSRC IDs, without requiring an updated session description. However, if more than one source collides at once, or if sources are leaving and re-joining, this inference is not possible. To avoid confusion, therefore, sending updated SDP messages is always RECOMMENDED.)

Endpoints MUST NOT reuse the same SSRC ID for identified sources with same CNAME for at least the duration of the RTP session's participant timeout interval (see Section 6.3.5 of [RFC3550]). They SHOULD NOT reuse any SSRC ID ever mentioned in SDP (either by themselves or by other endpoints) for the entire lifetime of the RTP session.

Endpoints MUST be prepared for the possibility that other parties in the session do not understand SDP source-level attributes, unless some higher-level mechanism normatively requires them. See Section 9 for more discussion of this.

6. Source Attributes

This section describes specific source attributes that can be applied to RTP sources.

6.1. The "cname" Source Attribute

a=ssrc:<ssrc-id> cname:<cname>

The "cname" source attribute associates a media source with its Canonical End-Point Identifier (CNAME) source description (SDES) item. This MUST be the CNAME value that the media sender will place in its RTCP SDES packets; it therefore MUST follow the syntax conventions of CNAME defined in the RTP specification [RFC3550]. If a session participant receives an RTCP SDES packet associating this SSRC with a different CNAME, it SHOULD assume there has been an SSRC collision, and that the description of the source that was carried in the SDP description is not applicable to the actual source being received. This source attribute is REQUIRED to be present if any source attributes are present for a source. The cname attribute MUST NOT occur more than once for the same ssrc-id within a given media stream.

Figure 12 in Section 10 gives a formal Augmented Backus-Naur Form (ABNF) [RFC4234] grammar for the cname attribute.

6.2. The "previous-ssrc" Source Attribute

a=ssrc:<ssrc-id> previous-ssrc:<ssrc-id> ...

The "previous-ssrc" source attribute associates a media source with previous source identifiers used for the same media source. Following an SSRC change due to an SSRC collision involving a media source described in SDP, the updated session description describing the source's new SSRC (described in Section 5) MUST include the previous-ssrc attribute associating the new SSRC with the old one. If further updated SDP descriptions are published describing the media source, the previous-ssrc attribute SHOULD be included if the session description was generated before the participant timeout of the old SSRC, and MAY be included after that point. This attribute, if present, MUST list at least one previous SSRC, and MAY list any number of additional SSRCs for the source, if the source has collided more than once. This attribute MUST be present only once for each source.

Figure 13 in Section 10 gives a formal Augmented Backus-Naur Form (ABNF) [RFC4234] grammar for the previous-ssrc attribute.

6.3. The "fmtp" Source Attribute

```
a=ssrc:<ssrc> fmtp:<format> <format specific parameters>
```

The "fmtp" source attribute allows format-specific parameters to be conveyed about a given source. The <format> parameter MUST be one of the media formats (i.e., RTP payload types) specified for the media stream. The meaning of the <format specific parameters> is unique for each media type. This parameter MUST only be used for media types for which source-level format parameters have explicitly been specified; media-level format parameters MUST NOT be carried over blindly.

6.4. Other Attributes

This document only defines source attributes which are necessary or useful for an endpoint to decode and render the sources in a media stream. It does include any attributes which would contribute to an endpoint's decision to accept or reject a stream, e.g. in an offer/answer exchange. Such attributes are for future consideration.

7. Examples

This section gives several examples of SDP descriptions of media sessions containing source attributes. For brevity, only the media sections of the descriptions are given.

```
m=audio 49168 RTP/AVP 0
a=ssrc:314159 cname:user@example.com
```

Figure 6: Example: declaration of a single synchronization source

The example in Figure 6 shows an audio stream advertising a single source.

```
m=video 49170 RTP/AVP 96
a=rtpmap:96 H264/90000
a=ssrc:12345 cname:another-user@example.com
a=ssrc:67890 cname:another-user@example.com
```

Figure 7: Example: a media stream containing several independent sources from a single session member.

The example in Figure 7 shows a video stream where one participant (identified by a single CNAME) has several cameras. The sources could be further distinguished by RTCP Source Description (SDES) information.

```
m=video 49172 RTP/AVP 97
a=rtpmap:97 SVC/90000
a=ssrc-group:DDP 271828 14142135
a=ssrc:271828 cname:layered-codec@example.com
a=ssrc:14142135 cname:layered-codec@example.com
a=ssrc:14142135 depend:lay 271828
```

Figure 8: Example: relationship among several sources: layered coding

The example in Figure 8 shows a relationship among several sources, grouped by the "DDP" grouping semantics defined in Signaling of Layered and Multi-Description Media [I-D.schierl-mmusic-layered-codec]. (Note that this is only an example; multiplexing of layered codecs among several sources in an RTP session is currently not specified or encouraged.)

```
m=video 49174 RTP/AVPF 96 98
a=rtpmap:96 H.264/90000
a=rtpmap:98 rtx/90000
a=fmtp:98 apt=96;rtx-time=3000
a=ssrc-group:FID 11111 22222
a=ssrc:11111 cname:user3@example.com
a=ssrc:22222 cname:user3@example.com
a=ssrc-group:FID 33333 44444
a=ssrc:33333 cname:user3@example.com
a=ssrc:44444 cname:user3@example.com
```

Figure 9: Example: relationship among several sources: retransmission sources

The example in Figure 9 shows how the relationships among sources used for RTP Retransmission [RFC4588] can be explicitly signaled. This prevents the complexity of associating original sources with retransmission sources when SSRC multiplexing is used for RTP retransmission, as is described in Section 5.3 of [RFC4588].

8. Usage With the Offer/Answer Model

When used with the SDP Offer/Answer Model [RFC3264], SDP source-specific attributes describe only the sources with which each party is willing to send (whether it is sending RTP data or RTCP report blocks). No mechanism is provided by which an answer can accept or

reject individual sources within a media stream; if the set of sources in a media stream is unacceptable, the answerer's only option is to reject the media stream or the entire multimedia session.

The SSRC IDs for sources described by an SDP answer MUST be distinct from the SSRC IDs for sources of that media stream in the offer. Similarly, new SSRC IDs in an updated offer MUST be distinct from the ssrc IDs for that media stream established in the most recent offer/answer exchange for the session, and SHOULD be distinct from any SSRC ID ever used by either party within the multimedia session (whether or not it is still being used).

9. Backward Compatibility

According to the defintion of SDP, interpreters of SDP session descriptions ignore unknown attributes. Thus, endpoints MUST be prepared that recipients of their RTP media session may not understand their explicit source descriptions, unless some external mechanism indicates that they were understood. In some cases (such as RTP Retransmission [RFC4588]) this may constrain some choices about the bitstreams that are transmitted.

Source descriptions are specified in this document such that RTP endpoints that are compliant with the RTP specification [RFC3550] will be able to decode the media streams they describe whether or not they support explicit source descriptions. However, some deployed RTP implementations may not actually support multiple media sources in a media stream. Media senders MAY wish to restrict themselves to a single source at a time unless they have some means of concluding that the receivers of the media stream support source multiplexing.

10. Formal Grammar

This section gives a formal Augmented Backus-Naur Form (ABNF) [RFC4234] grammar for each of the new media and source attributes defined in this document. Grammars for existing session or media attributes which have been extended to be source attributes are not included.

```
ssrc-attr = "ssrc:" ssrc-id SP attribute
; The base definition of "attribute" is in RFC 4566.
; (It is the content of "a=" lines.)
ssrc-id = integer ; 0 - 2**32 - 1

attribute /= ssrc-attr
```

Figure 10: Syntax of the ssrc media attribute

```
ssrc-group-attr = "ssrc-group:" semantics *(SP ssrc-id)
; The definition of "semantics" is in RFC 3388.
; (It is the type of grouping being done.)

attribute /= ssrc-group-attr
```

Figure 11: Syntax of the ssrc-group media attribute

```
cname-attr = "cname:" cname
cname = byte-string
; Following the syntax conventions for CNAME as defined in RFC 3550.
; The definition of "byte-string" is in RFC 4566.

attribute /= cname-attr
```

Figure 12: Syntax of the cname source attribute

```
previous-ssrc-attr = "previous-ssrc:" ssrc-id *(SP ssrc-id)

attribute /= previous-ssrc-attr
```

Figure 13: Syntax of the previous-ssrc source attribute

11. Security Considerations

All the security implications of RTP [RFC3550] and of SDP [RFC4566] apply. Explicitly describing the multiplexed sources of an RTP media stream does not appear to add any further security issues.

12. IANA Considerations

Add ssrc and ssrc-group in Section 4 as media-level attributes.

Define source-level IANA registry and populate it with source attributes from Section 6.

13. References

13.1. Normative References

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

[RFC3264] Rosenberg, J. and H. Schulzrinne, "An Offer/Answer Model with Session Description Protocol (SDP)", RFC 3264, June 2002.

[RFC3388] Camarillo, G., Eriksson, G., Holler, J., and H. Schulzrinne, "Grouping of Media Lines in the Session Description Protocol (SDP)", RFC 3388, December 2002.

[RFC3550] Schulzrinne, H., Casner, S., Frederick, R., and V. Jacobson, "RTP: A Transport Protocol for Real-Time Applications", STD 64, RFC 3550, July 2003.

[RFC4234] Crocker, D., Ed. and P. Overell, "Augmented BNF for Syntax Specifications: ABNF", RFC 4234, October 2005.

[RFC4566] Handley, M., Jacobson, V., and C. Perkins, "SDP: Session Description Protocol", RFC 4566, July 2006.

[RFC4756] Li, A., "Forward Error Correction Grouping Semantics in Session Description Protocol", RFC 4756, November 2006.

13.2. Informative References

[I-D.ietf-avt-rtcpssm]
Chesterfield, J., "RTCP Extensions for Single-Source Multicast Sessions with Unicast Feedback", draft-ietf-avt-rtcpssm-13 (work in progress), March 2007.

[I-D.ietf-avt-rtp-svc]
Wenger, S., "RTP Payload Format for SVC Video", draft-ietf-avt-rtp-svc-01 (work in progress), March 2007.

[I-D.ietf-avt-topologies]
Westerlund, M. and S. Wenger, "RTP Topologies", draft-ietf-avt-topologies-04 (work in progress), February 2007.

[I-D.ietf-mmusic-ice]
Rosenberg, J., "Interactive Connectivity Establishment (ICE): A Protocol for Network Address Translator (NAT) Traversal for Offer/Answer Protocols", draft-ietf-mmusic-ice-16 (work in progress), June 2007.

[I-D.mehta-rmt-flute-sdp]
Mehta, H., "SDP Descriptors for FLUTE", draft-mehta-rmt-flute-sdp-05 (work in progress), January 2006.

[I-D.schierl-mmusic-layered-codec]
Wenger, S. and T. Schierl, "Signaling media decoding dependency in Session Description Protocol (SDP)", draft-schierl-mmusic-layered-codec-04 (work in progress), June 2007.

[RFC3524] Camarillo, G. and A. Monrad, "Mapping of Media Streams to Resource Reservation Flows", RFC 3524, April 2003.

[RFC4091] Camarillo, G. and J. Rosenberg, "The Alternative Network Address Types (ANAT) Semantics for the Session Description Protocol (SDP) Grouping Framework", RFC 4091, June 2005.

[RFC4588] Rey, J., Leon, D., Miyazaki, A., Varsa, V., and R. Hakenberg, "RTP Retransmission Payload Format", RFC 4588, July 2006.

Appendix A. Open issues

- Does a separate IANA registry need to be defined for "ssrc-group" semantics, distinct from "group" semantics?
- What additional SDP media-level attributes should be defined, in this or other documents?
- Does there need to be some way of saying in SDP "I understand that RTP media streams can contain multiple sources, and I'm prepared to accept them"?

Appendix B. Changes From Earlier Versions

Note to the RFC-Editor: please remove this section prior to publication as an RFC.

B.1. Changes From Draft -00

- Clarified that this document is expressly defining declarative source descriptions, not source offer/answer or other information.
- Removed the definitions of the "information", "bandwidth", "sendrecv", "sendonly", "recvonly", "inactive", "charset", "sdplang", "lang", "framerate", and "quality" source attributes. They are all unnecessary for source decodability, and to the extent they are otherwise useful they are probably better handled

by RTCP Source Description (SDES) packets or feedback (AVPF) messages.

- Added text to the Backward Compatibility and Security Considerations sections.

Authors' Addresses

Jonathan Lennox
Layered Media, Inc.
433 Hackensack Avenue
Sixth Floor
Hackensack, NJ 07601
US

Email: jonathan@layeredmedia.com

Joerg Ott
Helsinki University of Technology (TKK)
Networking Laboratory
PO Box 3000
FIN-02015 TKK
Finland

Email: jo@acm.org

Thomas Schierl
Fraunhofer HHI
Einsteinufer 37
D-10587 Berlin
Germany

Phone: +49-30-31002-227
Email: schierl@hhi.fhg.de

Full Copyright Statement

Intellectual Property

Acknowledgment

Funding for the RFC Editor function is provided by the IETF Administrative Support Activity (IASA).