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Guidelines for the Codec Development Within the IETF
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Abstract

This document provides general guidelines for work on developing and specifying a codec within the IETF. These guidelines cover the development process, evaluation, requirements conformance, and intellectual property issues.

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 April 5, 2012.

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1. Introduction

This document describes a suggested process for work at the IETF on standardization of a codec that is optimized for use in interactive Internet applications and that can be widely implemented and easily distributed among application developers, service operators, and end users.

2. Development Process

The process outlined here is intended to make the work on a codec within the IETF transparent, predictable, and well organized. Such work might involve development of a completely new codec, adaptation of an existing codec to meet the requirements of the working group, or integration between two or more existing codecs that results in an improved codec combining the best aspects of each. To enable such procedural transparency, the contributor of an existing codec must be willing to cede change control to the IETF and should have sufficient knowledge of the codec to assist in the work of adapting it or applying some of its technology to the development or improvemnet of other codecs. Furthermore, contributors need to be aware that any codec that results from work within the IETF is likely to be different from any existing codec that was contributed to the Internet Standards Process.

Work on audio codec development is expected to proceed as follows:

1. IETF participants will identify the requirements to be met by an Internet codec, in the form of an Internet-Draft.

2. Interested parties are encouraged to make contributions proposing existing or new codecs, or elements thereof, to the codec WG as long as these contributions are within the scope of the WG. Ideally, these contributions should be in the form of Internet Drafts, although other forms of contributions are also possible, as discussed in [PROCESS].

3. Given the importance of IPR to the activities of the working group, any IPR disclosures must be made in a timely way. Contributors are required, as described in [IPR], to disclose any known IPR, both first and third party. Timely disclosures are particularly important, since those disclosures may be material to the decision process of the working group.

4. As contributions are received and discussed within the working group, the group should gain a clearer understanding of what is achievable within the design space. As a result, the authors of the requirements document should iteratively clarify and improve their document to reflect the emerging working group consensus. This is likely to involve collaboration with IETF working groups in other areas, such as collaboration with working groups in the Transport area to identify important aspects of packet transmission over the Internet and to understand the degree of rate adaptation desirable, and with working groups in the RAI area to ensure that information about and negotiation of the codec can be easily represented at the signaling layer. In

parallel with this work, interested parties should evaluate the contributions at a higher level to see which requirements might be met by each codec.

5. Once a sufficient number of proposals has been received, the interested parties will identify the strengths, weaknesses, and innovative aspects of the contributed codecs. This step will consider not only the codecs as a whole, but also key features of the individual algorithms (predictors, quantizers, transforms, etc.).

6. Interested parties are encouraged to collaborate together and combine the best ideas from the various codec contributions into a consolidated codec definition, representing the merging of some of the contributions. Through this iterative process, the number of proposals will reduce and consensus will generally form around one of them. At that point, the working group should adopt that document as a working group item, forming a baseline codec.

7. IETF participants should then attempt to iteratively add to or improve each component of the baseline codec reference implementation, where by "component" we mean individual algorithms such as predictors, transforms, quantizers, and entropy coders. The participants should proceed by trying new designs, applying ideas from the contributed codecs, evaluating "proof of concept" ideas, and using their expertise in codec development to improve the baseline codec. Any aspect of the baseline codec might be changed (even the fundamental principles of the codec) or the participants might start over entirely by scrapping the baseline codec and designing a completely new one. The overriding goal shall be to design a codec that will meet the requirements defined in the requirements document. Given the IETF's open standards process, any interested party will be able to contribute to this work, whether or not they submitted an Internet-Draft for one of the contributed codecs. The codec itself should be normatively specified with code in an Internet-Draft.

8. In parallel with work on the codec reference implementation, developers and other interested parties should perform evaluation of the codec as described under Section 3, IETF participants should define (within the PAYLOAD Working Group) the codec's payload format for use with the Real-time Transport Protocol [RTP]. Ideally, application developers should test the codec by implementing it in code and deploying it in actual Internet applications. Unfortunately, developers will frequently wait until RFC or until a stable bitstream is guaranteed before deployment. As such, this is a nice-to-have and not a

requirement for this process. Lab implementations are certainly encouraged.

9. The group will produce a testing results document. The document will be a living document that captures testing done before the codec stabilized, after it has stabilized, and after the codec specification is issued as an RFC. The document serves the purpose of helping the group determine whether the codec meets the requirements. Any testing done after the codec RFC is issued helps implementors understand the final performance of the codec. The process of testing is described in Section 3.

3. Evaluation, Testing, and Characterization

Lab evaluation of the codec being developed should happen throughout the development process because it will help ensure that progress is being made toward fulfillment of the requirements. There are many ways in which continuous evaluation can be performed. For minor, uncontroversial changes to the codec it should usually be sufficient to use objective measurements (e.g., PESQ, PEAQ, and SegSNR) validated by informal subjective evaluation. For more complex changes (e.g., when psychoacoustic aspects are involved) or for controversial issues, internal testing should be performed. An example of internal testing would be to have individual participants rate the decoded samples using one of the established testing methodologies, such as ITU-R BS.1534 (MUSHRA).

Throughout the process, it will be important to make use of the Internet community at large for real-world distributed testing. This will enable many different people with different equipment and use cases to test the codec and report any problems they experience. In the same way, third-party developers will be encouraged to integrate the codec into their software (with a warning about the bit-stream not being final) and provide feedback on its performance in real-world use cases.

Characterization of the final codec must be based on the reference implementation only (and not on any "private implementation"). This can be performed by independent testing labs or, if this is not possible, using the testing labs of the organizations that contribute to the Internet Standards Process. Packet loss robustness should be evaluated using actual loss patterns collected from use over the Internet, rather than theoretical models. The goals of the characterization phase are to:

- ensure that the requirements have been fulfilled
- guide the IESG in its evaluation of the resulting work
- assist application developers in understanding whether the codec is suitable for a particular application

The exact methodology for the characterization phase can be determined the working group. Because the IETF does not have testing resources of its own, it has to rely on the resources of its participants. For this reason, even if the group agrees that a particular test is important, if no one volunteers to do it, or if volunteers do not complete it in a timely fashion, then that test should be discarded. This ensures that only important tests be done, and in particular those tests which are important to participants.

4. Specifying the Codec

Specifying a codec requires careful consideration around what is required vs. what is left to the implementation. The following text provides suggestions for consideration by the working group:

1. Any audio codec specified by the IETF must include source code for a normative software implementation, documented in an Internet Draft destined for standards track RFC. This implementation will be used to verify conformance of an implementation. Although a text description of the algorithm should be provided, its use should be limited to helping the reader in understanding the source code. Should the description contradict the source code, the latter shall take precedence. For convenience, the source code may be provided in compressed form, with base64 encoding.

2. Because of the size and complexity of most codecs, it is possible that even after publishing the RFC, bugs will be found in the reference implementation, or differences between the implementation and the text description. An errata of the RFC should be maintained. Although a public software repository containing the current reference implementation is desirable, the normative implementation would still be the RFC.

3. It is the intention of the group to allow the greatest possible choice of freedom in implementing the specification. Accordingly, the number of binding RFC2119 keywords will be the minimum that still allows interoperable implementations. In practice this generally means that only the decoder needs to be normative, so that the encoder can improve over time. This also enables different trade-offs between quality and complexity.

4. To reduce the risk of bias towards certain CPU/DSP architectures, ideally the decoder specification should not require "bit-exact" conformance with the reference implementation. In that case, the output of a decoder implementation should only be "close enough" to the output of the reference decoder and a comparison tool should be provided along with the codec to verify objectively that the output of a decoder is likely to be perceptually indistinguishable from that of the reference decoder. An implementation may still wish to produce an output that is bit-exact with the reference implementation to simplify the testing procedure.

5. To ensure freedom of implementation, decoder-side only error concealment does not need to be specified, although the reference implementation should include the same packet loss concealment

(PLC) algorithm as used in the testing phase. Is it up to the working group to decide whether minimum requirements on PLC quality will be required for compliance with the specification. Obviously, any information signaled in the bitstream intended to aid PLC needs to be specified.

6. An encoder implementation should not be required to make use of all the "features" (tools) in the bit-stream definition. However, the codec specification may require that an encoder implementation be able to generate any possible bit-rate. Unless a particular "profile" is defined in the specification, the decoder must be able to decode all features of the bit-stream. The decoder must also be able to handle any combination of bits, even combinations that cannot be generated by the reference encoder. It is recommended that the decoder specification shall define how the decoder should react to "impossible" packets (e.g. reject, consider as valid). However, an encoder must never generate such packets that do not conform to the bit-stream definition.

7. Compressed test vectors should be provided as a means to verify conformance with the decoder specification. These test vectors should be designed to exercise as much of the decoder code as possible.

8. While the exact encoder will not be specified, it is recommended to specify objective measurement targets for an encoder, below which use of a particular encoder implementation is not recommended. For example, one such specification could be: "the use of an encoder whose PESQ MOS is better than 0.1 below the reference encoder in the following conditions is not recommended".

5. Intellectual Property

Producing an unencumbered codec is desirable for the following reasons:

- It is the experience of a wide variety of application developers and service providers that encumbrances such as licensing and royalties make it difficult to implement, deploy, and distribute multimedia applications for use by the Internet community.

- It is beneficial to have low-cost options whenever possible, because innovation - the hallmark of the Internet - is hampered when small development teams cannot deploy an application because of usage-based licensing fees and royalties.

- Many market segments are moving away from selling hard-coded hardware devices and toward freely distributing end-user software; this is true of numerous large application providers and even telcos themselves.

- Compatibility with the licensing of typical open source applications implies the need to avoid encumbrances, including even the requirement to obtain a license for implementation, deployment, or use (even if the license does not require the payment of a fee).

Therefore, a codec that can be widely implemented and easily distributed among application developers, service operators, and end users is preferred. Many existing codecs that might fulfill some or most of the technical attributes listed above are encumbered in various ways. For example, patent holders might require that those wishing to implement the codec in software, deploy the codec in a service, or distribute the codec in software or hardware need to request a license, enter into a business agreement, pay licensing fees or royalties, or adhere to other special conditions or restrictions. Because such encumbrances have made it difficult to widely implement and easily distribute high-quality codecs across the entire Internet community, the working group prefers unencumbered technologies in a way that is consistent with BCP 78 and BCP 79. In particular, the working group shall heed the preference stated in BCP 79: "In general, IETF working groups prefer technologies with no known IPR claims or, for technologies with claims against them, an offer of royalty-free licensing." Although this preference cannot guarantee that the working group will produce an unencumbered codec, the working group shall follow BCP 79, and adhere to the spirit of BCP 79. The working group cannot explicitly rule out the possibility of adopting encumbered technologies; however, the working group will try to avoid encumbered technologies that require royalties or other

encumbrances that would prevent such technologies from being easy to redistribute and use.

When considering license terms for technologies with IPR claims agains them, some members of the working group have expressed their preference for license terms which:

- are available to all, worldwide, whether or not they are working group participants
- extend to all essential claims owned or controlled by the licensor
- do not require payment of royalties, fees or other consideration
- do not require licensees to adhere to restrictions on usage (though, licenses which apply only to implementation of the standard are acceptable)
- do not otherwise impede the ability of the codec to be implemented in open-source software projects

The following guidelines will help to maximize the odds that the codec will be unencumbered:

1. In accordance with BCP 79 [IPR], contributed codecs should preferably use technologies with no known IPR claims or technologies with an offer of royalty-free (RF) licensing.
2. As described in BCP 79, the working group should use technologies that are perceived by the participants to be safer with regard to IPR issues.
3. Contributors must disclose IPR as specified in BCP 79.
4. In cases where no RF license can be obtained regarding a patent, BCP 79 suggests that the working group consider alternative algorithms or methods, even if they result in lower quality, higher complexity, or otherwise less desirable characteristics.
5. In accordance with BCP 78 [TRUST], the source code for the reference implementation must be made available under a BSD-style license (or whatever license is defined as acceptable by the IETF Trust when the Internet-Draft defining the reference implementation is published).

Many IPR licenses specify that a license is granted only for technologies which are adopted by the IETF as a standard. While reasonable, this has the unintended side-effect of discouraging

implementation prior to RFC status. Real-world implementation is beneficial for evaluation of the codec. As such, entities making IPR license statements are encouraged to use wording which permits early implementation and deployment.

IETF participants should be aware that, given the way patents work in most countries, the resulting codec can never be guaranteed to be free of patent claims because some patents may not be known to the contributors, some patent applications may not be disclosed at the time the codec is developed, and only courts of law can determine the validity and breadth of patent claims. However, these observations are no different within the Internet Standards Process than they are for standardization of codecs within other SDOs (or development of codecs outside the context of any SDO), and furthermore are no different for codecs than for other technologies worked on within the IETF. In all these cases, the best approach is to minimize the risk of unknowingly incurring encumbrance on existing patents. Despite these precautions, participants need to understand that, practically speaking, it is nearly impossible to _guarantee_ that implementers will not incur encumbrance on existing patents.

6. Relationship with Other SDOs

It is understood that other SDOs are also involved in the codec development and standardization, including but not necessarily limited to:

- The Telecommunication Standardization Sector (ITU-T) of the International Telecommunication Union (ITU), in particular Study Group 16
- The Moving Picture Experts Group (MPEG) of the International Organization for Standardization and International Electrotechnical Commission (ISO/IEC)
- The European Telecommunications Standards Institute (ETSI)
- The 3rd Generation Partnership Project (3GPP)
- The 3rd Generation Partnership Project 2 (3GPP2)

It is important to ensure that such work does not constitute uncoordinated protocol development, of the kind described in [UNCOORD] in the following principle:

> [T]he IAB considers an essential principle of the protocol development process that only one SDO maintains design authority for a given protocol, with that SDO having ultimate authority over the allocation of protocol parameter code-points; defining the intended semantics, interpretation, and actions associated with those code-points.

The work envisioned by this guidelines document is not uncoordinated in the sense described in the foregoing quote, since the intention of this process is that two possible outcomes might occur:

1. The IETF adopts an existing audio codec, and specifies that it is the "anointed" IETF Internet codec. In such a case, codec ownership lies entirely with the SDO which produced the codec, and not with the IETF, OR
2. The IETF produces a new codec. Even if this codec uses concepts, algorithms, codepoints, or even source code from a codec produced by another SDO, the IETF codec is a specification unto itself and under complete control of the IETF. Any changes or enhancements made by the original SDO to the codecs whose components the IETF used are not applicable to the IETF codec. Such changes would be incorporated as a consequence of a revision or extension of the IETF RFC.

Although there is already sufficient codec expertise available among IETF participants to complete the envisioned work, additional contributions are welcome within the framework of the Internet Standards Process, in the following ways:

- Individuals who are technical contributors to codec work within other SDOs can participate directly in codec work within the IETF.

- Other SDOs can contribute their expertise (e.g., codec characterization and evaluation techniques) and thus facilitate the testing of a codec produced by the IETF.

- Any SDO can provide input to IETF work through liaison statements.

However, it is important to note that final responsibility for the development process and the resulting codec will remain with the IETF as governed by BCP 9 [PROCESS].

Finally, there is precedent for the contribution of codecs developed elsewhere to the ITU-T (e.g., AMR Wideband was standardized originally within 3GPP). This is a model to explore as the IETF coordinates further with the ITU-T in accordance with the collaboration guidelines defined in [COLLAB].

7. Security Considerations

The procedural guidelines for codec development do not have security considerations. However, the resulting codec needs to take appropriate security considerations into account, for example as outlined in [DOS] and [SECGUIDE].

8. IANA Considerations

This document has no actions for IANA.

9. Acknowledgments

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10. References

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