

# On Engagement With ICT Standards and Their Implementations in Open Source Software Projects: Experiences and Insights From the Multimedia Field

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## ABSTRACT

The overarching goal in this paper is to investigate organisational engagement with an ICT standard and open source software (OSS) projects that implement the standard, with a specific focus on the multimedia field, which is relevant in light of the wide deployment of standards and different legal challenges in this field. The first part reports on experiences and insights from engagement with standards in the multimedia field and from implementation of such standards in OSS projects. The second part focuses on the case of the ITU-T H.264 standard and the two OSS projects OpenH264 and x264 that implement the standard, and reports on a characterisation of organisations that engage with and control the H.264 standard, and organisations that engage with and control OSS projects implementing the H.264 standard. Further, projects for standardisation and implementation of H.264 are contrasted with respect to mix of contributing organisations, and findings are related to organisational strategies of contributing organisations and previous research.

## KEYWORDS

AVC, H.264, Involvement, ISO, ITU-T, OpenH264, Participation, x264

## 1 INTRODUCTION

There are a number of different challenges related to provision of standards in the software sector, that can impact on the extent to which it is possible to faithfully implement the specification of a standard in software systems (Blind and Böhm, 2019; Gamalielsson and Lundell, 2013; Lundell et al., 2019; UK, 2015). A number of challenges that are related to implementation of specifications of standards have been identified in the literature, including challenges related to: interoperability (Bird, 1998; Ghosh, 2005; Krechmer, 2005), conformance to the specification of the standard (Egyedi, 2007; Lundell et al., 2019), and long term availability of software systems which implement specific standards and associated digital artefacts (Behlendorf, 2009; Lundell et al., 2011). Implementations of standards in Open Source Software (OSS) is one means to address these challenges, and such implementations need to be available over very long life-cycles. For this reason it is important to assess the longevity of organisational governance and development provided by organisations in standardisation- and OSS projects (Butler et al., 2020; Crowston and Howison, 2006). Organisational engagement with standardisation projects is an important aspect to consider in this regard, and there is previous

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research on this topic including studies with a focus on motives for organisational participation in standardisation (Blind, 2006; Blind and Mangelsdorf, 2016; Mangelsdorf, 2009; Riillo, 2013), and how participation in standardisation affects company performance (Wakke et al., 2016).

Previous research on standards and their implementations in software projects include studies the addressing of different aspects related to interoperability and compliance (e.g. Butler et al., 2020; Egyedi, 2007; Egyedi and Dahanayake, 2003; Friedrich, 2011), and aspects that relate to licensing conditions for standards and associated implementations in OSS (Friedrich, 2011; Ghosh, 2005; Lundell et al., 2019; Simcoe, 2006). In particular, the relationship between standards and their implementations in software is a contemporary concern that has been addressed in a number of different studies (Blind and Böhm, 2019; Egyedi and van Wendel de Joode, 2004; Lundell et al., 2019). However, there is a lack of case studies, especially with a focus on standards and their software implementations in the multimedia domain, which is of interest because of their wide deployment and associated legal challenges. Therefore, there is need for further research with a focus on specific implementations of standards and the engagement with standards and their associated implementations, and particularly related to implementations in OSS in the multimedia field. In fact, the openness of standards and associated implementations in OSS has been elaborated almost two decades ago (Krechmer, 2002) and the relationship between standards and their implementation in OSS continues to be an issue for ongoing discussion (Brock, 2013; Blind and Böhm, 2019; EU, 2012; FRAND, 2012; Friedrich, 2011, 2013; Krechmer, 2007; Lundell et al., 2019). Further, there is a practical relevance of research on standards and their software implementations in the multimedia field since a large proportion of ICT users consume multimedia content through broadcasting and streaming services, and are depending on and affected by those standards and implementations.

This research addresses ICT standards which can be implemented in software projects, and considers challenges and opportunities concerning their implementation in OSS projects. Software that complies with the Open Source Definition (OSI, 2020b) and is made available under a software licence which has been approved by the Open Source Initiative (OSI, 2020a) constitutes OSS. Specifically, we address standards in the multimedia field and in particular the H.264 standard that has been jointly standardised by the International Telecommunication Union - Telecommunication Standardization Sector (ITU-T) and the International Organization for Standardization (ISO)<sup>1</sup>, and investigate engagement with the ITU-T H.264 standard (hereafter referred to as H.264) and selected OSS implementations of the standard.

One reason for the choice to investigate standards in the multimedia field and H.264 in particular, is that the standard is widely deployed, especially in the context of online streaming of video content: “H.264/AVC continues to be a pillar of online streaming, taking the top spot three years in a row, as the most used video codec in 2019 at 91%” (Bitmovin, 2019). For example, the standard is used in different software implementations in public broadcasting scenarios, including in the context of the Swedish public broadcasting organisation SVT, where high definition transmissions exclusively rely on use of the H.264 standard (SVT, 2020). Further, the implementation of multimedia standards and particularly H.264 is known to be challenging from a legal perspective. For example, a large number of organisations hold standard essential patents (SEPs) for H.264 of which a subset of organisations provide licences for their SEPs through the MPEG LA patent pool (MPEGLA, 2019). Hence, since H.264 is not royalty free, it does not fulfil requirements for an open standard according to the European Interoperability Framework version 1.0 (EU, 2004). Despite that H.264 is not an open standard, there are numerous implementations of H.264 in software provided under different licences (including proprietary licences and OSS licences).

This paper contributes the first in-depth study on organisational engagement with multimedia standards and OSS implementation of such standards, and also with a more specific focus on the H.264 standard and OSS implementations of that standard. The *overarching goal* for this study is to investigate organisational engagement with an ICT standard and OSS projects that implement the standard. The study has two parts. In the **first part**, four research questions are addressed in

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