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Table of Contents

Research Articles

On Implementation of Open Standards in Software:
To What Extent Can ISO Standards be Implemented in Open Source Software?

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ABSTRACT

Several European countries, as well as the European Commission, have acknowledged the importance of open standards (under various definitions of that term) and have taken steps accordingly. Formal (e.g. ISO) standards are often referred to in software development and procurement, but may not necessarily also be open standards. The authors consider the application of formal standards where national policy promotes their use, and, since much contemporary software development involves open source software, they further consider the interaction between the requirement to comply with open standards, and the implementation of open and formal standards in open source software, with particular reference to patent licensing. It is shown that not all formal standards are open standards. SSO policies and procedures regarding the notification of standards-essential patents (SEPs) present challenges for organisations wishing to implement standards in software since such policies and procedures need to be compliant with procurement requirements, patent licences and open source software licences. This paper draws out some implications for those organisations (differentiating where appropriate between small companies and other organisations) and suggests a number of ways of addressing the challenges identified. Use of formal standards may create barriers for implementation in open source software and inhibit an open and inclusive business-friendly ecosystem, and to avoid such barriers is of particular importance for small companies that are essential players in an innovative and international society.

Keywords: *Formal Standards, Open Standards, Licensing, Open Source Software, Patents*

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1. INTRODUCTION

'Openness' including open standards and open source software is increasingly prevalent, but presents a number of challenges requiring effective policy and strategic initiatives. The European Commission (EC, 2013a, 2013b) and countries, such as the Netherlands (NOC, 2007), Portugal (Ballard, 2012), and the U.K. (UK, 2012a, 2015), have acknowledged the importance of open standards and have implemented initiatives accordingly.

Open standards have been discussed by researchers (e.g. Bird, 1998) and policy makers in the EU and different member countries (EU, 2004; SOU, 2009) for a long time. Some member countries mandate use of open standards, based on definitions which require that standards are provided on royalty-free conditions, as part of national policy (e.g. NOC, 2007; UK, 2012a). Such policies aim to promote use of standards which have certain open properties and can thereby be used as a basis for implementation in software under different (proprietary and open source) software licenses. For example, the U.K. Government has a national policy which promotes and mandates use of specific open standards (UK, 2012a, 2012b, 2014, 2015). In Sweden, the minister responsible for municipalities has expressed support for the definition of 'open standard' set out in the European Interoperability Framework version 1.0 (Odell, 2009) and national framework agreements for public sector procurement of software in Sweden refer to open standards (EU, 2004; SOU, 2009; Kammarkollegiet, 2013, 2014a, 2014b) in relation to the standards which can be referenced in procurement.

At the same time, there is confusion related to use of the term 'standard' and research shows that practitioners may regard products and applications (e.g. Microsoft Word) as standards (e.g. Lundell, 2011). It has also been shown that there is confusion amongst policy makers between the two concepts of open standard and open source software (e.g. Egyedi & Enserink, 2013). Previous research results also show that many standardisation organisations neglect implementation issues and conclude that standards development and implementation activities "cannot be meaningfully separated" (Egyedi, 2007, p. 612). In particular, implementation of standards for representation of data over long life-cycles, beyond the life-cycle for any specific software, is of particular importance for long-term maintenance of data (Lundell, 2012). For these reasons, this study considers standards for representation of data and the potential for implementation of such standards in software, with a specific focus on the extent to which different standards can be implemented in open source software (i.e. software provided under a license which is recognised by Open Source Initiative (OSI, 2015)).

Previous research shows various positive effects from use of open standards (e.g. Friedrich, 2011; Ghosh, 2005; Krechmer, 2005; Lundell, 2012; Simcoe, 2006) and its potential for promotion of innovation has been stressed in recent research (e.g. Lundell, 2012). Further, reports from the European Commission (EC, 2013a) and the U.K. Government (UK, 2012a, 2012b, 2015) show considerable potential for innovation from the use of open standards, which can also reduce certain risks, for example to enable interoperability and prevent different kinds of lock-in effects with associated unwanted dependencies on suppliers and proprietary technologies. Friedrich (2011) states that the "prime example for how Open Standards can boost innovation are the internet and the world wide web". Open standards facilitate collaboration in development of software which can be provided under different types of licenses, including open source software. Such open collaboration represents an early exemplar of open innovation (Lundell & van der Linden, 2013) and open standards and open source software are used by most innovative organisations. For example, on 5 May 2014 Rachael King reported in the Wall Street Journal that a Samsung representative stated during an open source business conference: "Today, you can't build a product without using Open Source"[1].

It is noted that "standards are subject to legal rights which impact upon, not only their development, but also their implementation" (Fitzgerald & Pappalardo, 2009, p. 467). Specifically, writing software to implement the technical specifications embodied in standards also requires addressing a number of legal issues since "technical standards may incorporate patented technologies, while the specification documents of standards are protected by copyright" (Fitzgerald & Pappalardo, 2009, p. 467). Legal experts have argued that some commonly used (F)RAND licences are incompatible with open source licensing owing to the inability of the licensee to sub-licence to downstream recipients (EC, 2012) and the European Commission acknowledges that such licensing conditions for standards "create barriers for Open Source projects to implement the technical specification" (EC, 2013b). Further, in a public response to an open consultation concerning establishment of a national open standards policy representatives for the World-Wide-Web Consortium argued: "If a standard is covered by a patent or is in a FRAND system potentially covered by a patent, an open source developer risks his/her economic survival by implementing it because the patent owner can always go back and ask for past royalties." (Dardailler et al., 2012)

There has been a long tradition of using and referencing formal standards when developing and procuring software. For many years it has been permitted to explicitly reference formal standards (as opposed to informal standards) in public sector procurement (Lundell, 2011). However, there is limited knowledge concerning the relationship between formal and open standards, despite inclusion of requirements for open standards in policies in several countries.

The *overarching goal* of our study is to clarify and characterise use of formal and open standards in national policy and implications for implementation in software. Based on this, the study addresses *three specific objectives*. First, we review and report on conditions for use of ISO standards which are to be implemented in software. Second, we report on insights concerning open and formal standards, and elaborate on conditions for use of formal standards in scenarios when national policy imposes requirements for use of open standards. Third, we establish under what conditions open standards can be implemented in open source software, and contrast this with conditions for implementation of formal standards in open source software with a view to suggest ways for resolving potential inhibitors.

Specifically, the paper makes *three novel contributions*. First, we elaborate conditions for use of ISO standards and highlight inhibitors for their implementation in software. Second, we elaborate conditions for use of open standards and formal standards, and present a conceptual model which can be used as an analytical device for analysis of specific standards. Third, we elaborate conditions for implementation of specific open and formal standards in open source software and thereby illuminate why certain formal standards are not open standards, and based on this elaboration suggest a number of ways of resolving certain inhibitors to implementation.

2. ON FORMAL AND OPEN STANDARDS

Definitions of 'standards' and the potential business benefit from use of standards in various contexts have been issues for ongoing discussion in the IT-field since the 1990s (e.g. Bird, 1998). Standards have a function of creating norms and can thereby "establish requirements that, though not expressed in formal legal instruments, are in practice mandatory and must be implemented by participants in certain fields of technical or business activity" (Fitzgerald & Pappalardo, 2009, p. 473). Formal standards are provided by organisations recognised as formal standardisation organisations (SSOs) (de Vries, 2006), which include ISO (International Organization for Standardization), ITU (International Telecommunication Union), ETSI (European Telecommu-

nication Standards Institute), and national standardisation organisations (e.g. British Standards Institute). Industry consortia and other bodies (e.g. W3C (World Wide Web Consortium)) which do not have the status of formal standardisation organisations also create standards which are adopted *de facto* by industry. Some of these informal standards are submitted to formal SSOs and each such standard may become a formal standard if the standard is adopted by a formal SSO. Broadly, formal standards[2] may, in accordance with relevant legislation[3], be specified as part of a procurement process, whereas informal standards do not automatically have this status[4] (although there exist circumstances in which informal standards may be specifically referenced).

Over the past decades, many consortia and industry fora have become involved in ICT standards setting (Jakobs & Mora, 2008). During this period there has also been a shift of control concerning content in technical standards from government to industry, something which in turn has led to difficulties in distinguishing IT-standards from proprietary technology controlled by individual companies. As stated by Krechmer (2001): "At the end of the nineteenth century, governments controlled the technical standards domain. In the past 100 years, the voluntary consensus standards process has developed and expanded to the point that we have difficulty distinguishing between a standard and a vendor's proprietary technology" (Krechmer, 2001, p. 100).

It has been argued that openness (as the term is used in relation to standards) "describes the fairness of the standardization process to all possible interest groups" (Krechmer, 2001). Further, Bird (1998, p. 76) states that "accessibility of the standard and the control of the standard" are two key principles for any definition of an open standard. First, concerning the principle for accessibility of a standard, it is argued that "any standard must be available to be implemented in product without encumbrance, no royalties, no excessive charges to gain access to the document" (Bird, 1998, p. 76). Second, concerning the principle for control of a standard, it is argued that the "standard must be evolved through a known and predictable process that is open to input and influence by all interested parties" (Bird, 1998, p. 76). However, we contend that these are not the only criteria determining openness. A further crucial criterion concerns its licensing conditions.

Besides copyright for "legal protection to access the standard documentation, there could also be some industrial property rights (that is, patents) on the technical solutions included and described in the standard itself. Therefore, whoever acquires such documentation could still be prevented from adopting and implementing the standard, unless by paying another royalty to the possible patent holders." (Aliprandi, 2011, p. 12) In some cases, patentees are willing to license their patents impacting on a particular standard under so called (F)RAND ('(fair,) reasonable and non-discriminatory') licensing terms, something which would imply that all would be allowed licences on supposedly fair royalty terms (Lea & Hall, 2004). However, it should be noted that 'fairness' in specific licensing terms for IT-standards are context-dependent and often cannot be assessed a-priori since "the license terms are usually kept secret" (Lea & Hall, 2004, p. 83). For this reason, when an IT-standard is provided under such unknown (F)RAND licensing terms it seems clear that an organisation which plans to use such a standard for implementation in software will face significant challenges.

It should be noted that not all informal standards bodies work on a Royalty-Free (RF) basis and many have adopted a RAND-based IPR-policy (e.g. OMA[5] and SMPTE[6]). Further, some standards bodies (e.g. OASIS and GS1) allow for both Royalty-Free and RAND-conditions. For example, OASIS allows for different IPR-models and when a Technical Committee (TC) is established the TC selects to operate under one of four different IPR-modes[7] (including RF and RAND terms). Similarly, the GS1 Intellectual Property (IP) Policy[8] states that "GS1 seeks to develop standards that can be practised on a royalty-free basis to the greatest extent possible", even if they also allow for RAND-based licensing commitments from companies.

3. RESEARCH APPROACH

For addressing the *first objective*, we reviewed conditions for use of ISO standards with a view to specifically considering implementation of standards in software. We considered patent policy and other information provided by ISO, such as information related to the ISO patent database. For addressing the *second objective*, we reviewed conditions for use of formal standards in scenarios when national policy imposes requirements for use of open standards. In so doing, we present a conceptual model aimed to clarify the dimensions openness and formality of standards. For addressing the *third objective*, we identified and analysed a relevant set of specific standards for populating and characterising the conceptual model to thereby establish insights and report on conditions (and potential inhibitors) for implementation of standards in open source software. To elaborate on the dimensions openness and formality of standards we undertook a review of conditions for use of standards provided by different formal and informal organisations (including ISO, IETF, W3C, etc.) in order to identify a relevant set of standards for analysis. To this end, our review considered information provided by standardisation organisations (ISO, IETF, W3C, etc.) concerning patent disclosures related to different standards and the extent to which specific standards have been recognised as open standards according to national policy. Our goal was to cover a representative set of standards which have either been recognised as open standards according to national policy (NOC, 2007; Standaardisatie, 2014; Standardisation Forum, 2011), or not so recognised, and within that set, to include standards provided by formal standards organisations on the one hand, and informal standards organisations on the other. Further, within the subset of formal standards, we focus on those for which declarations of patents have been made to the relevant SSO. Further, the study focused on standards for representation of graphics as such constitute a relevant group of (similar) standards for representation of data. An investigation of this type of standards is important for a number of reasons, including the fact that these constitute a basis for maintenance of valuable data for many organisations, sometimes over very long life-cycles. As an outcome of this, the analysis includes three specific examples of formal (ISO) standards (PNG[9], JPEG 2000[10], and TIFF/EP[11]). The analysis also includes a standard (PNG) which in addition to recognition by ISO is also provided as a W3C standard and one specific informal (W3C) standard (SVG[12]) which is not recognised by ISO. By inclusion of these four standards for analysis we cover examples of formal standards (PNG, JPEG 2000, and TIFF/EP), open standards (SVG and PNG), and standards which are both formal and open (PNG).

Specifically, we reviewed patent disclosures for all four selected standards provided by ISO and W3C. For the two standards provided by W3C (SVG and PNG) we investigated specific statements concerning patent disclosures provided at the W3C website[13]. Further, for the three ISO standards we reviewed the content in the ISO patent database[14] related to specific formal standards and collect data from all organisations that have declared patents related to specific standards. Data collection was undertaken by sending letters[15] (with reminders sent more than one month after initial requests) to organisations that have declared IPR related to the specific standard documents using contact information provided for each organisation. Responses led to additional requests for clarifications in several cases and in one case a conference call involving the researchers and legal representatives from the organisation controlling IPR related to specific standard documents.

4. RESULTS

4.1. On Conditions for Use of ISO Standards

ISO (International Organization for Standardization) is a formal standards body that has "published over 19 500 International Standards that can be purchased from the ISO store or from our members" (ISO, 2015a). A standard is defined by ISO as follows: "A standard is a document that provides requirements, specifications, guidelines or characteristics that can be used consistently to ensure that materials, products, processes and services are fit for their purpose." (ISO, 2015a)

The three formal standardisation organisations ISO, IEC and ITU have adopted a common patent policy which is applicable for ISO deliverables, IEC deliverables, ITU-T Recommendations, and ITU-R Recommendations. From their common patent policy, it follows that "a patent embodied fully or partly in a Recommendation | Deliverable must be accessible to everybody without undue constraints" (ISO, 2007, 2012, 2015d). In other words, the patent policy and associated guidelines clarify that a patent which impacts on use of a standard must be accessible to everybody. However, the standardisation organisations are not in any way involved in such arrangements, which is clarified as follows: "The detailed arrangements arising from patents (licensing, royalties, etc.) are left to the parties concerned, as these arrangements might differ from case to case." (ISO, 2007, 2012, 2015d) It follows that an organisation wishing to use a specific standard from any of these formal standardisation organisations must identify and obtain all necessary rights which are required for all patents impacting on the standard.

Patent databases are provided by the formal standardisation organisations as a means for clarifying which organisations control patents related to specific standards. The content in each database is based on information provided in patent declarations provided by patent holders and submitted to the standardisation organisation (ISO, 2012). For example, the ISO patent database contains 2854 declarations (24 October 2015) from organisations that control patents related to specific standards (ISO, 2015b). It should be noted that several of these declarations cover several patents impacting on a specific standard and that patent declarations made for one (or several) normative references are not visible when searching for patent declarations made for a specific standard number in the ISO patent database[16]. Further, most organisations have not disclosed the granted patent number(s) (or application number(s) if pending).

The patent databases are populated from data provided by organisations which make declarations to ISO. The current patent statement and licensing declaration form (which is uniform across ISO, ITU-T, ITU-R and IEC) currently allows the declarant to select one of three options. The options are numbered 1, 2 and 3, with the first being most favourable to a potential licensee, and the third being least favourable. The options are:

- **Option 1 ('Free of Charge'):** The Patent Holder is prepared to grant a Free of Charge license to an unrestricted number of applicants on a worldwide non-discriminatory basis and under other reasonable terms and conditions to make, use and sell implementations of the [standard]. [There are, further, two reciprocity options not discussed in this section of the paper];
- **Option 2 ('RAND'):** The Patent Holder is prepared to grant a license to an unrestricted number of applicants on a worldwide non-discriminatory basis and under other reasonable terms and conditions to make, use and sell implementations of the [standard]. [There is a further reciprocity option not discussed in this section of the paper];
- **Option 3 ('Unwilling to Grant'):** The Patent Holder is unwilling to grant licenses in accordance with the provisions of either 1 or 2 above. [In this case, the ISO strongly desires the declarant to notify ISO of relevant patents].

The ISO patent policy only impinges on parties which are involved in the standards-setting process. For this reason, it is possible that relevant patents held by other non-involved organisations may exist which are not reported (and hence not contained in the ISO database).

4.2. On Conditions for Use of Open and Formal Standards

This sub-section elaborates on use of open standards in national policy and reports on potential inhibitors for use of formal standards. In so doing we present a conceptual model aimed to clarify the dimensions openness and formality of standards.

The national policy in the Netherlands adopted the same definition of an open standard as the European Interoperability Framework (EU, 2004). According to the definition adopted in the Netherlands, a "standard is fully 'open' if:

1. The standard is adopted and will be maintained by a not-for-profit organisation, and its ongoing development occurs on the basis of an open decision-making procedure available to all interested parties (consensus or majority decision etc.);
2. The standard has been published and the standard specification document is available either freely or at a nominal charge. It must be permissible to all to copy, distribute and use it for no fee or at a nominal fee;
3. The intellectual property – i.e. patents possibly present – of (parts of) the standard is made irrevocably available on a royalty-free basis;
4. There are no constraints on the re-use of the standard" (NOVFS, 2011).

An important principle underlying the idea of an open standard is that it ensures that data can be interpreted independently of the software which generated it (Lundell, 2012). Further, a central characteristic of "open standards is that there are no restrictions regarding their use by ICT users and providers. Open standards are the opposite of closed standards, which do have restrictions" (NOVFS, 2011). Hence, of particular importance with open standards is that a standard which conforms to this definition can be implemented in software that is provided under different proprietary and open source software licenses.

If a standard is open, both in the sense that the process leading to its adoption is open to all, and that the ability to implement it is not encumbered by difficult or expensive access to the standards documentation itself, as well as challenges raised by obtaining licences to patents which are required to implement the standard without infringing, then the largest number of actors, from small companies through to multinational organisations, will be able to be involved in implementation of the standard.

A number of initiatives from government (for example, in the UK the G-Cloud/Digital Marketplace project is intended to attract the maximum number of potential suppliers for cloud-based services to the public sector) (UK, 2012c) are based on the premise that increasing the number of actors, and levelling the playing field to ensure that SMEs are not excluded from the procurement process because of barriers that are not explicit, but implicit in the complexity of the process, will increase competition, and therefore lower the cost to purchasing organisations. Likewise, where the standards are able to be implemented by the widest possible range of organisations, this can be expected to have a similar pro-competitive effect. Naturally, these arguments do not apply solely in the public sector procurement process, and a recognition that open standards have the potential to lower costs for all purchasers, from individuals to private organisations to the public sector, will be welcomed by many organisations.

Even though organisations that control patents which they believe impact on specific standards are encouraged to declare details of such it is important to note that declarations are voluntary and that not all organisations that control patents impacting on specific standards are involved in a process with the standardisation organisations. In addition, there may also be several other organisations that control patents which impact on a specific standard that cannot be found in the database, perhaps because these organisations have no interest in standardisation and therefore have not declared that they control patents to the standardisation organisation. Further, to maintain an up-to-date content in the patent database the guideline stresses the importance of providing "contact information that will remain valid over time" (ISO, 2012, 2015d) and that contact information therefore "should be generic" (ISO, 2012, 2015d). However, timeliness and the validity of the content in a patent database is considered as a challenge for a standardisation organisation: "The ITU Telecommunication Standardization Bureau (TSB), the ITU Radiocommunication Bureau (BR) and the offices of the CEOs of ISO and IEC are not in a position to give authoritative or comprehensive information about evidence, validity or scope of patents or similar rights" (ISO, 2007, 2012, 2015d).

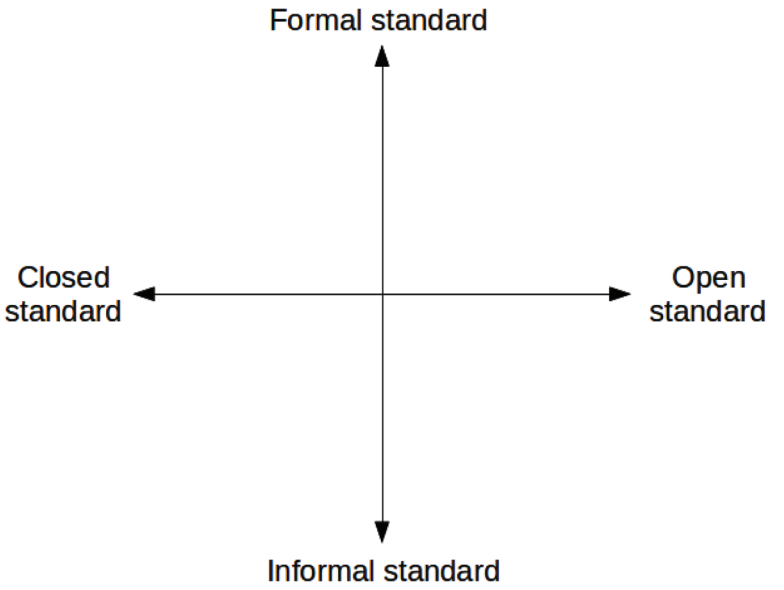
Figure 1 presents a conceptual model aimed to provide support for analysis of specific standards. The model consists of two orthogonal dimensions. One dimension in the model concerns openness of standards (open vs. closed standard), whereas the other dimension is formality of standards (formal vs. informal standard). For example, the ISO standard PNG (ISO/IEC 15948:2004) is considered to be an open standard in the Netherlands (by the Forum Standaardisate) according to the outcome of specific assessments (NOVFS, 2011) which require that a specific standard conforms to their definition of an open standard (EU, 2004). Hence, based on the outcome of their assessment, some ISO standards (e.g. PNG) belong in the upper right quadrant, whereas other ISO standards (e.g. JPEG 2000) belong in the upper left part of the conceptual model (see Figure 1). On the other hand, some industry consortia use closed processes for development and maintenance of standards (e.g. MXF-standards from SMPTE) which clearly do not fulfil the definition of an open standard (EU, 2004). Such standards belong in the lower left quadrant in Figure 1, and are therefore unsuitable for use in the public sector according to national policy in EU countries that have adopted policy for use of open standards. Hence, it follows that not all informal standards are open standards.

Note that both axes are continuous: a standard may be more or less open depending on any one of the applicable criteria. All other things being equal, a standard, the documentation for which is available free of charge, will be regarded as more open than a standard which costs EUR5,000 to obtain, and there is clearly a gradation in between. Likewise, the degree of formality varies from standards bodies. For example, previous research indicate that informal processes utilised by consortium SSOs (e.g. OASIS and IETF) are feasible for small companies (e.g. Gamalielsson et al., 2015, p. 41) as contributing to such typically involves remote participation via the web compared to participation in formal standardisation which typically involves additional need for travel.

4.3. Conditions for Implementing Open and Formal Standards in Software

In this sub-section we present a review of four specific standards with respect to the definition of an open standard and populate the conceptual model with these standards. Of the four specific standards analysed, one informal (consortium) standard (SVG) is provided as a W3C standard (but not as an ISO standard). Further, one formal (ISO) standard (PNG) is included[17] in the explicit list of open standards published in the Netherlands (Standaardisatie, 2014), whereas two

Figure 1. Openness vs. formality of standards



other formal (ISO) standards (JPEG 2000 and TIFF/EP) are not included in the explicit list and are consequently considered to be closed standards.

The SVG (Scalable Vector Graphics) standard ("Scalable Vector Graphics (SVG) 1.1 (Second Edition)", W3C Recommendation 16 August 2011[18]) is an informal (W3C) standard for representation of graphics included in the list of open standards in the Netherlands (Standaardisatie, 2014). SVG has been developed and maintained by the W3C SVG Working Group since 1998 and reached standard status (as "W3C recommendation") in 2001 (version 1.0). The current version (1.1) was released in 2011, and is currently widely deployed.

The outcome of the assessment made in the Netherlands implies that the informal (W3C) standard for the SVG standard is considered as an open standard and therefore belongs in the upper right quadrant of the conceptual model (see Figure 1). Considering the third criterion in the definition of an open standard (EU, 2004) and based on the outcome from our own analysis of patent disclosures provided by W3C it seems reasonable that the informal (W3C) standard has been included in the list of open standards (Standaardisatie, 2014).

The information provided by W3C concerning patents disclose that: "the SVG Working Group participants and the W3C are not aware of any royalty-bearing patents that are essential to implement the deliverables of the SVG Working Group, which includes all versions of the SVG specification and the SVG Mobile Profiles." Further, the same web page clarifies that one patent has been disclosed by one company and also acknowledges that the company does not believe it currently has any essential claims that fall within the specification of the recommendation as currently understood and interpreted by the company for implementors of SVG. Further, from information provided by W3C it is clear that several widely deployed (proprietary and open source licensed) software projects have implemented support for SVG[19], including several projects provided under the GPL license (e.g. Blender, Inkscape, and Scribus[20]). For these reasons it may be unsurprising that SVG is recommended for use in national policy concerning open standards, such as in the Netherlands.

The PNG (Portable Network Graphics) standard (ISO/IEC 15948:2004) is a formal (ISO) standard for representation of graphics included in the list of open standards in the Netherlands (Standaardisatie, 2014). Before accepted as an ISO standard, PNG was initially published in 1996 by the Internet Engineering Task Force (as RFC 2083) and soon after as a W3C standard (also in 1996).

The outcome of the assessment made in the Netherlands implies that the formal (ISO) standard for the PNG standard is considered as an open standard and therefore belongs in the upper right quadrant of the conceptual model (see Figure 1). Further, it should be noted that PNG is also provided as a W3C standard[21] (as "W3C recommendation" since 1 October 1996, i.e. before PNG was adopted as an ISO standard) and therefore also belongs in the lower right quadrant of the conceptual model (see Figure 1). Hence, based on adoption by both ISO and W3C, PNG belongs in both the upper right quadrant and the lower right quadrant of Figure 1. Considering the third criterion in the definition of an open standard (EU, 2004) and based on the outcome from our own analysis of the content in the ISO patent database it seems reasonable that the formal (ISO) standard has been included in the list of open standards (Standaardisatie, 2014). We note that no organisation is listed in the ISO patent database for the PNG standard (ISO/IEC 15948:2004).

The information provided by W3C concerning patents disclose that[22]: "the International Standards Organisation (ISO), the PNG Development Group and the W3C are not aware of any royalty-bearing patents that are essential to implement the Portable Network Graphics specification." Like for SVG, it is clear that several widely deployed (proprietary and open source licensed) software projects have implemented support for PNG[23], including several projects provided under the GPL license (e.g. GIMP, Inkscape, and TuxPaint[24]). For these reasons it may be unsurprising that PNG is recommended for use in national policy concerning open standards, such as in the Netherlands.

The JPEG 2000 standard[25] is a formal (ISO) standard for the representation of graphics which has not been included in the list of open standards in the Netherlands (Standaardisatie, 2014). The JPEG 2000 standard is developed by the Joint Photographic Experts Group[26] (i.e. a joint committee between ISO/IEC JTC1 and ITU-T). The standard consists of 14 parts (parts 1-6 and 8-15 since part 7 has been abandoned) and a number of technical corrigendum have been published for several parts. For example, part 1 of the ISO standard for JPEG 2000 (ISO/IEC 15444-1:2004) with all technical corrections and amendments consists of 12 standard documents in total and the other 12 parts consist of 33 standard documents in total which implies that the entire ISO standard for JPEG 2000 currently consists of 45 standard documents[27]. The total price for buying the 12 standard documents related to part 1 of the ISO standard is 310 CHF, whereas the total price for buying all parts (i.e. the 45 standard documents) of the ISO standard from ISO will be 2718 CHF. With this, the total cost for all these standard documents may be perceived as an inhibitor for adoption, in particular for small companies wishing to bid for contracts involving implementation of this standard. Further, in this case, the cost may seem to exceed what may be considered as reasonable for a "nominal charge" according to the second criterion in the definition of an open standard (EU, 2004).

Since the ISO standard JPEG 2000 is not included in the list of open standards (Standaardisatie, 2014) it is clear that the formal (ISO) standard for the JPEG 2000 standard is considered as a closed standard and therefore belongs in the upper left quadrant of the conceptual model (see Figure 1). Considering the third criterion in the adopted definition of an open standard (EU, 2004) and based on the outcome from our own analysis of the content in the ISO patent database it is clear that the formal (ISO) standard should not be considered an open standard and it is therefore not surprising that it is has not been included in the list of open standards (Standaardisatie, 2014).

We note that nine organisations are listed in the ISO patent database for part 1 of the JPEG 2000 standard (ISO/IEC 15444-1:2004) and that, in total, 16 organisations are also listed in the ISO patent database for all parts of the standard. Further, no information is provided in the database for most of these organisations concerning which patents these organisations control and some organisations even declare that they are willing to provide patent licenses under conditions which are not compatible with open source software.

To investigate the situation further we undertook a specific analysis aimed to clarify under which conditions the ISO standard can be used. This involved contacting each organisation listed in the ISO patent database with a set of questions sent in a letter[28] (sent via air-mail since email addresses were not available for most organisations in the database). In total, we sent questions to 16 organisations and after reminders (sent more than one month later) we have received some responses from three organisations. In total, letters from five organisations have so far been returned[29] since the contact information provided in the ISO patent database was incorrect or outdated (with the message "recipient unknown").

Amongst received responses, one organisation responded that they were unwilling to grant a license for their patents that would allow implementation in software to be provided under the GPLv3 license (i.e. a license which is recognised by both Open Source Initiative (OSI, 2015) and Free Software Foundation (FSF, 2015)). Another organisation explicitly stated that they decline to respond, whereas another declined to provide us information concerning which patents they control (the response was "we have at least 3 patents" on the specific standard). It should be noted that an annex in part 1 of the ISO standard (ISO/IEC 15444-1:2004) explicitly lists several organisations which have mentioned that they are willing to provide their patents (for part 1) free-of-charge but also that the patent database contains information with additional organisations since new patents have been declared after the publication of the ISO standard. Further, in one case the organisation that had declared patents declined to clarify conditions for use of the standard and instead referred our request to ISO. However, from a dialogue with ISO representatives we note that ISO as an organisation does not engage in clarifying conditions for use of standards for which patents have been declared. Hence, in this case specific questions concerning conditions for implementation of the standard were left unanswered (as one organisation controlling patent(s) for JPEG 2000 referred to ISO, and vice versa). In addition, it should also be noted that the ITU-T patent database contains information about a different set of organisations which have declared patents.

The TIFF/EP standard[30] is another of the formal (ISO) standards for representation of graphics which has not been included in the list of open standards in the Netherlands (Standaardisatie, 2014). The TIFF/EP (Tag Image File Format / Electronic Photography) standard is developed and maintained by the International Organization of Standardization (ISO). We note that 19 organisations are listed in the ISO patent database for the TIFF/EP standard. From this it follows that TIFF/EP is a closed standard according to the third criterion in the definition (EU, 2004) and that it therefore belongs in the upper left quadrant of the conceptual model (see Figure 1).

To investigate the situation further we undertook a specific analysis aimed to clarify under which conditions the ISO standard for TIFF/EP can be used. This involved contacting each organisation listed in the ISO patent database with a set of questions sent in a letter (sent via air-mail since email addresses were not available for most organisations in the database). In total, we sent questions to 19 organisations and after reminders (sent more than one month later) we did not receive any responses. In total, letters from four organisations were returned[31] since the contact information provided in the ISO patent database was incorrect or outdated (with the message "recipient unknown").

5. ANALYSIS

First, as one objective for our study involves analysing the conditions for use of formal (ISO) standards where national policy imposes requirements for use of open standards, it seems clear that the conceptual model presented can also support an analysis of the situation with respect to informal standards (e.g. those developed and maintained by various consortia, such as the W3C). However, it should be noted that several standards are recognised and maintained by more than one organisation. For example, the PNG standard is maintained both by ISO and by the W3C which implies that this specific standard could be seen as both a formal standard and an informal standard. Further, previous research shows that there are "many misconceptions and significant unawareness" concerning differences between standards for representation of data and their implementation in software amongst decision makers in public sector organisations (Lundell & Gamalielsson, 2013). By way of example, the Dutch Parliament requested in 2010 the Court of Audit to undertake an assessment of the benefits of open standards and open source software in the government IT which resulted in a criticised report that was published in March 2011 (Egyedi & Enserink, 2013). According to a critical review by Egyedi and Enserink (2013), the assessment was criticised for omitting to address effects of open standards on the market.

Second, our results show that the third criterion (about IPR) in the definition of an open standard adopted in the Netherlands brings with it several complexities for any organisation wishing to use a specific standard. Since different organisations developing and maintaining standards have different policies concerning patents it is important to realise that not all formal standards are open standards. Lea and Hall (2004) bring clarity to this complex issue as follows: "At the time patent policies first emerged, it was clear that few patentees would be willing to license on a 'royalty-free' (RF) basis in the sense of absolutely free: therefore, in some quarters, royalty-free came to mean 'for a lump sum up front' and, subsequently, the alternative concept of '[fair,] reasonable and non-discriminatory' ([F]RAND) licensing was developed, whereby all-comers would be allowed licenses but on royalty terms supposedly both fair across the industry as a whole and as between each of the licensees. This latter often cannot be proven, since the license terms are usually kept secret)." (Lea & Hall, 2004, p. 83)

Third, our results clearly illuminate differences between the investigated formal standards. Our results show clear differences between formal standards which are also 'open' compared to those which are also closed standards (e.g. the ISO standard for JPEG 2000). Our results show that a key issue impacting on the conditions under which formal standards can (or cannot) be implemented in open source software concern the third criterion in the definition of an open standard that has been adopted in the Netherlands (EU, 2004). From this, it is clear that while some formal (ISO) standards (e.g. the ISO standard for PNG) can (and have been) implemented in a variety of different open source software applications, it is also evident that for other formal (ISO) standards (e.g. the ISO standard for JPEG 2000) it is not possible to obtain licenses for the standard to permit implementation in open source software. For the investigated standards, our results clearly illuminate that amongst organisations which control patents impacting on the standard there is no interest in providing licences for those patents which would allow implementation in software to be provided under the GPLv3 licence. Further, given that the vast majority of organisations that have declared that they control patents impacting on the investigated standards either cannot be reached or decline to respond it is clear that any organisation considering an implementation of the standard under any open source software license would face significant risks. Hence, implementing a standard without first having obtained all necessary rights for use of the standard cannot be recommended to anyone.

Fourth, our results show that for several formal (ISO) standards a number of organisations have voluntarily declared that they control patents which are believed to impact on conditions for use of the specific ISO standard and also that investigations for clarifying the conditions are not easy to do in practice since several organisations cannot even be reached. As most organisations that have declared patents in the ISO database related to JPEG 2000 and TIFF/EP cannot be reached, it is implied that there is considerable uncertainty concerning conditions for use of such standards. Further, the complexity related to RAND conditions has been elaborated in previous research (e.g. Fomin et al., 2008). For example, in their study they report that: "Another expert elaborates on why (F)RAND issues, mentioned above, are important. He notes that IPR is the secret (in many senses of the word) tool of vendors to manipulate the standards process. The patent process can be easily manipulated to exclude competition, and flagrant abuses of it can be used to preclude challenge by smaller companies who cannot afford the fight even when they are right" (Fomin et al., 2008). Further, the same study argues that "without meaningful policies on IPR, operating on a global basis, standardization will be manipulated" using such business strategies (Fomin et al., 2008).

Fifth, adoption of requirements for use of standards in national policy may have a number of different effects for different stakeholder groups. Our results show that some formal (ISO) standards are provided under conditions that are unclear even after significant efforts for clarifying conditions for use of such standards. Such uncertainty may inhibit competition and impose challenges related to requirements expressed in public sector procurement. In the European context, legislation and directives for public procurement (Directives 2004/17/EC and 2004/18/EC) aim to achieve procurement practices that stimulate a fair and competitive market based on the important principles of transparency, non-discrimination and equal treatment (Lundell, 2011). Specifically, references to a technical specification "shall not refer to a specific make or source, or to a particular process, or to trade marks, patents, types or a specific origin or production with the effect of favouring or eliminating certain undertakings or certain products." (Directive 2004/17/EC (Article 34) and Directive 2004/18/EC (Article 23)). For this reason, results from an analysis of current practices in Swedish public sector organisations show significant lock-in and illuminate inclusion of requirements for specific standards which refer to specific products, trademarks and imply dependencies to access of specific patent licenses (Lundell, 2011; Wessman, 2013). Further, results from an analysis published by the Swedish competition authorities (Wessman, 2013) show that only a minority of decisions impacting on procurement consider any strategy for avoiding lock-in effects.

Finally, based on our results it is evident that some formal (ISO) standards analysed in this study cannot be implemented and deployed as open source software because of lack of clarity concerning IPRs. Further, when conditions for use of specific ISO standards cannot be clarified and all necessary patent licenses therefore cannot be obtained (as experienced in this study), it follows that such standards cannot be used for implementation in software under any software license without significant risks.

6. IMPLICATIONS FOR USE OF ISO STANDARDS AND IMPACT ON POLICY

Based on the analysis of our results, from having investigated the process of obtaining information on the conditions for use of specific standards from W3C and ISO, this section elaborates on the implications of our findings for practice. First we elaborate on the implications for small companies[32] wishing to implement ISO standards in software, and second, we suggest how the

ISO declaration form can be improved to allow a further option for holders of standards-essential patents (SEPs), to avoid some of the problems identified.

6.1. Implications for Companies Wishing to Implement Standards in Software

A small company wishing to implement a standard in software will typically have one or more of the following characteristics:

1. It will not have or control patents of its own;
2. It will not be party to any patent pool arrangement[33];
3. It will not have access to an in-house legal department or have in-depth knowledge of the patent landscape;
4. It will not be actively involved in any standards setting process; and
5. It will wish to implement the standard using open source software components, which may include software licensed under the GPL family.

In seeking to implement an ISO standard in software, a prudent company may take the following steps, each of which raises a potential barrier to such a company implementing a standard, the implementation of which is dependent on patents:

1. The company must acquire a copy of the standard (the cost of which may itself be prohibitive, especially where the standard contains multiple parts and normative references to other standards copies of which themselves may need obtaining in a similar way. By way of example, the results of our analysis show that the cost to acquire the JPEG 2000 standard documentation, even without considering the cost of documentation relating to normative references, would be 2718 CHF per copy);
2. It must review the ISO database to determine whether the standard (including other standards it relies on, such as normative references) is subject to declared patents;
3. It must attempt to determine what patents are included in each declaration covering the standard (including other standards it relies on), OR if that is not possible, it must determine whether it is going to engage in a negotiation for licences as another way of reducing potential risk;
4. It must determine whether its own implementation of the standard covers the patents in question, and if so, it must contact, and engage in negotiations with, the declarant organisation (or, to the extent that it is possible to do so, decide to exclude provision of its software from the specific market(s) in which relevant patents are registered).

Steps 3 and 4 must be repeated for every declaration contained in the database which is listed against the standard (including those listed against relevant and normative references referred to in the standard) which the company wishes to implement. Clearly, a failure to reach an agreement with the declarant organisation in even one case where the relevant patent impinges on the standard will potentially render the implementing company open to a patent infringement claim.

The above steps present a number of challenges in terms of cost and risk to the implementing company, which we call ‘process barriers’. We elaborate further on some of these issues.

To obtain a licence, the implementing company first needs to know what the relevant patents are. Several SSOs (including ISO) have databases populated by organisations which have taken part in the standards setting process, and which have declared that they hold patents which are

essential in implementing the standards. They do not necessarily declare (and it is not required as part of the ISO declaration process to declare) which specific patents they hold.

From our experience during the data-gathering process, it is by no means straightforward to obtain the information necessary to enable identification of the relevant patents. We even had problems in many cases eliciting any form of response from organisations listed in the database which claim they are in control of SEPs. We found that contact information provided in the database was no longer accurate for some of the declarations, leading to bounced emails and undelivered airmail letters.

The SSOs are clear that all patent licence negotiations are strictly between the company seeking a licence, and the organisation making the declaration, with the SSO taking no part in that process. However, where it is impossible even to engage the vast majority of declaring organisations, this process is clearly not fit for purpose.

As identified in this study, in the case of the ISO standard TIFF/EP, none of the 19 organisations identified in the ISO database responded to our questions. In the case of JPEG 2000, we were able to establish contact with three organisations from the 16 identified in the database, all of which we attempted to contact.

From the information provided in the dialogues where we were able to engage with the declaring organisations, we were able to establish that one referred us to ISO (which, as we have established, is not prepared to become part of licensing discussions between parties), one was prepared to license, in theory, on RAND terms (but did not provide a draft license), and the third was not prepared to grant a licence which was compatible with the GPLv3 licence. Even if we had received licences from the three respondents that we were able to engage in a dialogue, in the absence of licences from the other declarants (and assuming that those declarants genuinely held SEPs), we would still have been unable to implement the standard without infringing.

Were an enquiring organisation to proceed to implement the standard in software without a complete set of appropriate licences to SEPs, it would be at risk of patent claims from the holders of the SEPs (other than those from whom it had received licences). Those claims could lead to monetary damages (which may, under the US patent regime, have been tripled, given that disclosure on the database would put the enquirer on notice that patents potentially existed) and an injunction restraining any further use or distribution of the software. It is no guarantee of safety that a company is operating solely in one jurisdiction where no SEPs exist. Since software development practices currently tend to involve US based repositories such as GitHub, and since, in any event, exploitation and marketing of the software is likely to occur on the internet and hence worldwide, claims may arise from any jurisdiction where SEPs are registered.

SSOs do not, in general, guarantee completeness of the database or that it is up to date. For example, ISO (2015c) states that "ISO does not verify the veracity or accuracy of the information nor the relevance of the identified patents/patent applications to ISO Standards."

Even assuming that the database is comprehensive, it will not be clear to the implementing company whether:

1. The (part of the) standard it wants to implement is covered by a patent held by the disclosing company or not;
2. The patent(s) in question are still in force, or have expired;
3. The patent(s) in question in fact impinge on the implementation of the standard at all.

Assuming that implementation of the standard in question will infringe a patent which is disclosed, the implementing company will have to enter into negotiations with the declarant

organisation, on the basis, as selected by that organisation of either Option 1 (Free of Charge) or Option 2 (RAND) (as such terms are set out in section 4.1).

This process is expected to occur outside the context of ISO. It also assumes that the company wishing to implement is, in practice, able to find, and successfully engage with, the declarant organisation.

If, on the other hand, the company wishing to implement is a larger organisation, by reason of its greater resources, it may, in practice, have a number of other options open to it. It may be able to:

1. Determine that the means by which it wishes to implement the standard does not, in fact, infringe any patent, (or modify the means of implementation to avoid the patent) and so no licence is required;
2. Determine that it already has access to a licence to the relevant patent, either through a patent pool arrangement, or through a pre-existing licence or cross-licence;
3. Negotiate with the patent holder outside the scope of the free-of-charge or RAND option, possibly by cross licensing its own patents, or by joining a relevant patent pool;
4. Seek to invalidate the patent; or
5. Assess the risk that there may be a successful patent claim, and determine it is prepared to accept that risk.

Options 1, 4 and 5 (above) are also potentially accessible to the smaller company, but are likely to be at a disproportionate cost.

In either case, the implementing company has the option to implement the standard and risk a claim from a patent holder (option 5 above). If that occurs, the larger company will have the advantage of:

1. Using its own patent portfolio to offer a cross-licensing deal;
2. Using its superior resources to fight the claim, either by invalidating the patent or demonstrating that its implementation does not infringe the underlying patent.

An organisation will experience minimal process barriers where it is possible for that organisation to implement the standard in software without concern for patent infringement, and be permitted to use software which is covered by any of the entire range of licenses approved by OSI (2015) and FSF (2015). It is the case that companies, even where they have no desire to supply software under an open source licence, will nonetheless frequently use open source code as a component in their product as a consequence of near-universal modern software development practices. Hardly any new system is built without using the high quality, easily accessible code which is often available as part of open source development projects (Simeonova, 2015; Milinkovich, 2015). Barriers to entry are likely to impact smaller companies disproportionately[34].

For a company wishing to implement a standard in software it is critical that it can obtain all necessary licenses to do so. In seeking to implement a standard, such a company should initially review the relevant SSO's database to determine whether its implementation is likely to infringe any patents which have been declared by a declarant organisation.

Since details of the specific patents declared by the declarants are not necessarily disclosed in the database (although the declarants are encouraged by the SSO to do so), further investigation may be necessary to even determine what patents may possibly be infringed. For example,

previous research shows that it is not uncommon for companies to declare that they own essential patents without specifying any details about these patents (Bekkers & West, 2009, p. 83).

If a company is comfortable that its implementation will not require a licence under a particular patent – perhaps because:

- It is not implementing the part of the standard which is covered by the patent; or
- The patent has expired; or
- It does not wish to implement or provide the software product in the jurisdiction where the patent is registered; or
- On close reading of the patent, it is not essential in implementing the standard.

Then it will, naturally, not need to approach the relevant declarant. In all other cases, to minimise its risk of infringement in implementing the standard, it will need to ensure that relevant licences are in place and engage with the patent holder accordingly.

If any patents are declared under option 3, this presents a serious risk to a company wishing to implement the standards (in practice, this is unlikely to occur, as the ISO's wider patent policy excludes from the standardisation process essential patents which are unavailable under RAND, or Free of Charge terms). Where patents are declared under Options 2 or 1, the company wishing to implement will need to engage with each relevant declarant organisation to negotiate a patent licence (on RAND or Free of Charge terms).

It is important to recognise that when an organisation declares to ISO that it is willing to provide its patents related to the specific standard at hand according to Option 1 (or indeed Option 2) this does not imply that the organisation *has* provided a license for these patents or that a license is automatically available on defined terms. A declaration under Option 1 implies that the organisation has declared that it is committed to provide its patents on Free of Charge terms and that it is willing to engage in a negotiation with the organisation which wishes to use the standard on that basis.

For many companies it is important to be able to implement the standard in open source software that is to be provided under common open source licences, including licences from the GPL-family. As GPL-licensed open source software is the most common type of open source software (under various accepted measures), and previous research from the embedded systems domain has showed that this is particularly essential for consultant companies, it is important for many companies to be able to use and implement standards in software that is provided under the GPL and its family of licences (Lundell et al., 2011).

6.2. Towards an Improved Standardisation System for Stakeholders

The standards ecosystem involves a number of different stakeholder groups. These include: legislators; SSOs; organisations which are involved in the standards setting process (and which may hold patents which impinge on the standards); and companies which wish to implement the standards.

For companies wishing to implement standards it would clearly be of significant benefit if the friction inherent in this process could be reduced by minimising the number of decision points that occur in the process. As our results have shown, one set of decision points arises in relation to the implementation of ISO standards at the stage where the implementing company undertakes an analysis of the patents which may possibly be infringed by the implementation of the standard in software, based on the data disclosed in the ISO database (or possibly elsewhere), and entering into negotiations with the parties it identifies as (possibly) having relevant patents

to obtain appropriate licences. Any initiative which simplifies this process and brings clarity will be welcomed by the implementing company by both reducing the time and effort involved in the process, and providing improved data on which the company can assess its commercial risk.

One way forward would be to introduce a mechanism whereby a relevant licence may, if selected by the patent holder as part of the patent declaration process applicable to a specific standard, automatically be available on suitable terms covering patents which may possibly impinge on an implementation of the standard. In such a case, the implementing company would no longer need to:

- Assess whether the declared patent did cover its implementation of the standard;
- Consider not trading in a jurisdiction where a relevant patent was registered, if it perceives negotiating the licence to be too complex (to the extent that it is possible to do so, given the global reach of the internet, and its almost universal role in software distribution);
- Assess the risk of implementing the standard without a suitable licence;
- Enter into negotiations with the declaring body;
- Reject methods of implementation (for example, the use of GPL code) which may be incompatible with any licence granted.

All of which potentially represent a significant investment and time and, possibly (for small companies in particular), the purchase of external professional advice.

To minimise friction, and maximise the ability for all companies, including SMEs, to implement standards under transparent conditions in a way which enables them to more accurately assess and manage risk (thus encouraging competition and innovation by allowing more actors with diverse interests to enter the market), we propose that an additional option for patent-holders declaring their approach to patent licensing with respect to a specific standard may be offered to patent-holders as follows (we call this 'Option Zero'):

1. By selecting this box, the declarant agrees to license, perpetually, and irrevocably except as specifically set out below, on a worldwide, royalty-free, non-exclusive basis to all third parties ('licensee') seeking to make, use and sell software implementations of the above document solely to the extent that such software implements the standard;
2. The licence set out in (1) above arises automatically in favour of all licensees without the need to execute any document;
3. The licence set out in (1) above may only be revoked against a specific licensee where the licensee is in breach of the licence set out in (1) above, and, having received notice specifying such breach fails to cure it within 30 days.

The most significant characteristics of Option Zero, in contrast with Option 1, are:

- An Option Zero licence is automatically available. There is no need to negotiate it;
- An Option Zero licence is explicitly perpetual and irrevocable, except in specified circumstances. As well as protecting the licensees' investment in development of a compatible solution, this is intended to aid compatibility with various definitions of 'open standard' (including version 1 of the European Interoperability Framework); and
- An Option Zero licence is explicitly designed to be compatible both with a proprietary software development model, and an open source development model.

This last point is somewhat problematic as regards certain open source licences. It has been noted (Mitchell & Mason, 2010), that there may be a fundamental mismatch between the requirements of some open source software licences (notably those of the GPL family), and parallel patent licences, unless the terms of those licences are extremely liberal.

In brief, as an analysis of this point is beyond the scope of this paper, there is a spectrum of opinion as to the interaction between the GPL and typical patent licensing structures. On the one hand, the least problematic view is that so long as the implementer of a standard using software licensed under a GPL family licence can distribute that software in such a way that the recipient has no fewer rights that the implementer has, then there is no problem (in other words, if the implementer has the benefit of a specific patent licence, any recipient of the implementer's code will also need to have the benefit of a patent licence on the same terms, either directly from the licensor, or as a sub-licence from the implementer). On the other hand, a more problematic view is that the implementer of a standard containing third party GPL code has to cause any recipient of that code to receive a licence (including a patent licence) which would enable the recipient to exercise *all* rights permitted under the GPL, including the right to modify the code so that it no longer implements the standard, but nonetheless still has the benefit of a relevant patent licence. Clearly, such a broadly drafted patent licence would render the economic value of the patent close to zero, so it would be unlikely to be acceptable.

The approach we have taken falls midway between these two extremes and is guided by the scope of the patent licence in GPLv3 (which does not expect a distributor of GPL software to provide a blanket patent licence to recipients covering all possible modifications of the code transferred). If the ISO were to adopt something similar to Option Zero, we would expect this to follow consultation with relevant stakeholders in the worlds of both proprietary and open source software, and, in particular, seek assurances from organisations like the Free Software Foundation (custodian of the GPL family of licences) that an approach like this would be compatible with both the spirit and the legal terms of the relevant licence (noting that such organisations' comments are at best only persuasive: legal interpretation of the licence is ultimately the responsibility of the courts of any jurisdiction in which the licence is litigated).

Many companies involved in the standards setting process are also companies which are heavily involved in the development of open source code, and will be familiar with the concept of licensing their patents on a royalty-free basis (e.g. HP, 2015) in a way which is typically compatible with open source licences. Many licences (GPLv3 and LGPLv3, Mozilla 2.0 and Apache 2.0) contain widely accepted and understood patent licensing clauses, which typically limit the licence granted to the scope of the claims implemented by the version of the software as distributed by the patent licensor. In other words, and by way of example, if a recipient received some word-processing software from the licensor, the recipient cannot expect the patent licence to cover the recipient's use of it should the recipient choose to modify the word processing software to act as a control system for a nuclear power plant. Any open source licence will grant the recipient under its copyright provisions the freedom to make those changes, the patent sections of the same licence may not. By analogy, we believe it is within the scope of acceptable open source practice to limit the scope of the patent licence granted to implementations of the standard. The recipient may, under the open source licence, modify the software so that its functionality no longer meets the requirements of the standard, but, should Option Zero apply, it will not receive the benefit of the patent licence in so doing.

By adopting a mechanism which is similar to that which organisations, including those with large patent portfolios, are already employing to license their patents under various open source licences, we believe that the introduction of similar licence terms as an option in the ISO patent declaration would not be an unusual step. We stress that Option Zero is, as the name implies, only

an option which the patent-holder may select, and there is no compulsion in selecting Option Zero. For the many organisations which already license software under licences such as GPLv3 or the Apache licence which contain a similar patent licensing clause, we submit that this option is entirely consistent with, and readily reconcilable with, their current patent licensing policies.

Option Zero does raise a number of interesting issues, which could be considered as sub-options. The patent sections of open source licences frequently contain provisions which are intended to foster reciprocity by ensuring that any actor taking advantage of such a patent licence loses the licence if they themselves assert patent rights against a third party in certain circumstances. We would suggest that suitable wording to implement this would be to allow the declarant to terminate the licence against a specific licensee where, *the licensee asserts any patent claim against a third party, where that third party is implementing the standard and the patent claim covers the implementation of that standard (where 'implementation' includes distribution and importation of software which implements the standard)*[35].

In other words, where someone takes the benefit of an Option Zero licence, that licence will terminate if that person starts issuing claims for infringement of its own patents where the claim covers the alleged infringer's implementation of the relevant standard.

Note that the currently-existing Options 1 and 2 also contain sub-options which allow (in the case of Option 1) the declarant to specify that it is only prepared to grant a licence to entities which are prepared to grant a similar Free of Charge licence themselves. Similarly, in the case of Option 2, there is an equivalent sub-option which allows the declarant to specify that it is only prepared to grant a licence to those entities which are prepared to grant a RAND licence (which may not be Free of Charge) themselves.

Another way of achieving a similar aim, which may be neater conceptually, is to state that the Option Zero reciprocity sub-option requires that any licensee taking the declarant's licence is itself deemed to have granted a licence to its own SEPs under Option Zero.

Notwithstanding these suggestions, we have identified two further issues which may impose risk for potential standards-implementing entities.

The first issue involves reliance on the information contained in the patent disclosure database itself. The second issue involves patent ambush, where an organisation initiates a patent claim relating to an implementation of a standard, where that patent has not been disclosed at all. We acknowledge that for the ISO standards investigated in this research, the question of undisclosed patents did not become relevant (because, as our results show, we were unable even to establish contact with many declarant organisations). However, this is an issue which is commonly understood in this field (see, for example, Baird (2007); EC (2007, 2009); Updegrove (2009)), and in the interests of complete disclosure we consider it appropriate to refer to this issue and the extent to which it impacts on our proposals.

In relation to the first issue, we have found that the content in the ISO database is not always accurate or up to date, and, at the very least, ISO should (1) take steps to check the content of its database from time to time, and/or (2) consider implementing sanctions on declarants which fail to keep their entries up to date. To improve the situation, one possibility would be to implement a rule that if a declarant fails to notify ISO on an annual basis that its information remains the same, or if it has changed, the nature of the changes, then that declarant is deemed to have selected Option Zero. Note that once an option has been selected, ISO's rules state that it may only be reclassified to a lower number (e.g. a declarant may make a submission that it is selecting Option 1 in relation to a specific disclosure, only where it has already made an Option 3 or 2 disclosure, or none at all). To retain consistency with this rule, an Option Zero selection would be perpetual (at least until all potentially relevant patents have expired). Note that an inaccuracy in an Op-

tion Zero declaration (given that it contains the licence itself, and not an invitation to negotiate a licence), is less impactful on licensees and potential licensees than any of the other options.[36]

From the declarants' perspective, an Option Zero may be attractive (compared to Option 1 – given that both Options Zero and 1 bear no fee or royalty), for reasons of reducing the time and effort involved in responding to, and negotiating individual licences. Further, Option Zero may also have the positive effect of creating an ad-hoc patent pool since declarants are themselves likely to be implementing the standard, and will therefore require their own licences from the other declarants. However, if Option Zero is selected, there may also be possible disadvantages for the declarant:

- The declarant loses the opportunity to negotiate individual terms with the implementer;
- The declarant will not automatically have a list of implementing companies.

These issues also arise when comparing Option Zero with Option 2. In this case, there is the additional disadvantage, from the declarant's perspective, that it will be unable to charge a fee to the licensee.

In relation to the second problematic issue, we have identified concerns relating to patent ambush. Patent ambush occurs when an organisation initiates patent litigation in relation to implementations of a standard, where is has not disclosed those patents during the standards-setting process, either because the entity in question chooses not to disclose the patent in breach of the relevant SSO's rules, or because the entity in question is not part of the standards setting process itself in the first place. The only solutions to this issue which present themselves to us require either the non-trivial implementation of legislation, which, because of the international nature of standardisation would necessarily require a treaty, or some form of international concerted effort requiring states to coordinate approaches in competition/antitrust law. One form of international legislation may provide that entities which hold a patent which impinges on a proposed standard, drafts of which standard have been made publicly available through ISO or another recognised international SSO, are deemed, unless they respond to the standards setting organisation and select a specific option in the patent declaration, to have granted an Option Zero licence in respect of that patent. Alternatively, it may be that competition or anti-trust law provides a solution, possibly by mandating compulsory licensing in this context (but see Chronopoulos (2009), which also covers a number of other possible solutions, analysis of which is beyond the scope of this paper). We are under no illusion as to the significant challenges raised in implementing these suggestions.

7. DISCUSSION AND CONCLUSION

Our study highlights that open standards are important for a number of different reasons, both in private and public sectors, something which is apparent in some countries based on recognition and adoption in national policy.

The study shows that while some formal (ISO) standards (e.g. the ISO standard for PNG) are also considered open standards according to the definition adopted in several national policies (including the one adopted in the Netherlands), it is also clear that other formal (ISO) standards (e.g. the ISO standard for JPEG 2000) are not considered open standards by the same policies. Further, from our analysis of the unclear situation related to patents which several organisations have declared related to the ISO standard for JPEG 2000 it is clear from this example that some ISO standards cannot be considered open standards.

Findings from the study contribute to reducing confusion concerning the use of standards in software. In particular, the conceptual model aimed to clarify the dimensions 'openness' and 'formality' of standards may provide an important means for analysing specific standards. Further, it seems apparent that any decision maker involved in specification of requirements for development and procurement of software in which standards are implemented needs to understand and account for conditions under which formal and open standards can be used.

Our study has identified a number of issues for any company wishing to implement an ISO standard. These issues include the ability to determine which organisations hold patents which may impinge on the standard, the complexity of the process under which such a company is expected to engage with the patent-declaring organisation. We found that information contained in ISO's database was, for two of the ISO standards investigated, so inaccurate as to cause attempts even to contact the relevant patent-declaring organisation to fail. In considering these issues, we suggest a number of ways in which they can be effectively addressed.

Our research has shown that there are significant risks associated with use of formal (ISO) standards for which conditions for use are unclear. For any organisation it is essential to clarify conditions for use of any standard before undertaking efforts to implement such in software, irrespectively under which license the software is to be provided. In situations when most organisations that have declared patents related to a specific standard do not respond and cannot be reached (as in the case of JPEG 2000 and TIFF/EP), it seems clear that the content of the patent database (as currently structured) provides limited support for any organisation wishing to clarify conditions for implementation of the standard in software. Our research has elaborated on the implications of the implementation of standards in software for which the patent landscape is unclear. Further, our contribution proposes a mechanism for addressing challenges related to unclear patents by suggesting the addition of an Option Zero to the ISO patent policy and associated patent declaration form.

In summary, the study shows that some formal standards create barriers for implementation in open source software, a finding which confirms previous observations expressed in reports from the European Commission. Thereby, the results from this study provide an important contribution to a more comprehensive understanding concerning conditions (and inhibitors) for implementation of standards in open source software. From these results it follows that inclusion of explicit requirements for use of some formal standards in development and procurement of software may significantly inhibit an open and inclusive business friendly ecosystem. In contrast, a relatively simple change to the process by which patent holders declare patents to the ISO and other SSOs may have the effect of promoting such an open and inclusive ecosystem, something which is of particular importance for small companies that are essential players in an innovative and international society.

REFERENCES

A guide for government organisations Governance of Open Standards. (2011, September). *The Standardisation Forum*, The Hague.

Aliprandi, S. (2011). Interoperability and Open Standards: The Key to True Openness and Innovation. *International Free and Open Source Software Law Review*, *3*(1), 5–24. doi:10.5033/ifosslr.v3i1.53

Antitrust: Commission accepts commitments from Rambus lowering memory chip royalty rates, IP/09/1897. (2009, December 9). European Commission.

Antitrust: Commission confirms sending a Statement of Objections to Rambus, MEMO/07/330. (2007, August 23). European Commission, Brussels, .

Baird, S. (2007). The Government at the Standards Bazaar. *Stanford Law & Policy Review*, *18*(1), 35–100.

Ballard, M. (2012, November 22). Portugal's prescribed open standards. *ComputerWeekly.com*. Retrieved from http://www.computerweekly.com/blogs/public-sector/2012/11/-tablemytable-border-collapsec.html

Bekkers, R., & West, J. (2009). The limits to IPR standardization policies as evidenced by strategic patenting in UMTS. *Telecommunications Policy*, *33*(1-2), 80–97. doi:10.1016/j.telpol.2008.11.003

Bird, G. B. (1998). The Business Benefit of Standards. *StandardView*, *6*(2), 76–80. doi:10.1145/301688.301691

Chronopoulos, A. (2009). Patenting Standards - A case for US Antitrust Law or a Call for Recognizing Immanent Public Policy Limitations to the Exploitation Rights Conferred by the Patent Act? *International Review of Intellectual Property and Competition Law*, *40*(7), 782–816.

CloudStore opens for business, Cabinet Office and The Rt Hon Lord Maude of Horsham. (2012, February 19). Retrieved from https://www.gov.uk/government/news/cloudstore-opens-for-business

Commission staff working document: Guide for the procurement of standards-based ICT — Elements of Good Practice, SWD(2013) 224 final. (2013b, June 25). European Commission, Brussels. Retrieved from http://ec.europa.eu/information_society/newsroom/cf/dae/document.cfm?doc_id=2326

Dardailler, D., Archer, P., & Wenning, R. (2012, May 25). W3C Response to UK Cabinet Office Open Standards Consultation. *W3.org*. Retrieved from http://www.w3.org/2012/04/openstandards.html

de Vries, H. J. (2006). IT Standards Typology. In K. Jakobs (Ed.), Advanced Topics in Information Technology Standards and Standardization Research – (Vol. 1, pp. 1–26). Hershey, PA, USA: IGI Global. doi:10.4018/978-1-59140-938-0.ch001

European Commission: Press Release, Digital Agenda: Open standards would save public sector €1 billion a year. (2013a, June 25). EC, Brussels. Retrieved from http://europa.eu/rapid/press-release_IP-13-602_en.htm

Egyedi, T. (2007). Standard-compliant, but incompatible?! *Computer Standards & Interfaces*, *29*(6), 605–613. doi:10.1016/j.csi.2007.04.001

Egyedi, T. & Enserink, B. (2013). Measuring the Benefits of Open Standards: A Contribution to Dutch Politics. *Standards Today,* 12(1).

European Interoperability Framework for pan-European eGovernment Services (Version 1.0). (2004). European Commission. Retrieved from http://ec.europa.eu/idabc/servlets/Docd552.pdf?id=19529

Fitzgerald, A., & Pappalardo, K. (2009). Moving Towards Open Standards. *SCRIPted*, *6*(2), 467–483.

Fomin, V. V., Pedersen, M. K., & de Vries, H. J. (2008). Open Standards and Government Policy: Results of a Delphi Survey. *Communications of the Association for Information Systems*, *22*(1), 25.

Free Software Foundation. (2015). Retrieved from www.fsf.org

Friedrich, J. (2011). Making Innovation Happen: The Role of Standards and Openness in an Innovation-Friendy Ecosystem. *Proceedings of 7th International Conference on Standardization and Innovation in Information Technology (SIIT)*, Los Alamitos. IEEE Computer Society. doi:10.1109/SIIT.2011.6083609

Gamalielsson, J., Lundell, B., Feist, J., Gustavsson, T., & Landqvist, F. (2015). On organisational influences in software standards and their open source implementations. *Information and Software Technology*, *67*(Nov), 30–43. doi:10.1016/j.infsof.2015.06.006

Ghosh, R. A. (2005, December). An Economic Basis for Open Standards. *FLOSSPOLS*. Retrieved from http://www.flosspols.org/deliverables/FLOSSPOLS-D04-openstandards-v6.pdf

Guidelines for Implementation of the Common Patent Policy for ITU-T/ITU-R/ISO/IEC, Revision 1. (2012). *ISO*. Retrieved from http://isotc.iso.org/livelink/livelink/fetch/2000/2122/3770791/Common_Guidelines_01_March_07.pdf

Guidelines for Implementation of the Common Patent Policy for ITU-T/ITU-R/ISO/IEC, Revision 2. (2015). *ISO*. Retrieved from http://www.itu.int/dms_pub/itu-t/oth/04/04/T04040000010004PDFE.pdf

HP Response to Consultation on Patents and Standards. (2015, February 12). *Hewlett-Packard*.

Implementing FRAND standards in Open Source: Business as usual or mission impossible? (Report summary). (2012, November 22). European Commission (EC) and the European Patent Office workshop Brussels.

ISO/IEC/ITU common patent policy. (2007, April 18). *ISO*. Retrieved from http://isotc.iso.org/livelink/livelink/fetch/ 2000/2122/3770791/Common_Policy.htm

Standards: What is a standard? (2015). *ISO*. Retrieved from http://www.iso.org/iso/home/standards.htm

ISO Standards and Patents. (2015). *ISO*. Retrieved from http://www.iso.org/iso/standards_development/patents

Jakobs, K. & Mora, M. (2008). Coordinating Rule Setters – Cooperation in ICT Standards Setting. *CONFIRM 2008 Proceedings*.

Kammarkollegiet (2013). Programvaror och tjänster 2013, Statens Inköpscentral, Kammarkollegiet, 5 February, Dnr. 96-40-2013.

Kammarkollegiet (2014a). Programvaror och tjänster 2014 - Kontorsstöd, Dnr 96-33-2014, 2014-09-11.

Kammarkollegiet (2014b). Programvaror och tjänster 2014 - Grundläggande it, Dnr 96-34-2014, 2014-09-11.

Krechmer, K. (2001). The Need for Openness in Standards. *IEEE Computer*, *34*(6), 100–101.

Krechmer, K. (2005). The Meaning of Open Standards. *Proceedings of the 38th Hawaii International Conference on System Sciences*, Los Alamitos. IEEE Computer Society. doi:10.1109/HICSS.2005.605

Lea, G., & Hall, P. (2004). Standards and intellectual property rights: An economic and legal perspective. *Information Economics and Policy*, *16*(1), 67–89. doi:10.1016/j.infoecopol.2003.09.005

Lijst met open standaarden. (2014). *Forum Standaardisatie*. Retrieved from https://lijsten.forumstandaardisatie.nl/lijsten/open-standaarden/

Lundell, B. (2011). e-Governance in public sector ICT-procurement: what is shaping practice in Sweden? *European Journal of ePractice, 12*(6), 66-78.

Lundell, B. (2012). Why do we need Open Standards? In M. Orviska, & K. Jakobs (Eds.), *Proceedings 17th EURAS Annual Standardisation Conference 'Standards and Innovation'* (pp. 227-240).

Lundell, B., & Gamalielsson, J. (2013). Usage of Open Standards and Open Source in Swedish schools: On Promotion of Openness and Transparency. In E. Petrinja et al. (Eds.), Open Source Software: Quality Verification, IFIP Advances in Information and Communication Technology (Vol. 404, pp. 207-221). Heidelberg: Springer.

Lundell, B., Lings, B., & Syberfeldt, A. (2011). Practitioner perceptions of Open Source software in the embedded systems area. *Journal of Systems and Software*, *84*(9), 1540–1549. doi:10.1016/j.jss.2011.03.020

Lundell, B., & van der Linden, F. (2013). Open Source Software as Open Innovation: Experiences from the Medical Domain. In J. S. Z. Eriksson et al. (Eds.), *Managing open innovation technologies* (pp. 3–16). Berlin: Springer. doi:10.1007/978-3-642-31650-0_1

Milinkovich, M. (2015, May 17). How the Eclipse community works. *Keynote presentation @ the 11th International Conference on Open Source Systems*, Florence, Italy.

Mitchell, I. G., & Mason, S. (2010). Compatibility of the licensing of embedded patents with open source licensing terms. *International Free and Open Source Software Law Review*, *3*(1), 25–58. doi:10.5033/ifosslr.v3i1.57

The Netherlands in open connection: an action plan for the use of open standards and open source software in the public and semi-public sector. (2007). NOC, Ministry of Economic Affairs. Retrieved from https://www.ictu.nl/archief/noiv.nl/files/2009/12/Action_plan_english.pdf

Open Document Standards for the Government Guide, Programma Nederland Open in Verbinding & Forum Standaardisatie. (2011, April 13). NOVFS. Retrieved from https://www.forumstandaardisatie.nl/fileadmin/os/documenten/Handreiking_ODF_Engelse_versie.pdf

Odell, M. (2009, November 5). European Public Sector Award, Public speech by Swedish minister, Maastricht.

Open Source Initiative. (2015). Retrieved from opensource.org

Patent declarations submitted to ISO. (2015). *ISO*. Retrieved from http://isotc.iso.org/livelink/livelink/13622347/Patents_database.xls?func=doc.Fetch&nodeId=13622347

Simcoe, T. S. (2006). Open Standards and intellectual property rights. In H. Chesbrough et al. (Eds.), *Open Innovation researching a new paradigm*. Oxford: Oxford University Press.

Simeonova, D. (2015). Digital Solutions: Can we 'Open Source' the Future? *Commission en direct*, 21(April-May), 49-50.

Standards Hub, CabinettOffice. (2014). *UK Government*. Retrieved from http://standards.data.gov.uk/

Strategi för myndigheternas arbete med e-förvaltning, Statens Offentliga Utredningar: SOU. (2009, October 19). e-Delegationen, Finansdepartementet, Regeringskansliet, Stockholm. (in Swedish)

Open Standards in Government IT: A Review of the Evidence. (2012). *UK Government*. Retrieved from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/78891/Review-of-the-Evidence_CIPPM.pdf

UK. (2012a). Open Standards Principles: For software interoperability, data and document formats in government IT specifications, HM Government, UK. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/183962/Open-Standards-Principles-FINAL.pdf

UK. (2015). Open Standards Principles, Updated 7 September 2015, HM Government, UK. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/459075/OpenStand-ardsPrinciples2015.pdf

Updegrove, A. (2009, June 22). The EC Settlement: Rambus, Writs and the Rule of Law, ConsortiumInfo.org, Retrieved from http://www.consortiuminfo.org/standardsblog/article.php?story=20090622043038212

Wessman, R. (2013). *Upphandling av IT - inlåsningseffekter och möjligheter, Uppdragsforskningsrapport 2013:2*. Swedish Competition Authorities.

ENDNOTES

1 http://blogs.wsj.com/cio/2014/05/05/open-source-eating-software-world-samsung/

2 It should be noted that active participation in international meetings organised in standardisation projects (e.g. ISO and SMPTE) may constitute major inhibitors for a small company, as experienced by representatives from small companies in previous collaborative research involving authors of this manuscript (e.g. Gamalielsson et al., 2015).

3 See Directive 2014/24/EU, http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014L0024&from=EN; Regulation (EU) No 1025/2012, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:316:0012:0033:EN:PDF

4 For example, the Regulation (EU) No 1025/2012 (EC, 2012) clarifies that consortia standards must not "limit the possibilities for implementers" to use the standard. Further, this EU regulation states

that some consortia developing 'informal standards' do not fulfil requirements according to this regulation: "Some ICT technical specifications are not developed in accordance with the founding principles" (i.e. "coherence, transparency, openness, consensus, voluntary application, independence from special interests and efficiency"). From this it follows that 'informal standards' from such consortia cannot be referenced in public sector procurements according to this regulation. However, a legal review of this regulation is beyond the scope of this paper.

5 Open Mobile Alliance (OMA), http://openmobilealliance.org/, clarifies that "No license to any patent, trademark, copyright or other proprietary right is granted under this Agreement or through any disclosure hereunder except as expressly stated in this Agreement", see http://openmobilealliance.org/about-oma/policies-and-terms-of-use/use-agreement/

6 Society of Motion Pictures & Television Engineers (SMPTE), https://www.smpte.org/, clarifies that documents "may include technology that is subject to Essential Claims" only "if all known patent holders are prepared to agree to terms that are RAND for all Essential Claims" (i.e. a claim which "is necessarily infringed by implementing the Normative Text of that Engineering Document and is 'necessarily infringed' only when there is no commercially-reasonable non-infringing alternative for implementing the Engineering Document"), see https://www.smpte.org/sites/default/files/SMPTE_IP_Policy_2013-08.pdf.

7 The OASIS IPR-rules clarifies that when a TC is established it can chose to operate under one (of four different) IPR Modes. At time of writing, we note that for the 89 currently active TC:s in OASIS we find that: 52 have selected to operate under the mode "RF on Limited Terms"; 18 have selected to operate under the mode "RF on RAND Terms"; 18 have selected to operate under the mode "Non-Assertion"; and 1 has selected to operate under the mode "RAND" (for an overview of the 4 models, see further https://www.oasis-open.org/policies-guidelines/ipr#tcformation). In addition, there are also additional "Legacy IPR rules" for other OASIS TC:s (e.g. see https://www.oasis-open.org/committees/tc_home.php?wg_abbrev=wss; https://www.oasis-open.org/committees/wss/ipr.php).

8 See http://www.gs1.org/ip

9 ISO/IEC 15948, "Information technology -- Computer graphics and image processing -- Portable Network Graphics (PNG)", ISO/IEC JTC1/SC24.

10 ISO/IEC 15444, "Information technology -- JPEG 2000 image coding system", ISO/IEC JTC1/SC29.

11 ISO 12234-2, "Electronic still-picture imaging -- Removable memory -- Part 2: TIFF/EP image data format", ISO/TC 42.

12 W3C Recommendation, "Scalable Vector Graphics (SVG) 1.1 (Second Edition)", 16 August 2011.

13 www.w3.org

14 http://www.iso.org/iso/standards_development/patents

15 Initial letters (air-mail) were sent in May 2014. Further, requests were also sent via email to all organisations that included email addresses as part of their contact details in the patent database.

16 For example, the ISO standard PDF/A-2 (ISO 19005-2:2011) contains several normative references to other standards (maintained by ISO and other SDOs) which thereby constitute inherent parts of the ISO 19005-2:2011 standard. One of these normative references is Part3 of the ISO standard JPEG 2000 for which several patent declarations can be identified in the ISO patent database. However, the same declarations cannot be found when searching for declarations made for ISO 19005-2:2011 in the ISO patent database (and it is instead necessary to manually search the ISO patent database for all normative references at all levels). Hence, it follows that a simple search in the ISO patent database gives a misleading indication of the scope of how patents declared for the investigated standards impact on other standards.

17 It should be noted that PNG is also provided as a W3C standard, but it is only included as an ISO standard in the explicit list of open standards in the Netherlands.

18 http://www.w3.org/TR/2011/REC-SVG11-20110816/

19 http://www.w3.org/Graphics/SVG/WG/wiki/Implementations

20 http://www.blender.org/; https://inkscape.org; http://wiki.scribus.net

21 http://www.w3.org/TR/2003/REC-PNG-20031110/

22 http://www.w3.org/Graphics/PNG/Disclosures

23 http://www.w3.org/TR/PNG/; http://www.libpng.org/pub/png/png-sitemap.html

24 http://www.gimp.org/; https://inkscape.org; http://www.tuxpaint.org/

[25] For the rest of this paper, we write "JPEG 2000" when referring to the complete ISO standard ISO/IEC 15444.

[26] For an overview of the JPEG 2000 standard as presented by the JPEG committee,see http://jpeg.org/jpeg2000/index.html

[27] In addition, there are a number of draft specifications and several outdated standard documents, which also may be relevant for implementation in software in different usage scenarios (e.g. for scenarios with long life-cycles)

[28] For the six organisations that provided email addresses as part of their contact details in the patent database related to JPEG 2000 we observed that the email addresses to four organisations were invalid (most likely outdated) which implied that we used air mail addresses instead.

[29] We consider data collection to be finished since more than 19 months have elapsed since the initial request. Further, the most recently returned letter was received in March 2015 (i.e. more than eight months after the last reminder).

[30] For the rest of this paper, we write "TIFF/EP" when referring to the complete ISO standard ISO 12234-2:2001.

[31] We consider data collection to be finished since more than 19 months have elapsed since the initial request. Further, the most recently returned letter was received in March 2015 (i.e. more than eight months after the last reminder).

[32] In this section, we use the terminology 'companies' and 'implementing companies', but this term should be understood to embrace other organisations, such as open source projects, which may also want to implement software which implements the standard, and many of the issues investigated will also impact larger companies.

[33] Organisations exist, such as the Open Invention Network (OIN), which act as the nexus of cross-licensing arrangements between their member organisations, typically in relation to a specific application or vertical market (in the case of the OIN, this covers the various components that they define as the 'Linux System'). Essentially, this enables the members to pool their patent portfolios. The pool may also assist members when third parties claim that the relevant technology infringes their own patents. The OIN, in addition to holding licences from members, also holds patents that it licenses to members.

[34] It should be noted that decisions concerning whether or not small companies will participate in international standardisation is also affected by (perceived and experienced) barriers to entry, as indicated by experiences from previous research published by authors of this paper: "From our own experiences of participation in IETF and W3C standardisation it is highly feasible for small companies to contribute due to low barriers for participation" (Gamalielsson et al., 2015, p. 41).

[35] This mechanism, and to a lesser degree, the specific wording, implements a mechanism which will be familiar to many organisations of all sizes which are involved in the licensing of open source software, given that a similar mechanism appears in many common open source licences.

[36] One would hope that such a declaration would remain, under all relevant jurisdictions, both irrevocable and also pass with the underlying patent, should the patent be assigned to a third party. The legal analysis of these points will vary from jurisdiction to jurisdiction and is beyond the scope of this paper. In most common-law jurisdictions (Ireland being an exception that immediately comes to mind), the ISO rules could be amended to render potential licensees under Option Zero third party beneficiaries. There are other possible mechanisms to facilitate transfer of the commitment alongside the patent (deed poll, promissory estoppel, for example), but an analysis of them is beyond the scope of this paper.