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AN APPROACH FOR IDENTIFYING GAPS AND OVERLAPS IN STANDARDS TO DETERMINE PRODUCT APPLICABILITY

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ABSTRACT

Standards and regulations have become an important part of today's society. Organizational and geographical dispersions often create situations where manufacturers are forced to meet various standards for a product to reach expanded markets or improve branding. In this paper we propose an approach that provides stakeholders with the means to harmonize a set of standards by identifying similarities and differences between their coverage. Using an analysis approach based on the Zachman framework, we are able to identify both overlaps and gaps that may transpire when analyzing multiple standards associated with a single product domain. To demonstrate our approach, we apply it to a subset of electronics-related sustainability standards. The results are sets of terms that can be used to define the gaps and overlaps between three standards: RoHS (Restriction of Hazardous Substances Directive), WEEE (Waste Electrical and Electronics Equipment Directive), and IEEE (Institute of Electrical and Electronics Engineers) P1680. We then discuss some of the challenges encountered when analyzing these standards. Finally, we briefly discuss the potential for an expanded approach that could assist in the development of domain models and ultimately help identify necessary actions in business processes that will lead to additional standard compliance.

Keywords: standard analysis, Zachman framework, gaps and overlaps, sustainability

1. UNDERSTANDING STANDARDS

According to standards.gov [1] standards are "the common and repeated use of rules, conditions, guidelines or characteristics for products or related processes and production methods, and related management systems practices." As such, in the context of manufacturing, standards can be considered as best and recommended practices that product manufacturers should follow to produce quality products. Similar to standards, regulations[1] or directives (henceforth referred to within the context of 'standards'), play the additional role of providing legal guidance for governing bodies. In either scenario, as an agreed, repeatable way of 'doing something,' [2] they serve as "common guidelines" for many practices.

To provide common guidelines product standards must be "agreed upon" by the different stakeholders involved. The British Standards Institution (BSI) group [2] notes "Committees of manufacturers, users, research organizations, government departments and consumers work together to draw up standards that evolve to meet the demands of society and technology." While involvement and contribution from multiple stakeholders may highlight the importance of standards, it inadvertently introduces a major obstacle, the idea of bringing together "interested parties such as producers, sellers, buyer, and regulators." While standards are meant to serve as a common understanding for the betterment of society, in practice the 'interested parties' or various stakeholders of a

[1] Regulations are understood to "*specify mandatory (legal) requirements that (1) must be met under specific laws and (2) implement general agency objectives [1].*

standard often differ in their priorities. As a result, there is rarely a single standard for any given product.

Standards may differ in many ways based on variables such as geographical location, product categorization, governing body, or developing organization [3]. This complexity is compounded by the fact that these standards are living documents, that is, they are updated often. Given their diversity and fluidity, it has become difficult and expensive for stakeholders, particularly manufacturers, to identify which standards a product should comply with to be sold in a particular market or branded a particular way [4]. There are many circumstances in which such situations may arise, for instance: when a new product is introduced to an existing market, when an existing product is introduced to a new market, when significant changes are made to the design of a product, and when new standards are introduced to a market. The inability to meet a standard may result in the reduction of consumer interest, loss of potential industry clientele, or even the inability to participate in a market entirely.

The responsibility of conforming to standards has become burdensome for both government and industry, especially when considering compounding information requirements. To address this issue, some governments have begun to review and remove regulations [5]. This, however, is not always an obtainable solution, especially when evolving environments must be met with new standards and regulations. As an alternative, this paper presents an analytical approach to understanding the gaps and overlaps of standards in order to simplify industry's task of identifying and conforming to them. This paper will then discuss how this approach may be expanded to assist companies in identifying necessary actions in business processes that will lead to additional standard compliance (Section 6.2).

2. CATEGORIZING STANDARDS

Standards exist in many forms and with many different applications. For instance, in relation to manufacturing, they apply to processes and products. When applied to products, they may vary not only across product categories, but also across different stages of a life cycle. There are standards for technical drawing, modeling, analysis, and even for recycling. Other variants may come from sources such as the requirements of an intended market, industrial clientele, and/or perspective buyers. The notion of the "product applicability" of a standard occurs when the standard being analyzed is found to govern or pertain to the product in question in some form or fashion. To better manage the myriad of standards different classification systems have been proposed.

In [6], a typology was proposed to primarily reflect how standard content should be communicated and implies the appropriate expressiveness and language choices for each type. Within each type, individual standards may be classified according to origin, intent, development process, and, to some extent, scope. In [7], the authors created 36 different characterizations to categorize healthcare and healthcare information system standards. In this scheme, each standard has a primary category, describing the informatics, based on its placement into one of these 36 cells.

The Healthcare Information Technology Standards Panel (HITSP) was formed to promote and facilitate the harmonization of standards used to exchange health data in the United States. As part of this effort, HITSP addressed various challenges of the standards, especially gaps, overlaps, and missing standards. The HITSP has defined the following terms with respect to a standard [8]:

- Harmonization – the selection of standards most appropriate to support specific events, actions, and actors in a use case.
- Context – the unique requirements of a specific actor within a use case.
- Gap – missing or incomplete standards that are required to support events in a use case.
- Overlap – overlaps refer to instances where some or all of the requirements are met by multiple standards.

In [9] gaps and overlaps of select standards were studied as they pertained to stages of a product's life cycle. The gaps and overlaps were identified as they related to the sustainability of electronic components, identifying the life cycle phases of products in which these standards play an important role. In the next section we will explore the use of gaps and overlaps of standards to determine product applicability.

3. PRODUCT-MINDED STANDARD CATEGORIZATION THROUGH GAPS AND OVERLAPS

A product-minded approach to the understanding of gaps and overlaps can offer insight into standards as they apply to products and product families. Analyzing standards can identify shared roles and activities of different standards, as well as the distinct differences between them.

Overlaps result from multiple standards covering a single domain. Indentified overlaps can be used to create an environment where roles and activities related to the development and deployment of a product can be associated with relevant standards, providing a means for interested parties to identify when a standards applies. The identification of overlaps between standards can also be used to identify where the development and deployment of information management techniques should be concentrated. Another benefit of understanding the overlaps is the ability to understand when conforming to one standard means conforming to others. This can be important knowledge for industry as it can be used to simplify the requirements of meeting multiple standards.

Gaps represent a divergence in standard coverage. Understanding gaps is how individual standards can be differentiated. As noted by HITSP, gaps may result from comparing standards with different levels of comprehensiveness. This situation may arise when one standard is more detailed than another, or even with different interpretations of a single standard. Gaps can also be a result of a focus, such as on a specific product type or geographical location. Here, the identification of diverging roles between standards can help interested parties understand the specifics of when one standard may apply over another.

Identifying gaps between multiple standards can help Standard Development Organizations (SDOs) to focus on individual areas in a domain where a new standard may be required or additional detail is needed. Gaps can also be used to help industry understand the boundaries of standard requirements, or when the effects of product changes must be considered when conforming to a particular standard. In addition, the understanding of gaps can be used to help industry identify potential and restricted markets of a product, as many standards/regulations apply only to specific geographical locations.

Resources such as the North American Industry Classification System [2] (NAICS) are available for product categorization, but these categories do not directly translate to standards. We believe the approach presented here can be used to develop a similar categorization resource with standard domains. Together, the identification of gaps and overlaps can be used to harmonize a family of standards and help define a domain of discourse, as shown in Figure 1. To visualize the approach, Figure 1 uses four separate, shaded, circles to represent separate standards. The darker shaded areas represent the overlaps, while the lightly shaded areas represent the gaps. The encompassing circle with the thick border represents the domain that is created when analyzing the four standards together. The overlaps may represent the focus of a domain and the gaps may define the outer limits of the domain. The analysis of gaps and overlaps can be used to acquire and characterize the explicit information necessary to create such domains for standards. These domains could then serve as references for standard development as well as industry compliance.

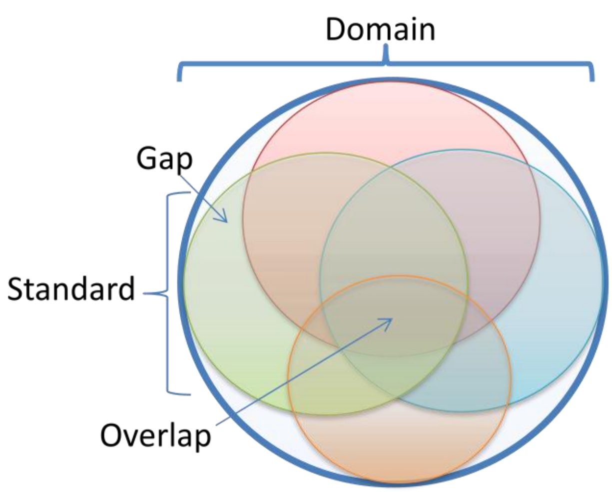

Figure 1. Gaps and overlaps.

[2] http://www.census.gov/eos/www/naics/index.html

4. DETAILED STANDARD ANALYSIS

A robust approach is required to overcome the diversity of content and representation styles that can exist across standards so that standards can be more easily identified with and met. The adopted approach must be abstract enough to address the many possible variances, yet powerful enough to manage information at varying levels of detail. These requirements have led our team to adopt an approach based on a widely used and proven method, the Zachman framework, to conduct standard analyses at varying levels of abstraction for the identification of gaps and overlaps amongst standards. Originally developed as an enterprise architecture framework, the Zachman framework provides a formal and structured way of analyzing an enterprise using a matrix. The initiatives mentioned in [6] and [14] have indicated a previous level of success using the Zachman Framework to analyze standards, further validating the use of a Zachman-based approach.

4.1. Introduction to Zachman Framework

The Zachman framework [10] was designed to describe any idea that is complex to understand [11] and is widely used for enterprise architecture modeling. It is depicted as a 6 x 6 matrix, with cognitive primitives as columns and abstract levels of information as rows. The six cognitive primitives used in this framework are what, how, when, who, where, and why. These are fundamental question primitives for communication, and integration of each question enables the comprehensive and composite description of the enterprise information.

The six rows in the matrix help to separate the problem into different levels of detail, with more detailed information being introduced in the lower levels. The top row describes the context of information, and is used to set up the domain of discourse. The second row is for domain experts to describe their business concepts. The third row describes system logics specialized from the second row, and the fourth row describes the technology applied to the system logics. The fifth row describes solutions that are actually implemented for the technology, and the bottom row denotes the operation of the enterprise. As each enterprise operates differently, a 6 x 5 matrix is used for the presented approach.

In the Zachman framework, the columns who, what, where, when, why, and how can also be understood as people, data, network, time, motivation, and function, respectively. This synonymy allows for enterprise model associations to clearly be made with the "5 Ws and an H." Similar synonymy exists for the rows, where the contextual, conceptual, logical, physical, and out-of-context can be directly associated with an enterprise's scope, business model, system model, technology model, and detailed representations, respectively.

As discussed in earlier sections, the information provided by standards often goes far beyond that needed to identify product applicability. Section 4.2 will discuss a methodology for the analysis of standards based on the

Zachman framework. As this methodology can offer multiple levels of abstraction, here we will also examine what extent of detail is necessary to determine product applicability through gaps and overlaps. To better explain how the Zachman framework can be used in the technical analysis of a standard or directive, we will describe an analysis of RoHS [12] (Restriction of Hazardous Substances Directive).

4.2. Technical Analysis Using Zachman Framework

The nature of the Zachman framework allows an analysis to begin from any cell of the 6 x 6 matrix. Here we will initially concentrate on the first row, which will analyze the contextual aspect, or scope of RoHS.

In defining the scope, we first took into account the specific requirements of all stakeholders involved. Through our interactions with the industry, academia and other government agencies, we identified a list of stakeholder groups based on the nature of information and support they require: 1) Generic user, 2) Consumer or buyer, 3) Manufacturer or producer, 4) Government or regulatory agency, 5) Software solution provider, 6) Researcher, and 7) Standard developer. Figure 2 demonstrates how concerns from individual stakeholders can be combined to develop the scope. As defined by Zachman, the information model in each cell in the contextual row is a list. The proposition and consideration of these stakeholders' issues/concerns led to a set of terms and concepts that provided the basis for setting up the domain of discourse for individual columns.

In first defining 'What', we considered the many entities associated with RoHS. This level of abstraction included the materials involved, the products considered, and the information involved. When identifying 'How', we took into consideration the *Supply-Chain Operations Reference* [13] (SCOR) model and identified the Source, Make, and Deliver

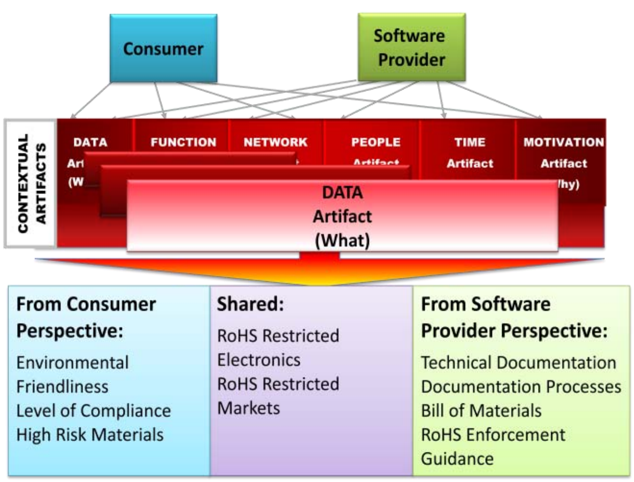

Figure 2. Contextual level of technical analysis.

processes of the supply chain as processes where RoHS becomes pertinent. This high level definition of processes was intentional, so as not to narrow the scope to a point where the RoHS application becomes ill-defined and perspectives are overlooked, yet not broaden the scope to a point where the analysis loses its effectiveness. Continuing along the contextual level, the 'Where' aspect of Zachman defined which geographical areas RoHS is active in. The 'Who' aspect was used to identify the parties or organizations who may have interest in RoHS, or the stakeholders. These stakeholders included electronics manufacturers and suppliers, government agencies, and customers. The 'When' row was used to identify events that will initiate cycles. We defined these events as the buying and selling of electronic goods. The 'Why' was used to identify the high level goals of RoHS, namely reduce environmental contamination by limiting hazardous waste, and from the perspective of the manufacturer also to avoid penalties and improve brand image. The purpose of Directive 2002/95/EC (RoHS) on the restriction of the use of certain hazardous substances in electrical and electronic equipment is to approximate the laws of the European Union (EU) Member States on the restrictions of the use of hazardous substances in electrical and electronic equipment and to contribute to the protection of human health and the environmentally sound recovery and disposal of waste electrical and electronic equipment [14]. The carefully executed analysis using the Zachman framework resulted in a transparent definition for the scope of RoHS.

To analyze the contribution from changes in levels of abstraction, we investigated contributions from the 'What' column. Recall at the highest level of abstraction, the contextual level, the 'What' column was used to provide the scope of what RoHS covers: the materials involved, the products involved, and the relevant information involved. In the Zachman framework, the second, conceptual, row is used to define the concept of a "business model" used in RoHS. At this level of abstraction a list is no longer used, instead a traditional business entity-business relationship model is employed. This level of abstraction provides some detail into how entities associated with RoHS interact. For instance a "product" is composed of an "assembly," which is composed of a "homogenous material[3]." As implied by its label, the second row allows for the conceptualization of interactions between entities through relationships, which can be considered as the "semantic model." While in Row 1 the analysis results were a conglomerate from all stakeholder concerns, these business models differ based on the stakeholder perspective taken. In our analysis, no new product-applicable gaps and overlaps were identified at this level of detail.

Progressing downward in the 6x6 matrix, the third row provides the logical data model. This level of abstraction is where data entities and their relationships exist, where a data

[3] "Homogeneous material" means a material of uniform composition throughout that cannot be mechanically disjointed into different materials, meaning that the materials cannot, in principle, be separated by mechanical actions such as unscrewing, cutting, crushing, grinding, and abrasive processes.

entity is a logical representation of an element from earlier levels of abstraction. Here, for example, is where an information model, including attributes, of what a homogenous material is can be found. The fourth row is where the Physical Data model is located. This row is technology constrained, so where the third row provided the attributes of a homogenous material, it is this row that describes how it is defined[4]. And finally the fifth row, or the detailed row, is where the data definition can be found. Row 5 is where the actual definition of the homogenous material can be found, for instance the composition of the solder used in an electronic product.

Based on the analysis results of the "What" row for RoHS, we concluded that by placing an emphasis on detail, the first, or contextual row, will provide sufficient information for determining the gaps and overlaps of standards in an analysis for the purpose of determining product applicability. Therefore, in Section 4 we will limit our analysis to the contextual row when identifying gaps and overlaps. However, that is not to say standard analyses at the other level of abstractions are unproductive. Section 5 will discuss some of potential applications with analyzing standards at these additional levels of detail.

5. GAPS AND OVERLAPS ANALYSIS TO DETERMINE PRODUCT APPLICABILITY

5.1. Overview

In Section 4, the ability of a Zachman-based approach to provide a detailed analysis of a standard was discussed and related back to the analysis of RoHS. This methodology was able to provide a detailed analysis of RoHS at multiple levels of abstraction in answering several cognitive primitives. In [15] it was shown how such an approach can be used by stakeholders to understand how a standard affects them and how this detailed analysis can lead to the development of business processes and conformity. Here, we will adopt the Zachman-based approach to identify gaps and overlaps in a family of standards.

The results from Section 4 show that, given a thorough approach, a contextual level analysis provided adequate detail for identifying the gaps and overlaps of standards to determine product applicability. The approach explained here will demonstrate how it is possible to harmonize a family of standards by identifying gaps and overlaps between the standards through the contextual level of a Zachman-based standard analysis.

5.2. Analyzing Sustainability Standards

To demonstrate the methodology discussed in this paper a proof-of-concept gaps and overlaps analysis will be executed between three different standards: RoHS, WEEE (Waste Electrical and Electronics Equipment Directive) [16], and IEEE (Institute of Electrical and Electronics Engineers) P1680 [17]. Each of these standards and regulations was developed to support or regulate the sustainability of electronics products.

Before gaps and overlaps analyses could be performed, a contextual analysis was completed for WEEE and IEEE P1680. Three separate tables (Figure 3) were created from the results of the contextual analyses. As stated in Section 4, when analyzing the contextual aspects of the three standards it was important to place an emphasis on the details. If this emphasis in detail was not placed, then: 1) The resulting gaps and overlaps analysis may be too generic to be useful, or 2) Analyses at lower levels of abstraction may be necessary to achieve useful results.

The identification of gaps and overlaps was performed by studying tables of results from the three separate standards. As the Zachman analysis provided explicit comparison criteria in the six columns representing cognitive primitives, comparing the results from each column yielded interesting results, highlights of which will be discussed in the following paragraphs. For the purpose of this paper, when analyzing the gaps and overlaps of the three selected standards the lessons learned were more important than the actual results. The intention is to demonstrate a repeatable approach to analyzing standards for identifying product applicability while also serving as a basis for future work.

The first results to be discussed will be from the gaps and overlaps analysis of the "What" column of the three sustainability standards. The three standards were analyzed within their respective scopes. This comparison can be seen in Figure 3. In Figure 3 the analysis has been color coded, where red means there is overlap, and purple, green, and orange information is associated with its respective standard.

All three addressed electronic products, as intended by the authors to create more revealing results. However, the type of electronics varies from standard to standard. WEEE addresses all electronics, while RoHS addressed only ten specific product categories. The P1680 standard serves as a baseline standard, so while this particular standard was developed to address all electronics, it is limited to the products addressed in a family of standards developed to utilize it (currently computers, imaging equipment, and televisions). This result raised two of the most important lessons learned during the analysis: 1) the need to differentiate between the level of detail (as it pertains to standards) and the level of abstraction (as it pertains to Zachman) and 2) addressing the existence of direct and indirectly stated information as it pertains to standards.

[4] The maximum permitted concentrations are 0.1% or 1000 ppm (parts per million)(except for cadmium, which is limited to 0.01% or 100 ppm) by weight of homogeneous material. This means that the limits do not apply to the weight of the finished product, or even to a component, but to any single substance that could (theoretically) be separated mechanically.

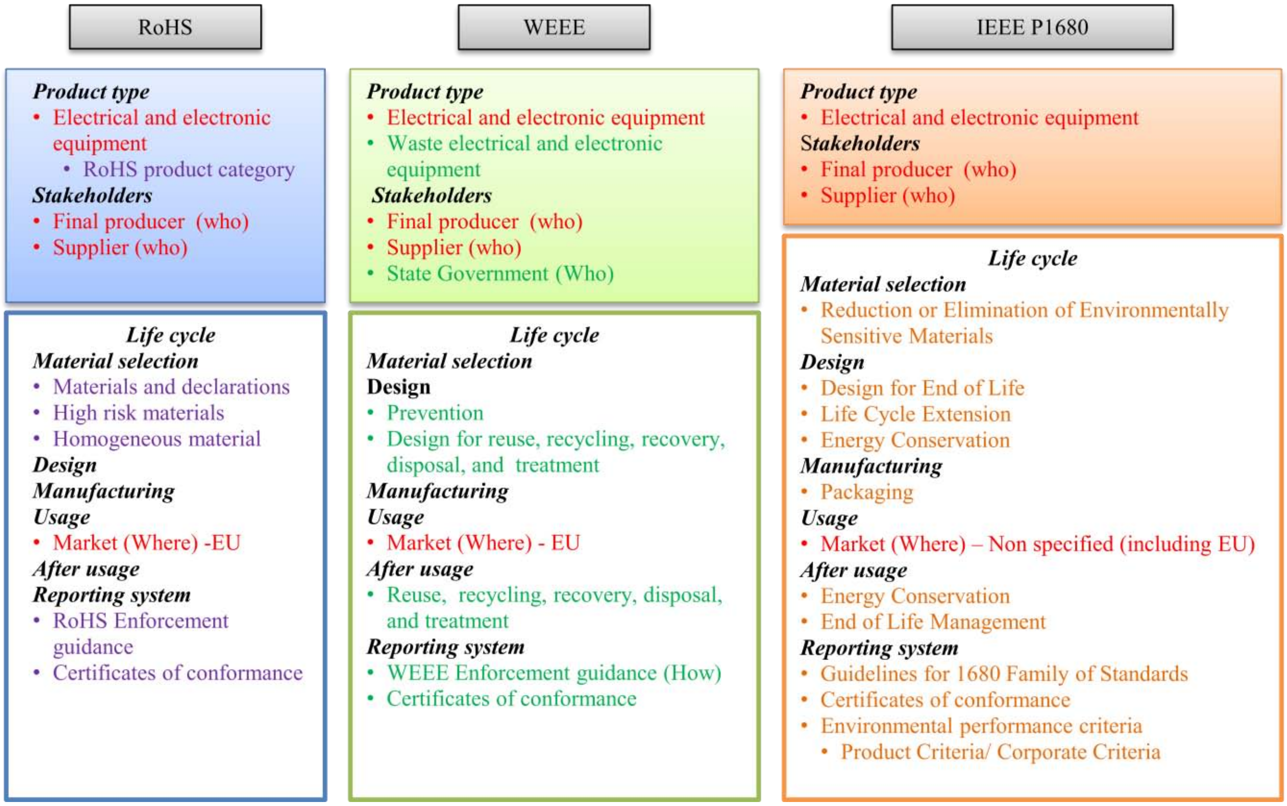

Figure 3. Comparison of standards.

In order to address 1) we must first recall Zachman details. In Section 4 we discussed how a Zachaman-based analysis offers different levels of abstraction, and how additional details can be learned from each level of abstraction. While this is a useful tool for learning more about a standard, it can only offer as much detail as the standard encompasses. A more detailed Zachman analysis does not always equate to improved comparison criteria. Some standards are simply more comprehensive than others, leaving gaps in the level of detail. This can be seen between RoHS, WEEE and P1680. Both WEEE and P1680 aim to address "environmentally sensitive" materials, while RoHS identifies six specific substances. In addition, RoHS explicitly states ten product categories, while both WEEE and P1680 refer only to electronics. It is P1680's reference to electronics which introduces the second lesson, addressing the existence of directly and indirectly stated information.

While RoHS explicitly states the ten product categories it was developed to address, the P1680 documentation refers to outside sources. The document declares it is meant to serve as a baseline for the P1680 family of standards (Currently consisting of IEEE 1680.1, 1680.2, 1680.3) and further details can be found in the additional reference materials. Reference materials such as these can complicate the gaps and overlaps analysis process, as additional documentation leads to further analysis. This will be discussed further in Section 6.

Continuing with the gaps and overlaps analysis, further divergence was seen in the "What" column when analyzing what processes each standard was meant to address. RoHS focused on the manufacturing stage of the product, while both WEEE and P1680 addressed multiples stages of a product lifecycle. The analysis of these lifecycles offers a third lesson learned: the need to address both explicit and implicit information.

While both WEEE and P1680 are meant to address the entire lifecycle of a product, P1680 addresses the lifecycle using eight separate categories, while WEEE uses six. For instance, P1680 addresses Design for End of Life, while WEEE addresses Reuse, Recycling, Recovery, Disposal, and Treatment. While Design for End of Life is not explicitly stated in WEEE, it contributes to each of the five criteria just mentioned in P1680. Though introducing the idea of implicit information brings a sense of ambiguity to the gaps and overlaps analysis, it is important to realize that such information may be necessary for effectiveness.

The analysis of the remaining columns of the contextual row offered contributions at various levels of detail. One notable result was created in the analysis of the "Where" column. Both RoHS and WEEE identified specific regions (The European Union), while P1680 identified where as "regions determined by Market Surveillance Entity," another example of direct vs. indirect information, however this time the source may vary. In the analysis of the "Why" column, the motivation for compliance of P1680 was determined to be the reduction of environmental impact, improvement of brand image, and achievement of market recognition through different levels of compliance. All of these reasons were to provide voluntary motivation, and left to the manufacturer to decide if compliance is worth the cost. RoHS and WEEE, however, were developed as directives. As European Union (EU) directives, compliance is no mandatory. In order for the manufacturer to sell its product in the EU it must comply with both RoHS and WEEE.

Now that we have discussed a proof-of-concept analysis, in the following section we will further discuss each of the encountered challenges and how they may be addressed. In addition, we will discuss how we believe our approach can be expanded to further applications.

6. DISCUSSION

6.1. Addressing Challenges

In Section 5 we presented a Zachman framework-based approach for analyzing and categorizing standards. The intention of the described approach was to identify the gaps and overlaps between a family of standards necessary to associate a product with a particular standard. The benefit of such an analysis is it can be used to provide stakeholders with insight into what standards may or may not apply to specific products, as well as the implications of meeting or not meeting a standard. The results of the proof-of-concept analysis demonstrated that, with only a contextual-level understanding of a standard, useful gaps and overlaps analyses can be conducted. The results also revealed several challenges that may be encountered in such an analysis. Here we will propose how similar challenges may be addressed in the future.

The first challenge we will address is differences in level of detail that different standards may offer. This is a challenge that may be best addressed using explicit information models. The benefits of representing standards as information models have been well documented. To address their goal of streamlining the IEEE standards development process, Read [18] explained how to view the information contained in IEEE standards not as simple unstructured documents, but as a structured collection of data elements that might be manipulated many different ways using model based techniques. With the development of explicit information models, the third identified challenge, identifying implicit gaps and overlaps can also be addressed.

The use of information models allows concepts to be made explicit. This explicitness can address challenges created by varying levels of detail and ambiguity. Explicitly representing and relating concepts to each other can provide insight into concept generalization. The relations can also provide insight into where implicit details may exist when comparing information models. Though the identification of implicit details may differ on a case by case basis, it is important to realize that they can exist and can be helpful when identifying gaps and overlaps.

The second challenge was addressing the information surplus that may develop when using multiple information sources. To address this challenge, it was best to first address the first challenge, harmonizing the level of detail and explicitness between standards. Once the level of detail provided by each standard is understood, then the need to abstract information from other sources can be addressed. For those standards with a more general level of detail and containing references to other sources, it may be best to analyze this information as well for an effective analysis. For those that are more comprehensive, it may be unnecessary to add from additional sources.

6.2. Potential applications

We believe that our approach to analyzing standards can be extended to address multiple applications to further serve the needs of different stakeholders. The approach detailed provides a solid foundation for future work aimed at assisting industry with standard compliance. Namely, we believe it can 1) serve as the foundation of a more detailed analysis to assist industry in identifying how to comply with standards, 2) be adopted to help develop product family information models, and 3) serve as the basis for the development of an industry tool.

It can be a daunting task to identify what changes, if any, must be made to business processes to ensure product compliance. While this paper used the Zachman approach to do a breadth analysis of product family standards, in [15] it was shown a similar approach can be used to provide an in-depth analysis. Providing additional depth to our approach has the potential to provide manufacturers with a method to analyze multiple standards and find out gaps and overlaps not only in the standard itself but also in different levels of the business procedures. This would indicate all the additional changes that are required to make a product compliant to another standard/directive. This additional complexity would benefit from the information management capabilities provided by information models.

With their diversity and importance, it stands to reason that standards should provide solid, comprehensive insight into the domains they were developed to guide. In Section 6.1. the benefits of information models were briefly discussed. In order to synthesize a family of standards it is necessary to analyze these standards from the information modeling point of view. This synthesis can lead the development of a common information model for standards belonging to a similar family. Information models are commonly used as a means for sharing and passing information within or between different organizations. They are able to provide formalized representations of knowledge and are often both human readable and computable. By representing the requirements of standards and regulations in a similar fashion, applicability[19] can be more accurately determined. The computability offered by information models also opens the door for the third possible application, the development of a tool.

In-depth analyses in combination with information modeling capabilities could be used to provide a knowledge basis for useful industry tools. After adopting some of the techniques proposed in our approach, we believe a computer-aided tool could provide a side by side comparison of required resources that the manufacturers need to allocate to make a product compliant to multiple standards and directives. Such a tool could assist evaluation and comparison of multiple standards in respect to areas such as what each standard measures, how these measurements are performed, what metrics are to be used, or what the difference in conformance criteria is.

7. SUMMARY

In this paper we proposed a product-minded approach to harmonizing standards. Using an analysis based on the Zachman Framework, we were able to identify both overlaps and gaps that may transpire when analyzing multiple standards associated with a single product domain. The results of the gaps and overlaps analysis provided explicit, useful, information pertaining to the sustainability standards RoHS, WEEE, and IEEE P1680. The proof-of-concept analysis revealed some of the challenges that may be encountered when taking such an approach, and these challenges were then addressed. While the results indicated our approach is able to identify gaps and overlaps in different standards, they also indicated that the certain variances must be accounted for, namely level of detail, source of information, and the possibility of accounting for implied information. Finally, we briefly discussed how our approach can provide a basis for expanded approaches to assist stakeholders in developing useful domain models and identifying necessary actions in business processes that will lead to additional standard compliance.

Disclaimer

Certain commercial products may be identified in this paper. These products were used only for demonstration purposes. This use does not imply approval or endorsement by National Institute of Standards and Technology, nor does it imply that these products are necessarily the best for the purpose.

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