An ontology-based knowledge representation using OWL for Indonesian local regulations

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ABSTRACT

Inconsistencies in legislation can significantly hinder the effectiveness and efficiency of the central and local government administrations. The Indonesian government requires standard harmonization of each piece of legislation to prevent such problems. However, this process is often manual and requires the involvement of multiple experts with varying backgrounds. This leads to high resource expenses regarding human resources, cost, and time. To address this, a software system should be developed to detect potential disharmony among legislation. However, the system requires a well-constructed legislation conceptual model represented in an appropriate modeling language. This research aims to develop the Indonesian local regulation ontology in web ontology language (OWL), where no such ontology exists. The ontology was created using the Ontology Development 101 methodology and evaluated using competency questions and expert judgment approaches. The resulting ontology becomes a basis for developing an automatic recommendation system to detect potentially inconsistent legislation in future works.

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1. INTRODUCTION

The success of a nation's development is closely linked to the management and enforcement of legislation that guides the government's administration, both at the central and local levels. Indonesia has various forms and legislation levels, each with its level of legal authority [1]. Such hierarchical arrangement reflects a tiered structure that directs the legislation-making process to be implemented using specific and standardized means and methods. All authorized institutions are bound by this hierarchy, which improves process coordination. Legal system reformation aims to improve the legal substance, structure, and culture, including reorganizing legal substance by reviewing and rearranging legislation based on legal principles and hierarchy.

Due to a lack of proper legal order, many issues with the existing legislation hierarchy lead to inconsistencies and disharmony. This problem negatively impacts the government administration's effectiveness, affecting the nation's competitiveness and strength. The main cause of this inconsistency is the overlap and conflict between central and local government legislation. Hence, the Ministry of Home Affairs canceled and withdrew many local regulations in recent years since such problematic regulations potentially hinder local economic growth, prolong bureaucratic processes, and contradict higher legislation [2].

The government has implemented a harmonization process outlined in Law No. 12 of 2011 [1] to address such inconsistencies. However, this process requires significant resources, including time, human expertise, and cost [3]. To streamline this process, a software system would be immensely helpful in that it can provide recommendations to relevant stakeholders due to legislation inconsistencies. However, it relies on a correct conceptual model of the legislation constructed using an appropriate modeling language, such as ontology, that is machine-processable. Unfortunately, such an ontology does not exist. This research aims to develop a preliminary ontology for representing local legislation at Malang City in East Java Province. Due to the vast and complex local regulations, we examined only regional revenues and expenditures budget (APBD) and taxation-related regulations, which are essential for local government administration.

This article is arranged as follows. Section 2 explores the related work. Section 3 introduces basic notions of the harmonization process and ontology. Section 4 describes the ontology development method. Section 5 presents the results and discussion. Section 6 draws a conclusion and future work.

2. RELATED WORK

The application of ontology for knowledge representation in various fields, including law and legislation, has been explored. ViLO was developed as an ontology for Vietnamese legal documents utilizing the NeOn methodology framework [4]. Hwang *et al.* [5] constructed a law ontology in Taiwan with legal keywords and relative definitions extracted from the laws and regulations database of the Republic of China represented in textual documents. Phan *et al.* [6] developed a legal taxonomy of semantic types in Korean legislation. Palmirani *et al.* [7] proposed a legal ontology on the general data protection regulation (GDPR), providing a legal knowledge model for general data protection regulation. Similarly, there have been studies in other fields [8]–[12].

3. BASIC NOTIONS
3.1. Indonesian legislation and harmonization process

The 1945 Constitution of the Republic of Indonesia and the local regulations are, respectively, at the highest and lowest levels in the hierarchy of legislation in Indonesia [1]. The local regulations include provincial and regency/municipal regulations. Provincial regulation comprises provincial regulation and governor regulation, while regency/municipal regulation comprises regency/municipal regulation and regent/mayoral regulation. In practice, the intensity of local regulation-making in Indonesia is very high compared to other legislation types [13]. This high intensity was triggered by the implementation of regional autonomy, which significantly motivated local governments to regulate their regions with various local regulations. In such a situation, inconsistency among legislation, which should be harmonized, potentially occurs.

The harmonization problems include overlapping and inconsistent legislation, unclear legislation formulation, and hampered implementation [3]. The harmonization process is carried out vertically and horizontally. Vertical engagement requires the content of the legislation does not conflict with the legislation above. While horizontal engagement requires the new legislation to override the old legislation. Further, the specific legislation overrides the general legislation. The problems in local regulations mainly originate from local regulations on taxes and retributions [13]. Some factors that cause such problems include ignoring community participation and limited competent human resources in drafting local regulations.

3.2. Ontology

Some ontology definitions exist in computer science. According to Gruber [14], "an ontology is an explicit specification of a conceptualization". Based on Studer's definition [15], "an ontology is a formal, explicit specification of a shared conceptualisation". While Noy and McGuinness [16] defines "an ontology is a formal explicit description of concepts in a domain of discourse". As such, conceptualization refers to an abstract model of related concepts in some phenomenon in the world explicitly defined and formally represented in a machine-readable format. Such conceptualization captures common knowledge acceptable to all relevant stakeholders.

An ontology combined with all related individuals of classes constitutes a knowledge base. Classes or concepts represent things in a particular domain, e.g., person, doctor, nurse, and patient in the healthcare domain. Individuals represent instances of classes, e.g., John Smith is an individual of the doctor class. Each class has at least one property, i.e., a relationship, to another class, so there is no island in an ontology. For

example, we may specify an 'instance of' the relationship between doctor and John Smith. Further, we may define a 'subclass of' relationship between Doctor and Person. Thus, the ontology can be used as a knowledge base for a problem domain in processing related to semantics, such as analyzing inconsistencies in legislation, without using complex natural language processing techniques (NLP). In practice, we may develop ontology from written documents through an information extraction process. Furthermore, ontologies share a common understanding of the information structure for stakeholders. As a result, ontology technology is widely used in various application domains, such as legal [17], [18], bioinformatics [19], medicine [20], and commerce [21].

Building an ontology involves methodology, language, and editing tools. Many ontological methodologies have been proposed, e.g., ontology development 101 [16], on-to-knowledge [22]. The ontological languages are used for describing ontology in a machine-readable manner to construct a formal description of concepts within a particular domain. They are classified into two categories, i.e., traditional and web-based ontology languages [23]. Traditional languages use the knowledge representation (KR) approach, e.g., ontolingua [24], OKBC [25]. While web-based languages use a markup approach mostly in XML, e.g., resource description framework (RDF) [26], web ontology language (OWL) [27]. OWL is a popular language developed by the world wide web consortium (W3C) based on DAML+OIL, as the extension of RDF [28]. OWL2 specification [27] is available as the extension of OWL1. The editor may be used for one or more ontological languages, e.g., Protégé, the most popular software developed by a Stanford University team [29].

4. METHOD

4.1. Methodological approach

We adopt a knowledge-engineering methodology [16] to develop ontology from scratch, as follows:

− Determining the ontology's domain and scope. This step defines the domain and scope of the ontology being developed. The domain specifies the area of the ontology discussion. The scope specifies what should and should not be included within the domain. For scoping purposes, we can utilize competency questions to verify whether or not related information is appropriately available in the ontology.
− Enumerating important things in ontology. All terms/concepts related to the domain and scope will be enumerated. We should focus on the concepts without worrying about their relationships, properties, and types [16]. All concepts may be extracted from domain experts and related documents.
− Defining the class and its hierarchy. All classes and their hierarchy will be defined based on all enumerated terms/concepts using a specific approach, i.e., top-down, bottom-up, or combination. The top-down approach starts with defining the most general concepts towards the most specific ones. The bottom-up approach starts with the most particular concepts towards the most general ones. The combination approach may begin with a few top-level and low-level concepts, followed by all middle concepts.
− Defining the properties of classes and creating instances. This step defines each class's properties, representing each concept's internal structure, including data and object properties, such that all competency questions can be answered properly. Some properties, i.e., intrinsic and extrinsic properties, parts, and relationships, may be considered. Further, we create all instances of the corresponding classes.

4.2. Data source and implementation tool

The primary data sources come from the local regulation documents downloaded from the Malang City legal documentation and information network website in pdf format [30]. Two relevant local regulations include municipal and mayoral regulations, which cover APBD- and taxation-related domains. All documents are written in the Indonesian language. We use Protégé desktop and its visualization plug-in OntoGraf [31] as the ontology editor to implement concepts and their relations.

4.3. Ontology evaluation

The evaluation uses a litmus test based on the constructed competency questions [16]. In addition, expert judgment is also used to evaluate the developed ontology based on the specified validity criteria to assess its correctness, including syntactic and semantic correctness. Syntactic correctness refers to the conformity of any used notation within the ontology language. In comparison, semantic correctness refers to the comprehension of the local regulations domain. Therefore, the presented ontology model of legislation in local government will be the essential contribution of this research.

5.   RESULTS AND DISCUSSION

5.1.   Determining the ontology's domain and scope

The ontology's domain is the APBD- and taxation-related local regulations in Malang City, Indonesia. Such local regulations are represented in municipal and mayoral regulations, which still apply in 2021. This restriction provides 46 local regulations to study, as described in Table 1. The ontology's scope is determined by the constructed competency questions [16], which can be used for ontology evaluation later. We identify the following competency questions:

— What is the hierarchy of legislation related to local regulations, which is fundamental for the future software-assisted legislation harmonization process? [CQ1]
— What provisions are regulated in local regulations for APBD or taxation in Malang City? [CQ2]
— Which regulations relating to APBD or taxation still apply today in Malang City? [CQ3]

Table 1. Detail of studied local regulation documents

Domain	Local regulations type		Total
	Municipal	Mayoral	
APBD	11	17	28
Taxation	6	12	18
Total	17	29	46

5.2.   Enumerating important things in ontology

All related terms/concepts written in the studied documents are identified in a list, i.e., nouns (objects), to be used in the subsequent classification of classes and instances. In this research, we translated every concept into English to make the knowledge understandable. However, given so many concepts to identify from so many local regulation documents, we only take the most important and basic concepts. The essential concepts include legislation, 1945 constitution, MPR (people's consultative assembly) decision, law, government regulation, presidential regulation, provincial regulation, regency/municipal regulation, governor regulation, regent regulation, mayoral regulation, local government, mayor, DPRD (regional house of representatives), APBD, taxation, and regional instrument. In addition, we also consider other essential concepts concerning the general description of the legislation itself, i.e. attribute, provision, and domain.

5.3.   Defining the class and its hierarchy

Figure 1 describes the top-level ontology representing the legislation domain based on the enumerated concepts. Every class is a subclass of thing. This top-level ontology includes the legislation class and all related classes representing its general description, i.e., attribute, provision, and domain. Attribute covers a description of the legislation relating to the number, topic/subject, and year. Provision corresponds to all material content of the legislation. Domain refers to the area in which the legislation applies. We consider each legislation to have a general description.

Figure 2 depicts all levels of the constructed ontology. The second-level legislation ontology covers all subclasses of each top-level class, as presented in Figure 2(a). This figure also denotes the third level, especially for Legislation class to show all its legislation types as regulated in [1]. ProvincialRegulation class is further divided into two specialized classes, i.e. FirstLevelLocalRegulation, GovernorRegulation. Regency/Municipal Regulation class is further specialized into three classes, i.e. SecondLevelLocalRegulation, RegentRegulatioin, MayoralRegulation. Figure 2(b) depicts the excerpt of the Provision class and all its subclasses representing all provisions regulated in MayoralRegulation and SecondLevelLocalRegulation.
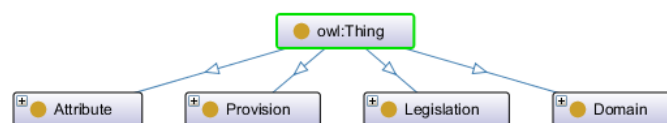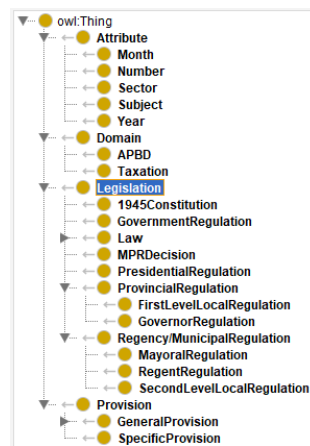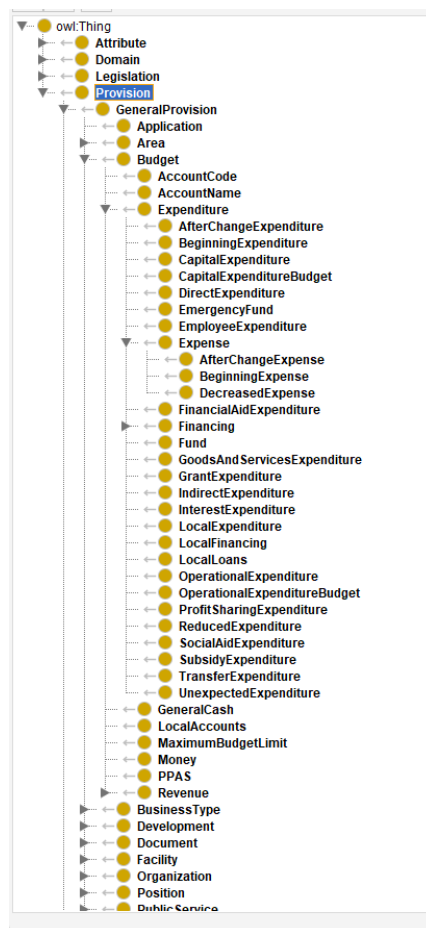

Figure 1. The subclass hierarchy of the top-level legislation ontology

(a)

(b)

Figure 2. Class hierarchy of local regulation ontology (a) the second- and third- levels legislation ontology and (b) the excerpt of provision class and its subclasses

5.4. Defining the properties of classes and creating instances

To answer the defined competency questions, each class requires specification of its object and datatype properties so that every class can be adequately understood. OWL properties constitute relationships. Figure 3 illustrates the excerpt of properties of the Legislation class and its environments. To make it more

understandable, we annotate such a figure with the corresponding relationship names according to their properties specified in Protégé. Legislation, derived from Thing, has many relationships, i.e. hasAttribute to Attribute class, hasProvision to Provision class, hasDomain to Domain class. While all subclasses of Legislation have confirms relationships with each other to realize the legislation hierarchy regulated in [1], e.g. Regency/MunicipalRegulation confirms ProvincialRegulation.
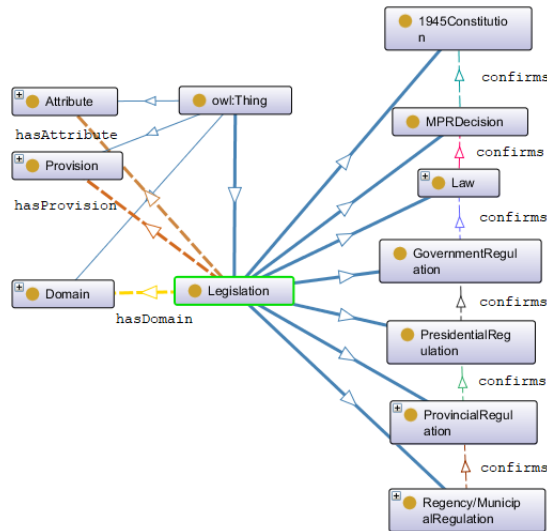
Figure 3. The excerpt of properties of the legislation and its subclasses

Further, we created individuals or instances of defined classes in the hierarchy. Since we study legislation in Malang City, MayoralRegulation and SecondLevelLocalRegulation apply. Figure 4 depicts the individuals or instances of the MayoralRegulation class. Figure 4(a) illustrates all instances of the MayoralRegulation class represented by hasIndividual property. We annotate such a figure with the relationship names according to their properties specified in Protégé. Such instances are related to APBD class derived from Domain class. While Figure 4(b) shows the excerpt of all individuals of the MayoralRegulation class. Each instance is denoted in its year and number, e.g. 2020/18 means a MayoralRegulation number 18 in 2020.

(a)   (b)
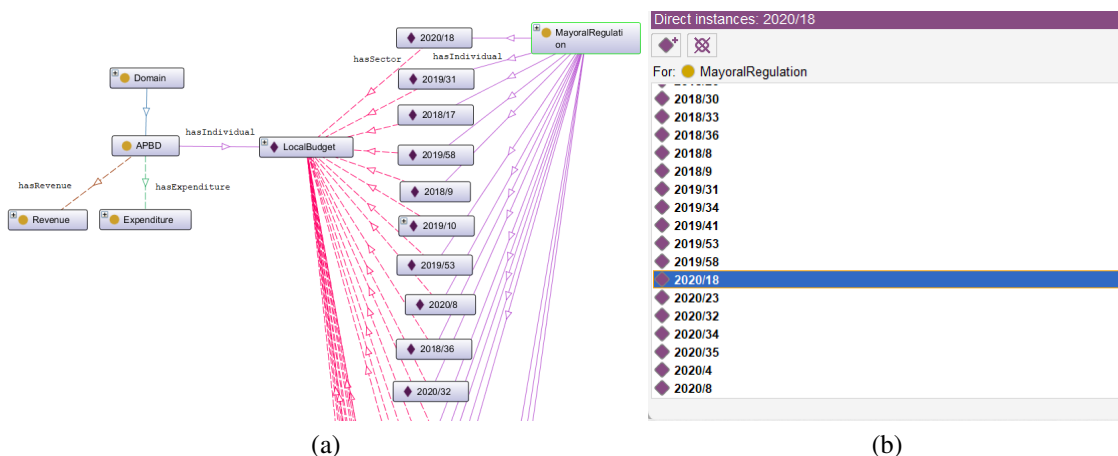
Figure 4. Class instances of local regulation ontology (a) LocalBudget, as the instance of APBD class, corresponds to the instances of MayoralRegulation class and (b) the excerpt of the instances of MayoralRegulation class

5.5.   Implementation and evaluation

The ontology is constructed in OWL using Protégé 5.5.0. We use OntoGraf 2.0.3 plug-in to navigate the classes and their properties interactively. The quality of the ontology is evaluated using the provided competency questions, which are already addressed by information illustrated in Figures 2(a) and 3 for CQ1, Figure 2(b) for CQ2, and Figure 4(a) for CQ3. We may also utilize SPARQL to evaluate such questions. Further, expert judgment assesses such ontology, resulting in the same conclusion.

6.   CONCLUSION AND FUTURE WORK

This article discusses a preliminary result of the Indonesian local regulations ontology in OWL. Such ontology comprises concepts and their relationships related to APBD and taxation domains, provisioned in mayoral and second level local regulations in Malang City. It becomes a fundamental part for further challenging research. Future work includes refining the presented ontology and completing it with other domains, e.g., education, infrastructure, and public health. We also consider to develop a tool for transforming local regulation documents into corresponding solid ontology.

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