Design and development of a digital compliance workbench

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Abstract

This paper reports on the design and development of a digital compliance workbench. It examines a series of experimental developments over the course of 15 years to allow domain experts from the regulatory sector and from the design sector to create and deploy automated compliance checking. It explores the criteria that such a system must meet, examining each of Eastman's 4-stage approach. Conclusion are drawn about the requirements for such a system, and the future development of the workbench and other solutions.

Problem statement

Many authors have summarised the research effort on automated compliance checking over the last 20 years. Most papers have focussed on the deployment of specific technologies related to BIM so as to implement a selected clause or class of clauses. There has been relatively little work on how this research work could be implemented as a complete system. A paradigm based on direct coding was established around the turn of the century by the Solibri desktop (2023) and Singapore ePlanCheck service (Solihin, 2018) and was described by Eastman (2009). Lee et al. (2020) reviewed IfcDoc, KBim, ePlanCheck, ACABIM, and SNACC, though not all of those are intended as automated compliance checking solutions. The direct coding paradigm has been unchallenged at least until the DCOM project (Beach et al, 2023). Zhang (2023) has offered some criteria from the point of view of designers. Bloch et al (2023) and Fauth et al (2022) have looked at the building permitting process in several jurisdictions from the point of view of the authority.

Specific research question

There is a gap in envisioning how applicants and inspectorates might implement newer techniques. and what the benefits might be over traditional coding approaches.

Method

This paper examines the development of a automatic compliance workbench 'AEC3 Require1', exploiting opportunities for increased accuracy, efficiency and completeness, so as to explore the requirements for and obstacles to the deployment of compliance checking. Using Eastmans 4 steps (2019)

Iteration (1) "rule interpretation and logical structuring of rules for their application";

Iteration (2) "building model preparation, where the necessary information required for checking is prepared";

Iteration (3) "the rule execution phase, which carries out the checking";

Iteration (4) the reporting of the results.";

Introduction

RASE is a knowledge ontology that can be represented as coloured mark-up in regulatory documents. The RASE methodology was first developed in 2007 to support the US ICC in their SmartCodes initiative. The motivation for a new method was that neither the existing desktop compliance tool (Solibri) not bespoke programmed solution (ePlanCheck) could deliver the accuracy and efficiency needed to automate the range of building code (regulation) found in 3000 county jurisdictions across the USA. A second motivation was that it was found that no spreadsheet/database template could manage the syntactic complexity of the ICC regulations. The RASE ontology was adopted as a flexible and efficient solution. Initially an off-the-shelf XML editor was used to add the RASE markup into ICC's proprietary XML document format. PNNL was commissioned to develop a 'SmartCodesEditor' to support the mark-up process and hide the technicalities of XML. Three separate rule engines were developed to demonstrate a fully automated code compliance system. Both Solibri and ePlanCheck were reconfigured to load and execute rules generated from the marked-up documents. A new solution named 'Xabio' was developed by AEC3 UK Ltd to exploit the methodology further including fully customized reporting and the generations of explanations and recommendations around the checking results. All three solutions consumed the rules as IFC constraint model and used IFC as the target project model.

In work for the USACE, RASE was generalized for use with HTML, reverting to an off-the-shelf XML editor. Text to be marked up was scraped from the WBDG website as HTML. Tables of medical room requirements were mapped systematically into HTML sentences with mark-up added systematically. This approach embedded several non-value-adding processes and assumptions. In order to allow domain experts to engage with the process, AEC3 began considering what a compliance workbench might look like.

Narrative

This paper considers the subsequent design and development of a compliance workshop so as to explore the requirements for and obstacles to the deployment of compliance checking. Using Eastmans 4 steps (2019)

> Iteration (1) "rule interpretation and logical structuring of rules for their application"; this stage of the development reduced the interpretation required, replacing it with RASE colored markup and where needed additional metadata to confirm numeric constraints. Multiple presentations (beyond the IFC constraint model) were developed to support the validation and re-use of the normative content.
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> Iteration (2) "building model preparation, where the necessary information required for checking is prepared"; this stage required the development of an interface to a dictionary of mappings, and further development of the handling of unknowns.
>
> Iteration (3) "the rule execution phase, which carries out the checking"; this stage required the implementation of a Case based approach where multiple federated regulations can be checked against multiple federated models.

Iteration (4) the reporting of the results."; this stage reintroduced a checking engine, previously implemented as a stand-alone command line application. Several refinements were introduced, including the reporting and enquiry for unknown values, the generation of certificates and other presentations. Other outputs include BCF. Finally a 3d view was added

Discussion

DCOM mirrors in a distributed architecture the same functions as found within the workbench. Several features of 'AEC3 Require1' remain unique.

- The flexibility of presentations and integrations from the RASE markup.
- The flexibility and deep diagnostics from the results.
- Authoring interfaces for managing dictionary resources.
- The management of a case as the key metaphor for applicants and inspectorates.
- The management of supplementary submittals.

Conclusion

The development of the compliance workbench has evolved to become a complete solution to the decision making element of a full DBP process, handling both the inputs and the common knowledge. If automated compliance checking is going to be adopted widely, then alternatives to the conventional coding paradigm are needed. The development of the compliance workbench has evolved to become a complete solution to the decision making element of a full DBP process. It provides a benchmark of functionality and opportunities which can be used in the next generation of solutions such as DCOM and the current EU projects.

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