Automated Compliance Audit of Fire Engineering Designs

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Background and Introduction

We live in a built environment designed in accordance with regulatory standards that protect the occupants, neighbouring properties, and the environment from harm and damage. All buildings in New Zealand must achieve the performance standards prescribed by the New Zealand Building Code (NZBC), which is the official set of performance-based regulatory documents.

Regulatory compliance audit in the Architecture, Engineering and Construction (AEC) domain is a major undertaking that is currently conducted manually. Automating this laborious and costly process has been the subject of considerable research [1, 2, 3, 5, 6, 7, 8, 9], but has no viable solution to date. The main challenge has been the continued practice of paper-based information exchange in the industry. The emergence of an ISO standard Building Information Modelling (BIM) to represent buildings as semantically rich digital objects has the potential to address part of the problem. However, there is still the need for an efficient computerised regulatory knowledge base and an effective method of processing these representations.

Motivation

In New Zealand, the AEC industry represents 8% of the economy and contributes 5% to GDP. Research has shown that a 1% productivity boost in this industry is worth a $300 million gain in annual GDP [4]. The government's target of 20% productivity improvement by the year 2020 is equivalent to $6 billion in annual GDP, which is a significant saving.

Any level of automation in the compliance process would contribute to this productivity boost and savings in the long run. More importantly, the ability to automate regulatory compliance audit is an incentive for the BIM uptake, which would streamline information sharing across the industry, reduce project time, minimise human-errors, and contribute to higher quality, safer and more economical buildings.

Objectives

- To develop a practical computerised representation of performance-based building codes with an application to New Zealand's fire codes.
- To implement an effective method of extracting required data from ISO standard BIM-based models.
- To develop a framework that could process the building model and the regulatory requirements to support automated performance-based audit.

Discussion and Summary

The ability for regulatory knowledge to be managed by domain experts, e.g. graphically via BPMN, is considered an important factor for the design of this system, which is to be evaluated using non-empirical Human Computer Interaction usability metrics.

A regulatory knowledge representation for performance-based fire safety design has been successfully developed to validate the framework. Qualitative criteria, however, require supplementary data from external computational tools to evaluate. Further work is to be undertaken to interface with these external tools.

Automated Audit Framework

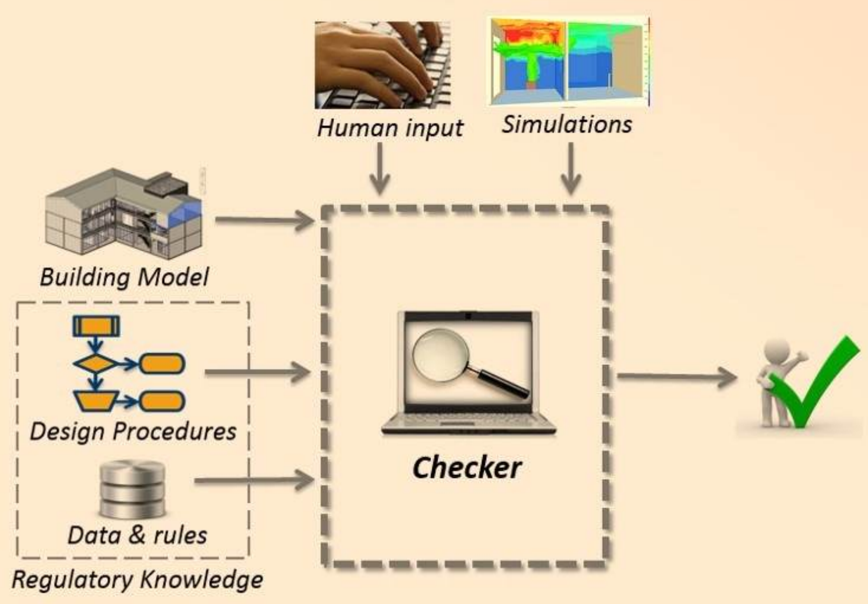

Figure 1: Proposed Automated Audit Framework

The proposed framework (figure 1) has the compliance checker at the core pulling in the building model (or a subset of the building model) and validating it against a library of a regulatory knowledge base.

The framework will have the ability to bring in results from external computation or simulation tools to help with evaluating qualitative performance-based criteria.

Some human input is anticipated to provide information that may be required but is missing from the building model.

Methodology

Regulatory knowledge can be represented as a set of compliant design procedures (figures 3 and 4) with the associated regulatory data and rules (figure 5) for different aspect of designs, e.g. fire safety, structural stability, etc. The representation can be maintained graphically by designers and regulators via the Business Process Model and Notation (BPMN) to suit different design scenarios and to help manage recurring code amendments.

An automated compliance audit starts with a particular design procedure, which extracts relevant building components from the BIM model (figure 2) and validates them against the associated regulatory rules. The output of the framework is a report highlighting any unresolved violations.

Figure 2: A BIM-based model

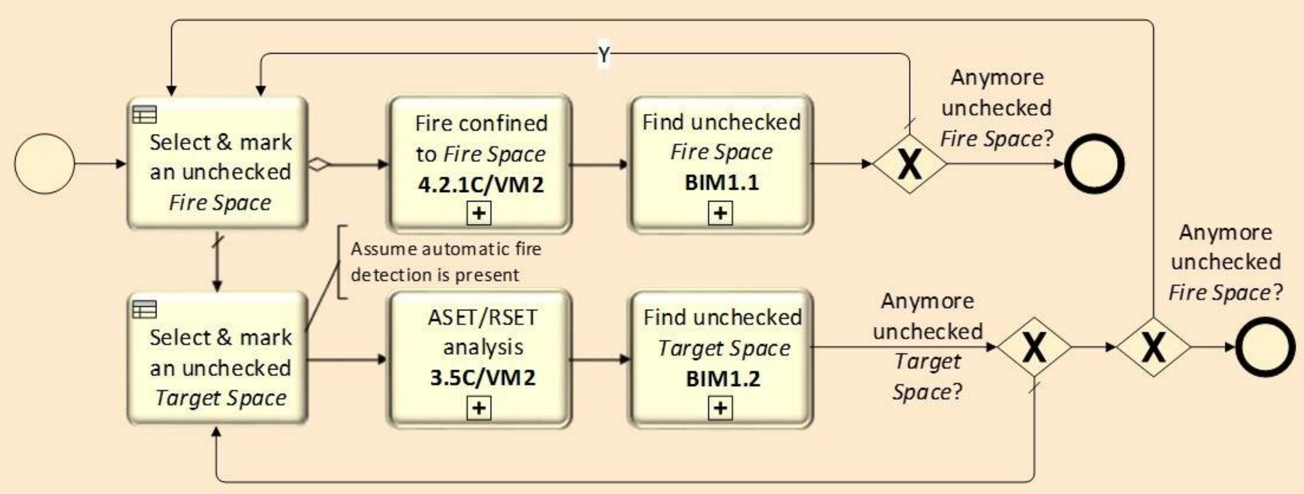

Figure 3: A compliant design procedure in BPMN 2.0

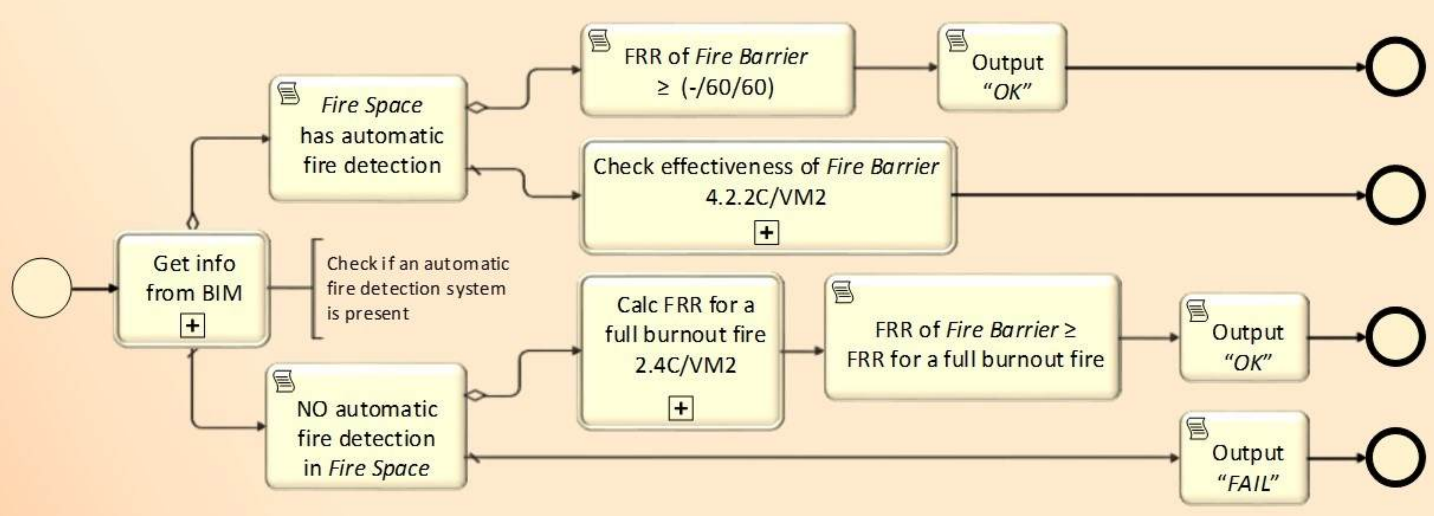

Figure 4: A compliant design procedure in BPMN 2.0

```
rule "CheckDoorOpeningDirection"
  when
    Occupant (OccupantLoad > 50) &&
    ExitDoor (OpeningDirection == "in")
  then
    alert("Door must open outwards");
end
```

Figure 5: Exemplar rule object in Drools Rule Language

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Acknowledgement

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