



Proceeding Paper

BIM-SPEED Inhabitant's App: A BIM-Based Application for Crowdsourcing of Inhabitants' Input in Renovation Projects [†]

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Abstract: This report summarizes the conceptual framework and the technical implementation of a BIM-based user-friendly application to gather inhabitant's input in the context of renovation projects developed in the European funded project BIM-SPEED. It starts with the underlying objectives and the role of data acquisition in the project. Then, it explains and outlines the conceptual framework and the methodology used in relation to the identified use cases, where inhabitants' input is required. Furthermore, it describes the implementation and the development of the proposed methods as a user-friendly app and, finally, it ends with ethical and privacy considerations, specifically the measures taken for safe handling of privacy-sensitive data.

Keywords: crowdsourcing; building information modeling; data collection; energy efficiency; renovation; inhabitants' comfort; data privacy



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1. Introduction

The BIM-SPEED project aims to improve energy efficiency of the existing buildings by means of BIM to reduce the planning, execution, engineering time, and costs of renovation projects [1]. This will be achieved by developing required protocols and technologies for providing a cloud-based and affordable BIM platform that can interoperate with a set of BIM tools to be utilized in all cycles of the renovation processes. In the context of as-built data collection, one of the objectives is to collect inhabitants' input from an existing building to complement the required input for further analyses and simulations, especially in relation to the comfort of inhabitants [2,3]. The proposed app is supposed to be tested in one of the BIM-SPEED demonstration cases located in The Netherlands.

2. Conceptual Framework

Inputs from the inhabitants are essential to detect the changes and weaknesses of an existing building as well as to develop optimal renovation strategies. To collect such inputs, a user-friendly application was developed.

One of the primary questions pertains to the identification of the data that needs to be collected from inhabitants [4]. This information can be collected at different levels (unit of observation). The unit of observation can differ from the most public unit (building level) to the most private unit (a component within the apartment, e.g., a kitchen).

We have identified all established BIM-SPEED use cases, particularly those which require inhabitants' inputs to perform specific assessment and, thus, to serve specific renovation goals. Next to the identification of the use cases, we have classified the potential privacy concerns with respect to the data to be collected from inhabitants, as shown in

Figure 1. For more information, check this tutorial (https://www.youtube.com/watch?v=_eJnRpQWUZM, accessed on 7 December 2021).

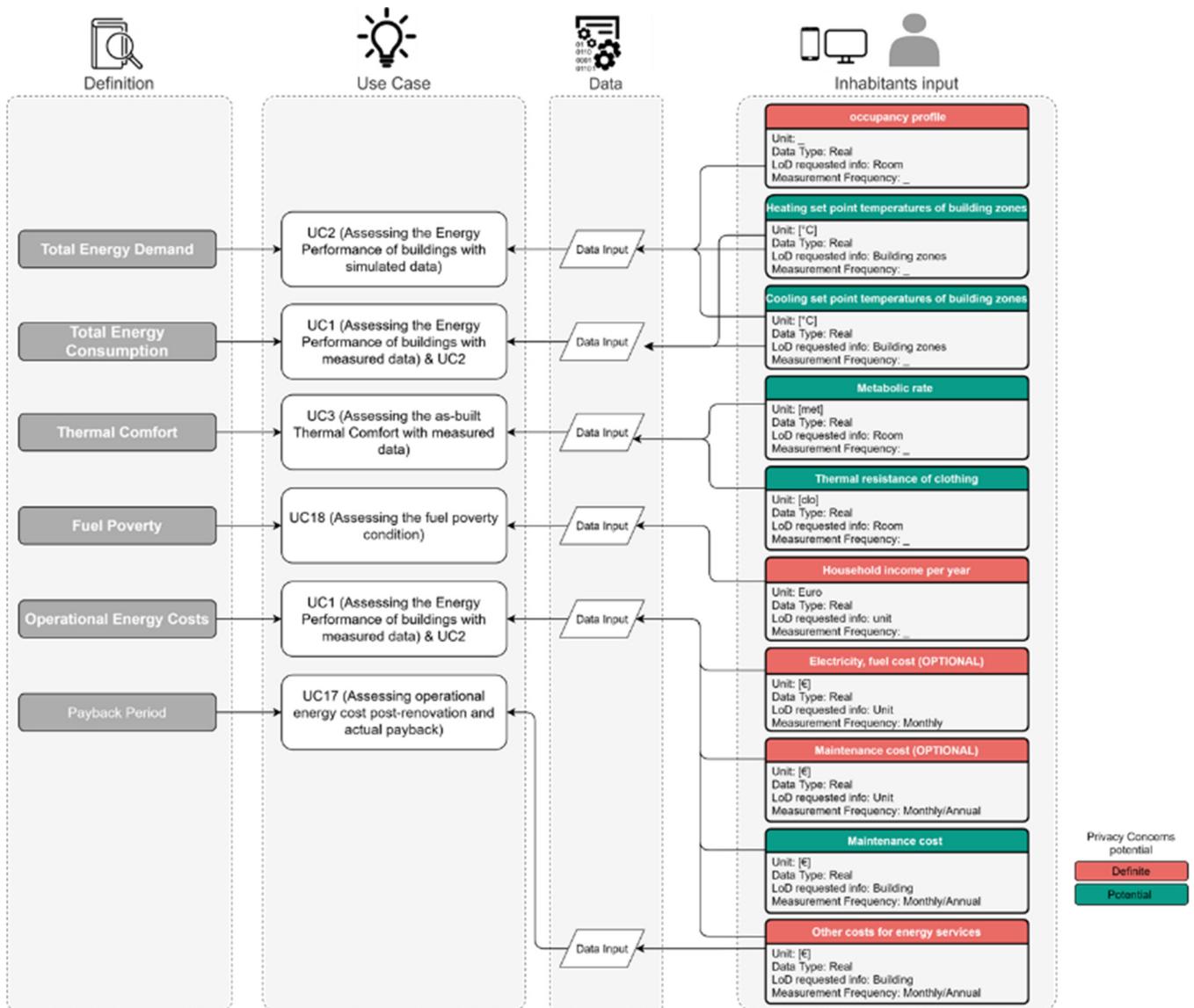


Figure 1. Relevant use cases and their privacy concerns of the collected data.

- A collected series of questions related to each use case, is divided into two categories:
1. **spatial questions**—such questions are pertained to a specific space (e.g., a room). In this case, all the collected responses relate to a global unique identifier (GUID) of that specific room for further analyses. This is achieved by implementing a BIM model in the app, which enables inhabitants to select a specific room or a component while replying to the set of questions;
 2. **non-spatial questions**—such questions are not pertained to a specific space. An upload functionality enables a user to provide additional material.

The collected information is stored structurally in the platform in such a way that it can be used by other tools for further analyses and calculations.

3. BIM-SPEED Inhabitants App

3.1. Conceptual IT Architecture and Workflow of BIM-SPEED Inhabitants App

The IT architecture for the BIM-SPEED inhabitants app is roughly divided in server-based functionality and mobile device functionality as seen in Figure 2. On the server, question lists are imported, configured, and made ready for distribution towards the relevant participating inhabitants. The mobile device draws upon the question lists and allows inhabitants to fill in relevant information before sending the results to the server. The server then processes these answers and enables a subsequent upload to the BIM-SPEED platform.

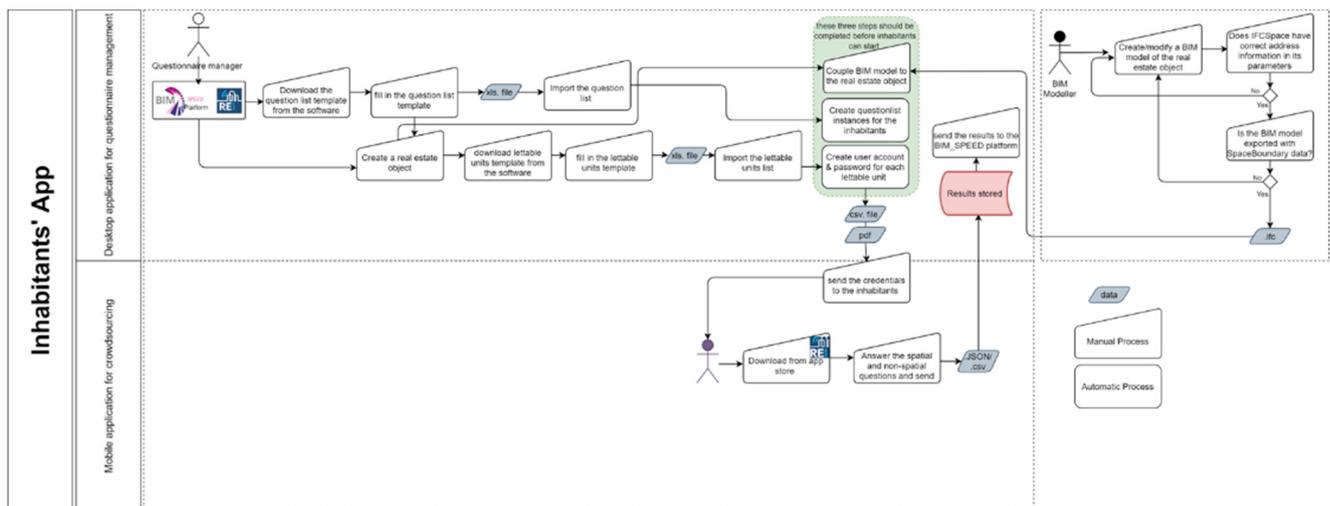


Figure 2. The conceptual IT architecture of the app.

3.2. Existing Tool and BIM-SPEED Adaptations

The BIM-SPEED inhabitant app is an upgrade of the older version module of Real Estate Suite (<https://www.demobv.nl/nl/re-suite>, accessed on 7 December 2021), which contains pre-existing architecture for managing question lists and distributing them to mobile devices that allow users to input the requested data.

One of the specific needs of the app was the BIM viewer which was reworked so that the space-based interaction was added to allow users to select spaces instead of elements and filter based on the floor. The excel template which is used to import rich question lists supports both open and multiple-choice questions as well as optional nesting of questions in groups and allows for additional (non-)hierarchical themes.

Question lists and BIM models are able to be linked by use of spatial questions. These questions guide the user to the 3D viewer where they can select a space in a BIM model as an answer to the question. In the background which is shown in Figure 3, the GUID of the space is extracted from the BIM model and used as an answer to the question.

3.3. Functionalities of the App

- Translation to other languages: The framework of the app uses a multilingual system by which the translation of all UI elements can be arranged automatically.
- Installation and configuration: The app can be downloaded from generic application stores such as the Apple AppStore.
- User identification: Users log in with their unique username based on postal code and unit number. This both uniquely identifies users and their apartments.
- User consent: Informing participants about how their data are collected and being used by the project is a basic requirement via a consent form.
- Navigating questions: The questionnaire is ordered in logical groups, which are displayed in summary using a (collapsed) tree-like structure.

- Answering questions: The user is guided to provide an appropriate answer for each question. For open questions, a text entry field allows any textual input. For multiple-choice questions, the available options are shown in a list. The app also allows users to take photos through a native device camera as an addition to textual answers. For questions that relate to the BIM-Model, the 3D model of the building, which can be rotated and zoomed in or out, is shown by clicking the 3D viewer button.
- Exhaustive questioning for room types: The question list contains questions relevant for room types, of which there may be multiple instances. A user will be led through a group of questions and finish with the question whether there is another instance. If answered yes, the user will be asked another group of question. This iteration repeats until the user indicates that there are no more instances.
- Completing the questionnaire: At the end, the user returns to the questionnaire summary, where he can review the answers and correct them if desired. Once satisfied, the user can choose to hand in the questionnaire.

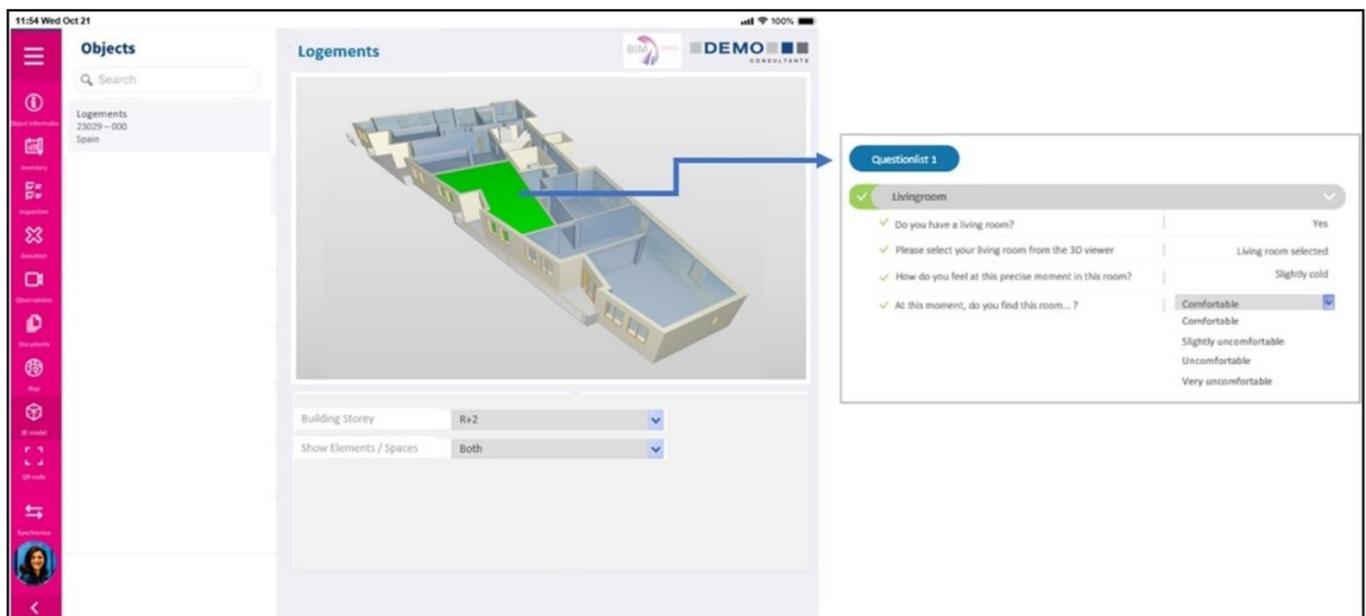


Figure 3. Spatial questions linked to the BIM model.

3.4. Storing the Result in the BIM_SPEED Platform

Question lists and their answers are stored securely in a SQL database. Transmitted data are end-to-end encrypted through the HTTPS protocol. On disk, the data are encrypted using transparent data encryption (TDE). For the purposes of BIM-SPEED, the answers are exportable by generating several JSON documents. Filenames identify the relevant postal code, unit number, and logical grouping of its contents. All JSON documents are uploaded to the BIM-SPEED platform. The upload process makes use of the following API call, which is specifically offered by the KROQI EDMS Server API:

```
/api/1.0/edms/projects/{project_id}/docs/{doc_id}/content
```

This API call can be used for both document content retrieval as well as document content update. In the case of document content updates, this call is used as a PUT request. The data stream is end-to-end encrypted through use of the HTTPS protocol.

4. Compliance with Privacy and Ethical Considerations

The data collected through the inhabitants app is seen as vital to achieve the objectives of the BIM SPEED project, as it will produce valuable data based on the lived experiences of occupants which are not easily achieved through sensors or monitoring equipment.

However, the use of this app relies on potentially sensitive personal data for effective use within the project. This raises privacy and ethical concerns; thus, the means to deal with key issues relating to the crowdsourcing of inhabitant information through the app was identified and determined.

- Inhabitant-informed consent informs participants about how their data are collected and used by the project. This indicates that data will be kept confidential and stored securely and that no personally identifiable information will be included in project reports or outcomes.
- Privacy and purpose specification is a critical aspect within the General Data Protection Regulation (GDPR) which requires assurances on safe handling of privacy-sensitive data. The tools and workflows used within the BIM SPEED project, in particular, the use of the inhabitants app, is fully GDPR-compliant.
- Data security is ensured and transferred between relevant databases within Europe. No inhabitant can view another inhabitant's answers or even the questions they were asked. Server-side data are protected by both firewalls, encryption, and authentication mechanisms, allowing access only to (a specified subset of) BIM-SPEED consortium members.

The integration of the data these processes within the developing BIM-SPEED platform and toolkit remains central to ethical concerns raised by digitalization processes within the renovation sector. Inhabitant participation in the BIM SPEED process should be seen as both an asset and a liability and the data produced treated with special attention.

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Conflicts of Interest: The authors declare no conflict of interest.

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