

University of Technology Sydney  
Faculty of Engineering and Information Technology

**Development of Multi-Level Indoor Navigation  
Ontology for Location-Based Services**

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## **Certificate of original authorship**

I, Sanya Khruahong declare that this thesis, is submitted in fulfilment of the requirements for the award of the degree of Doctor of Philosophy, in the Faculty of Engineering and Information Technology at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise reference or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

This document has not been submitted for qualifications at any other academic institution.

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## **Abstract**

About 90 percent of human activities are in indoor environments. A need for indoor navigation requires Location-Based Services (LBS). The LBS should be able to help people find the best route inside a building under all circumstances and with high reliability, supporting users to navigate to all indoor spaces on every level of a building.

The current research has been focusing on technologies and applications for LBS. There is little work on a standard for LBS. This research contributes to a new LBS standard using ontology theory. Two ontologies are developed in this thesis. Firstly, a Multi-level Indoor Navigation Ontology is developed. This ontology builds the standard for LBS in multi-level indoor environments and considers the building status of emergency and normal states for user navigation. This ontology is designed to present environmental attributes including location nodes, connection points, and building status in a multi-level building. Indoor location nodes with location information allow for navigation within a building, with connection points which can separate the map zones and the building floors. Secondly, an ontology for finding lost property in a multi-level indoor space is developed as a sub-level standard in an LBS application. These two ontologies are validated using experiments using an iBeacon network in a high-rise building.

**Keywords:** Indoor Navigation, Indoor Space, Indoor Ontology, Location-based Services, Smartphone

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