

# Personalised Information Systems in Multi-Modal Transportation Decision Making

Nicholas Gould<sup>\*1</sup>, William Mackaness<sup>†2</sup>, Sean Bechhofer<sup>‡3</sup>,  
Robert Stevens<sup>§3</sup>, Laurie Cooper<sup>\*\*1</sup>

<sup>1</sup>Manchester Metropolitan University, <sup>2</sup>University of Edinburgh, <sup>3</sup>University of Manchester

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## Summary

The ambition of this research was to explore ways of providing personalised, context sensitive information to public transport travellers: can generic information be replaced by individualised snippets of information tailored to help the traveller with his or her decision making? Using an ontological approach, we explicitly model the relationships between various types of information and travellers and the subtasks associated with their (multi-modal) journey. This affords a means of automatic reasoning, and the automatic delivery of tailored information. This paper focusses on the spatial aspects of the research.

**KEYWORDS:** personalisation, multi-modal transportation, spatial ontologies.

## 1. Introduction and Motivation

The degree of impact of disruption on the individual traveller depends on their imperative, approach to disruption, and the complexity of their journey (multi-modal or multiple segments). The effective and efficient sharing of information and solutions has a critical effect in ameliorating the impact of disruption. In the instance of a disruption, the focus is one of 1) what information to convey, and 2) when is it best to inform the traveller and thus improve the quality of their decision making. In order to understand the link between information requirements and traveller activities, we first need to model the traveller and their decision making; we need to additionally classify the information, and understand in more detail the types of activities that constitute a journey.

## 2. An Ontological Approach

The benefits and affordances of ontologies are well understood (Arp et al., 2015; Yim, 2015); the particular aim was to develop an ontology that could be used by traveller information systems to reason about traveller persona and information needs. The work presented here builds on the work of Corsar et al. (2015) and Keller et al. (2014) and the work of Sutterer et al. (2008) who sought to encapsulate user profiles and preferences, although not specifically in the transport domain.

The key to developing an ontology is to enumerate the key concepts of a domain and determine the relationships between those concepts (Noy and McGuinness, 2001). A semi-formalisation conceptualisation phase allowed us to visualise the ontology using labelled directed graphs (Figures 3, 4 and 5, colour coded by class) before its formal encoding in the Web Ontology Language (OWL) using the Protégé ontology editor (protege.stanford.edu). Protégé includes an inference tool or *reasoner*; we may assert, for example, that a particular traveller is a “confirmation seeker” or a “nervous traveller”,

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\* N.gould@mmu.ac.uk

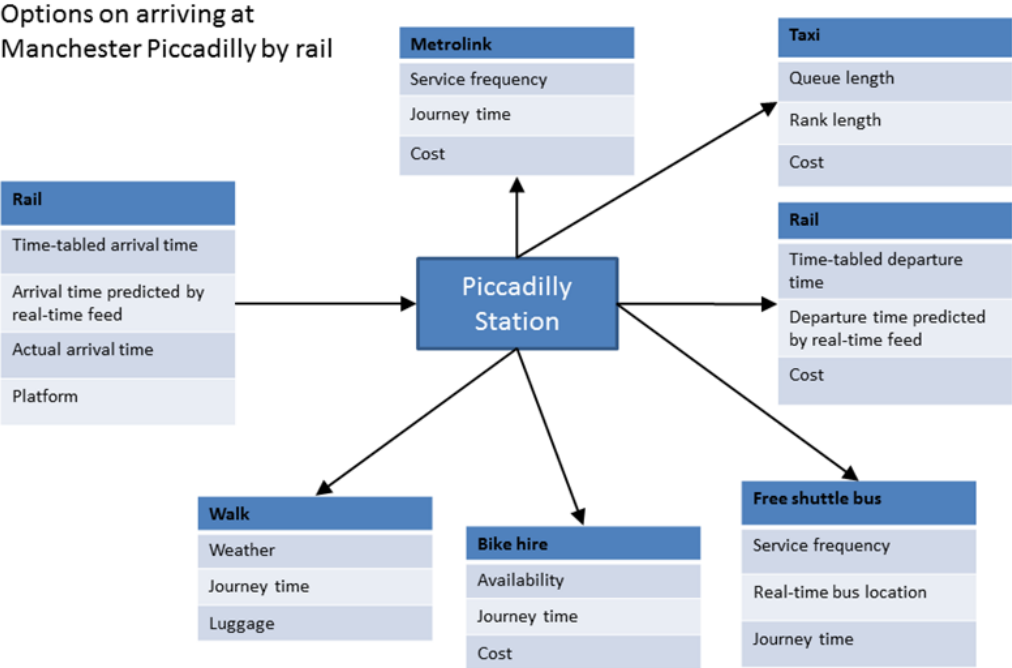
† William.mackaness@ed.ac.uk

‡ sean.bechhofer@manchester.ac.uk

§ robert.stevens@manchester.ac.uk

\*\* l.cooper@mmu.ac.uk

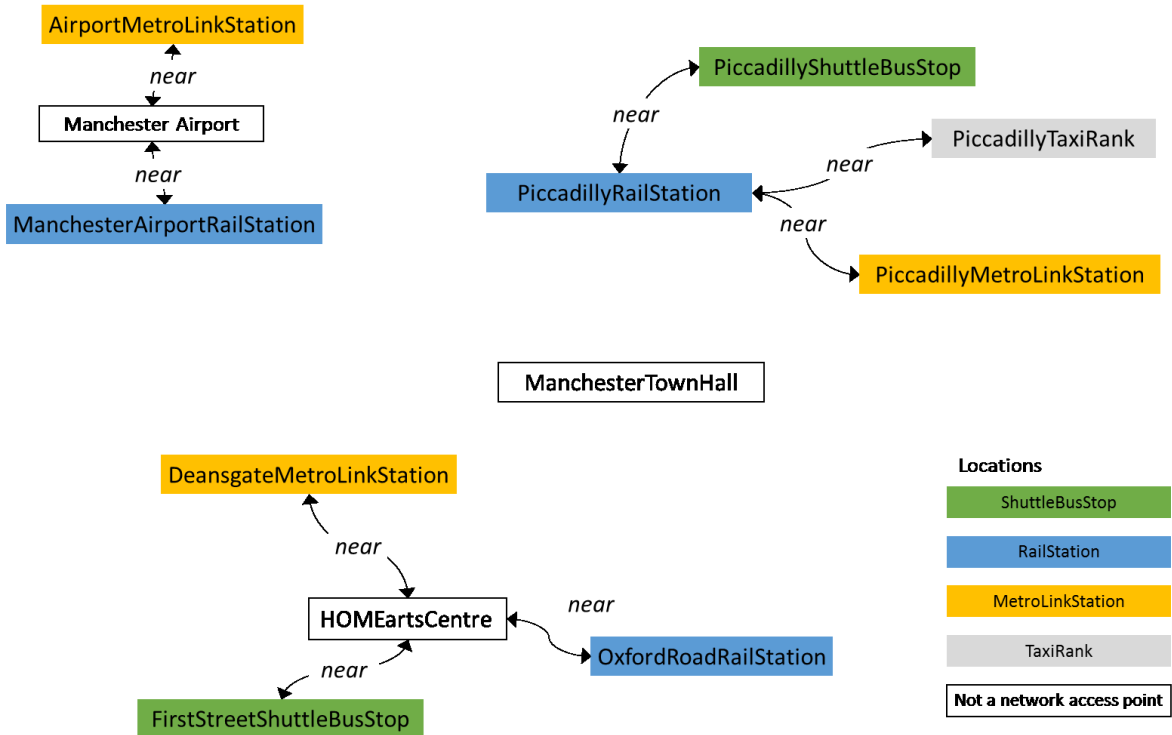
we should then be able to infer their information requirements, such as the location of the help desk. The ontology developed was extensive and included a detailed model of traveller characteristics and information needs and sources. This paper will focus on the spatial aspects of the ontology, in particular 1) how to determine which transport modes are viable for the onward journey (Figure 1) and 2) how to model the internal journeys within a large rail station, Manchester Piccadilly (Figure 7).



**Figure 1** Modelling choice: 6 different ‘next leg’ modes of transport from Manchester Piccadilly

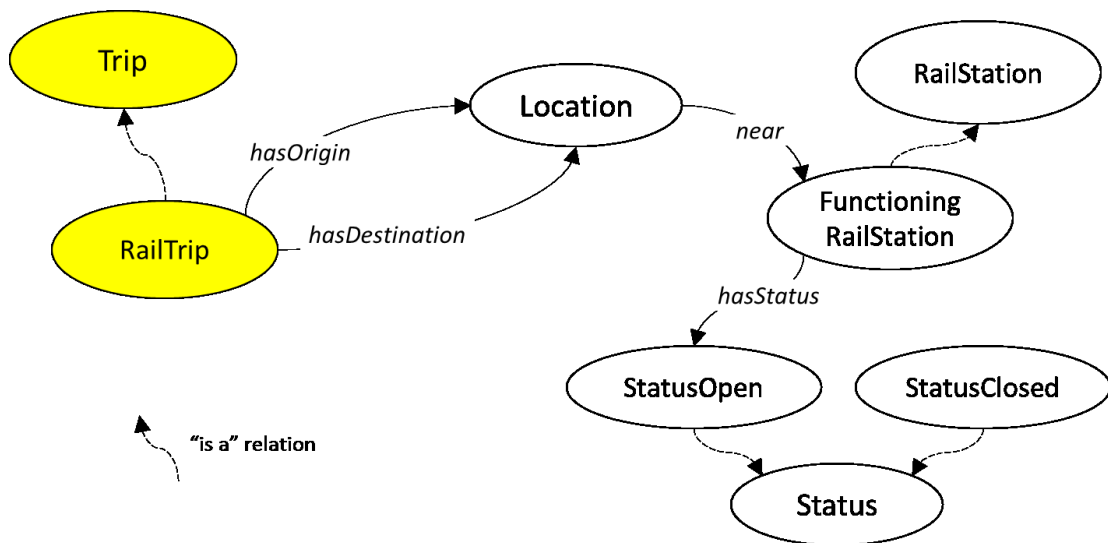
**3. What modes are available?**

The scenario is the passenger who is “shortly arriving at” Manchester Piccadilly and has an onward journey to either a venue in the city centre or to the airport (Figure 2). The first step is to determine which modes are possibilities, based on location. Figure 3, for example, defines a potential rail trip as having both an origin and destination that is *near* a (functioning) rail station. Of course, mere proximity to a rail station will not guarantee a viable rail journey; that will depend on the timetable, but the system will now know that a rail timetable is a relevant information source.



**Figure 2** The “geography” of the case study

Owing to their similarities, taxi trips and Shuttlebus trips are both classed as road trips (Figure 4), which are required to have good road traffic conditions. As with the rail trip, a shuttlebus trip origin and destination need to be proximate to an appropriate network access point. Taxi trips are slightly different in that only their origin need be near a taxi rank; the presence of a taxi rank at Piccadilly makes a taxi trip from there to the Town Hall a possibility, but there is no way back (Figure 2), other than possibly walking. Walking, too, is defined as a mode and its viability depends on a number of factors such as the weather, distance, and the circumstances and capacities of the traveller (Figure 5).



**Figure 3** Defining a potential rail trip

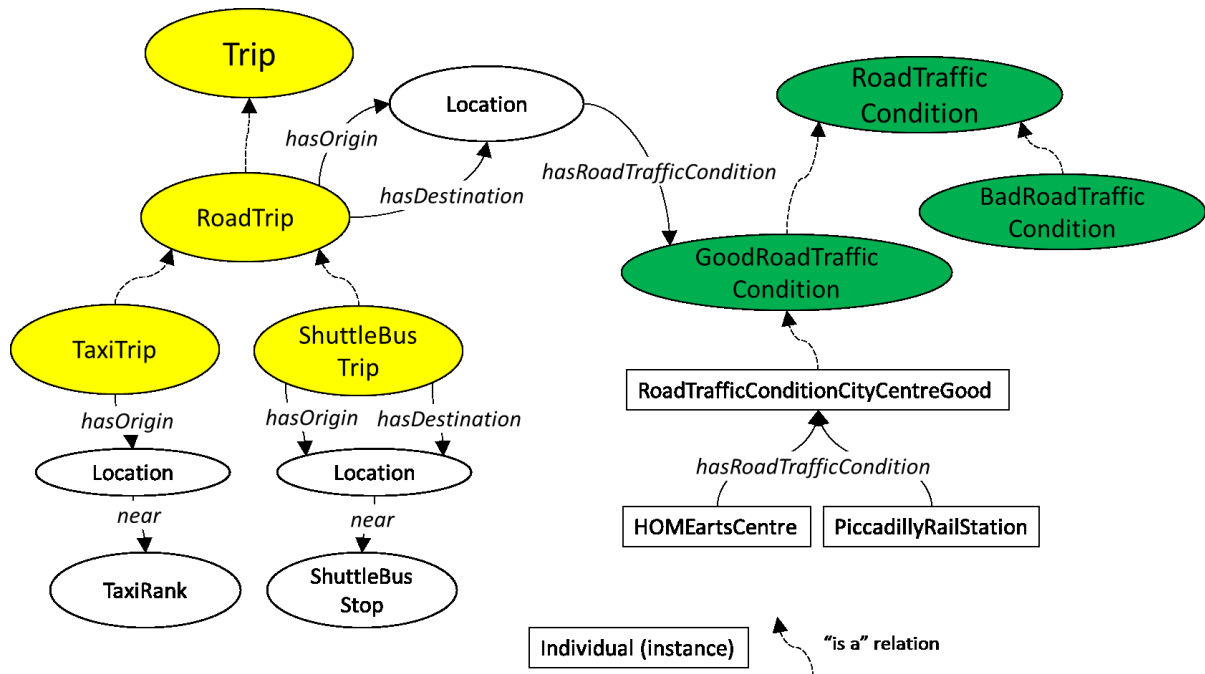


Figure 4 Defining a potential road trip

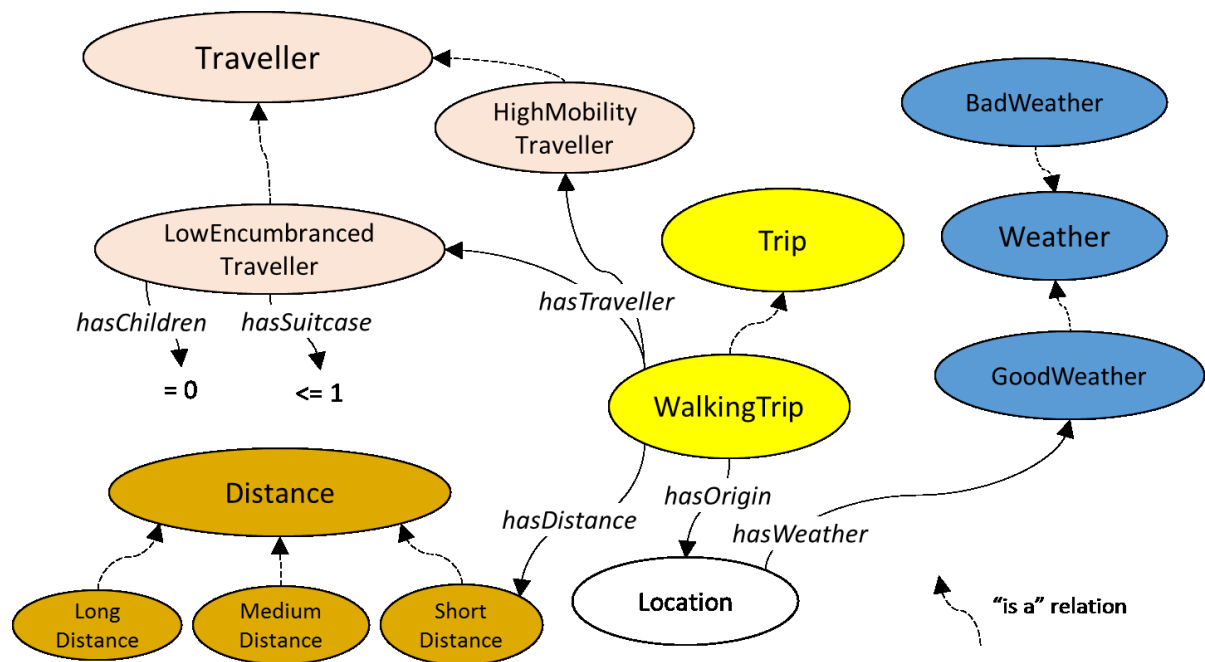
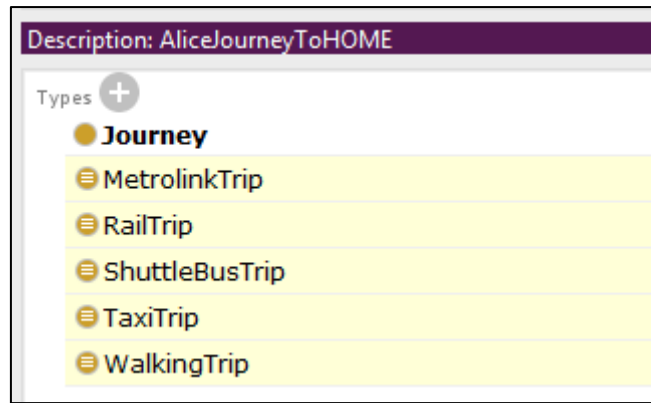


Figure 5 Defining a potential walking trip

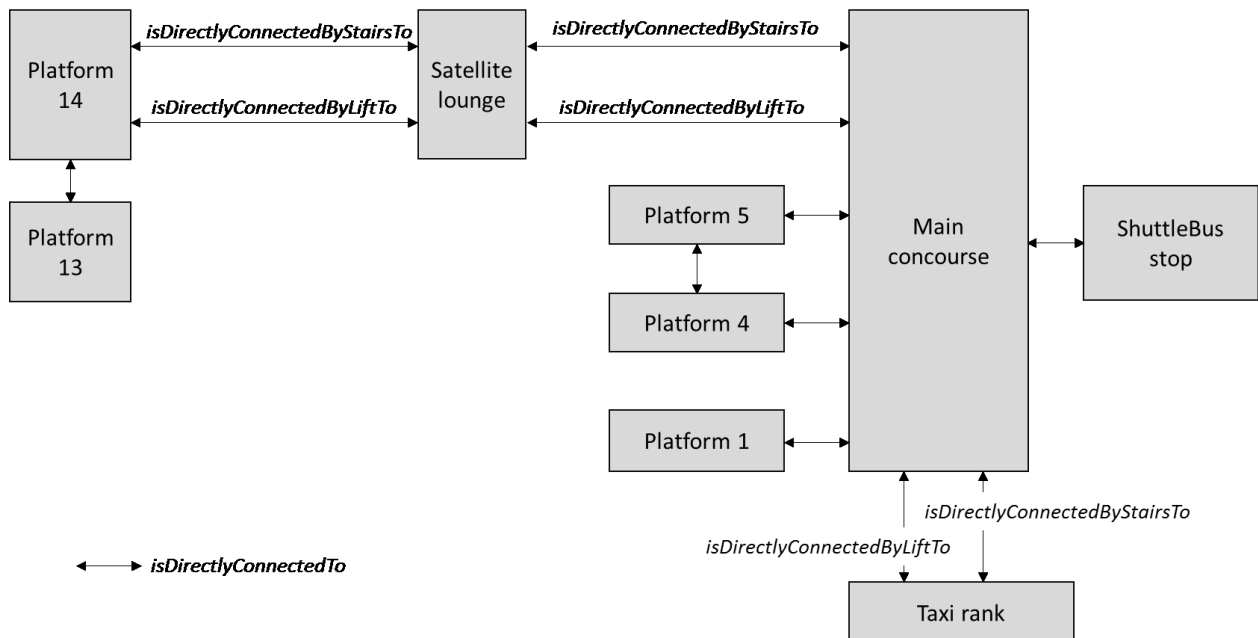
The model was tested by adding some individuals (instances) to the model. For example, Alice's journey to the HOME arts centre is asserted to have *PiccadillyRailStation* as the origin and *HOMEartsCentre* as the destination and *Alice* as the traveller. The reasoner implemented in Protégé then classifies Alice's journey as being potentially carried out by a number of different modes (Figure 6). Changing the external conditions or Alice's personal situation will change the options; giving Alice an extra suitcase or changing the weather will eliminate walking as an option; the existence of road congestion in the city centre will eliminate both a Taxi and the ShuttleBus as options.



**Figure 6** The classification of Alice's journey to HOME from Piccadilly rail station

#### 4. Modelling the internal journeys inside a large rail station

A neglected area of journey planning is the effect of internal journeys within large transport hubs on decision making. Consider the traveller arriving at Platform 1 (Figure 7) with the intention of travelling to the airport. There is a train from Platform 13 to the airport in 5 minutes and one from platform 4 in 10 minutes. The time-oriented travel planning system will highlight the former but much depends on the mobility of the traveller; a traveller with restricted mobility might prefer the latter. Consider also, the impact of lift failures on the traveller in a wheelchair. The failure of the lift between the Satellite lounge and Platform 14 will make Platforms 13 and 14 inaccessible for this traveller.



**Figure 7** Functional description of Piccadilly rail station

Platforms, the taxi rank and the bus stop are classed as *Locations*, specifically *Network Access Points*, in the ontology and are asserted to be *part of* Piccadilly Rail station. OWL/Protégé has the ability not only to define hierarchies of concepts (“is-a” relationships) but also of object properties (all other relationships). We can therefore define the property *isConnectedTo* and sub-properties such as *isDirectlyConnectedTo* (Table 1). Three types of relationships are represented in Figure 7: *isDirectlyConnectedTo* means there is no change in physical level between the two locations (and thus each is wheelchair accessible to the other); the other two relationships are where lifts or stairs are used to link two elements. These three relationships are the only ones where their existence is asserted; the

relationships *isConnectedTo* and *isAccessiblyConnectedTo* are inferred. These two relationships are defined as transitive; if A *isConnectedTo* B and B *isConnectedTo* C then we can infer that A *isConnectedTo* C.

**Table 1** Defining connections

Relationship	Sub-property	Sub-property	Transitive
<i>isConnectedTo</i>			Y
	<i>isAccessiblyConnectedTo</i>		Y
		<i>isDirectlyConnectedByLiftTo</i>	
		<i>isDirectlyConnectedTo</i>	
	<i>isDirectlyConnectedByStairsTo</i>		
	<i>isDirectlyConnectedTo</i>		

Since *isDirectlyConnectedTo* and *isDirectlyConnectedByLiftTo* are defined as sub-relationships of *isAccessiblyConnectedTo* then any route between two locations that consists of these relationships is inferred to be accessible. Usefully, Protégé will provide explanations for its inferences (Figure 8). This is useful when “debugging” unexpected or unwanted inferences.

Explanation for: PiccadillyRailStationPlatform1 isAccessiblyConnectedTo PiccadillyRailStationPlatform14	
1)	<b>Transitive:</b> isAccessiblyConnectedTo
2)	PiccadillyRailStationPlatform14 isDirectlyConnectedByLiftTo PiccadillyRailStationSatelliteLounge
3)	isDirectlyConnectedByLiftTo <b>SubPropertyOf</b> isAccessiblyConnectedTo
4)	PiccadillyRailStationSatelliteLounge isDirectlyConnectedByLiftTo PiccadillyRailStationMainConcourse
5)	isDirectlyConnectedTo <b>SubPropertyOf</b> isAccessiblyConnectedTo
6)	PiccadillyRailStationPlatform1 isDirectlyConnectedTo PiccadillyRailStationMainConcourse
7)	<b>Symmetric:</b> isAccessiblyConnectedTo

**Figure 8** Protégé’s explanation for the accessible connection between platforms 1 and 14.

We can then model the impact on accessibility of say, a lift breaking by, for example, removing the relationship *isDirectlyConnectedByLiftTo* between platform 14 and the Satellite lounge (Figure 7). The two platforms, although they still have the relationship *isConnectedTo*, no longer have the relationship *isAccessiblyConnectedTo* and any services departing from Platform 14 should not be suggested to the wheel-chair user.

## 5. Conclusion and future work

The ontological approach allows for reasoning about travel and the information required for traveller decision-making. However, to fully test the approach a technology demonstrator is required, which will incorporate the ontology in a traveller information system that allows the user to describe their ambitions and situation and integrates real-time data sources that describe services and disruption.

## 6. Acknowledgements

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## 7. Biography

Nicholas Gould is an early career researcher interested in the role of ontologies in supporting transport related information systems. William Mackaness' interests are in mobile technologies and visualisation methodologies. He is also interested in socio-technical contexts of GIS and ideas of empowerment. Robert Stevens' research specialises in the use of ontologies to describe, manage and use data and knowledge in software. Sean Bechhofer focuses on the use of semantic technologies, in particular ontologies and vocabularies, for information management. Laurie Cooper is an Enterprise Associate for DigitalLabs@MMU.

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