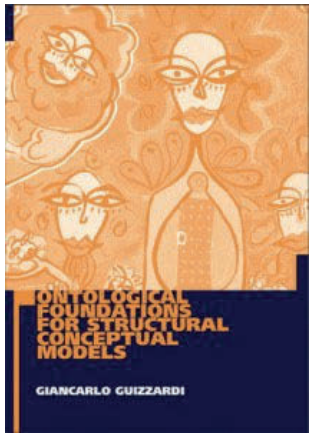
The Foundational Ontology UFO and the OntoUML modeling Language

Information is the basis of all rational decision making. We live in a scenario of information deluge, with rapidly increases in information volume, variety, and (creation) velocity. Moreover, information can only support decision making if it truthful to aspects of the world it purports to represent (veracity). Properly managing these four dimensions is paramount in critical domains such as Finances, Healthcare, Scientific Data Management, Security and Safety, Smart Industry, among many others. In particular, two of these dimensions stand out: veracity and variety. Firstly, we must be able to guarantee quality attributes of information artifacts such as timeliness, completeness, and clarity, to proper tie these artifacts to the phenomena in reality backing up their veracity. Second, most resources in modern information management initiatives are devoted to dealing with the vast heterogeneity of information sources and, in particular, in integrating them while preserving their original semantics. Furthermore, complementary approaches such as Machine Learning highlight the importance of proper information modeling to: safely integrate information from multiple silos; to separate signal from noise in vast information piles; to evaluate the quality of information items; and to avoid spending between 60-80% of the effort of Data Analytics in Data Cleaning activities.

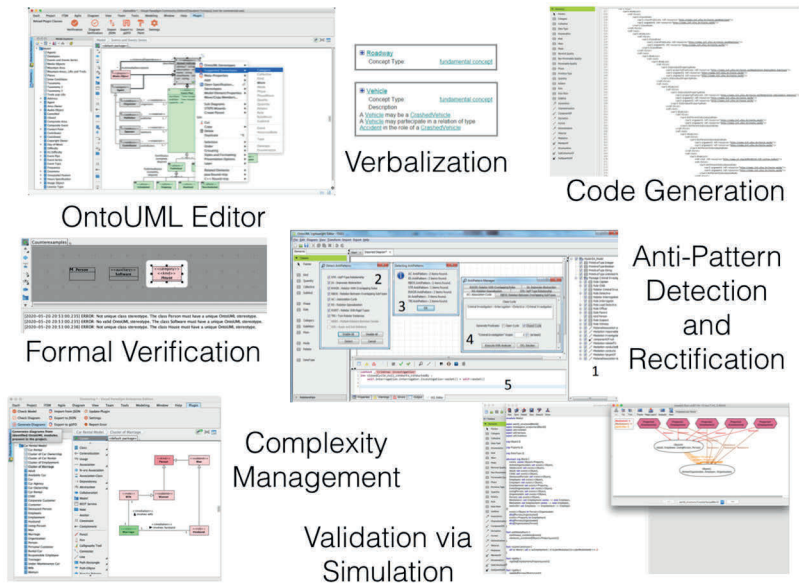
To address the challenge of proper information management, we need Next-Generation Information Modeling approaches. In particular, we need modeling approaches that are grounded in foundational theories that connect representation mechanisms to the underlying phenomena being represented, i.e., on proper ontological foundations for information analysis and representation. Two of the most prominent technologies in this respect trace back their origins to the University of Twente (UT). These are the foundational theory **UFO (Unified Foundational Ontology)** and the modeling language **OntoUML**. Both these results were initiated by the PhD work of Giancarlo Guizzardi in 2005 (then a PhD student at the UT, now a Professor at the Services & Cybersecurity Group). The PhD thesis received so far almost 1500 citations, and the ensuing technologies have been adopted and employed by a large number of academic, industrial, and governmental institutions around the world, as well as standardization bodies.



UFO (https://en.wikipedia.org/wiki/Upper_ontology#UFO_(Unified_Foundational_Ontology) is a rigorous axiomatic theory inspired by philosophical, logical, cognitive and linguistic considerations. It has been considered as a foundation for a proposal to address the ISO SC7 RFP for Ontology-Based Software Engineering standards, and, it has been used to provide an ontological analysis and re-design proposal, which has influenced the ArchiMate International Standard (Open Group). According to a recent study, UFO is the second most used foundational ontologies in conceptual modeling and the one with the highest rate of adoption. The UFO community is currently working towards a submission to address the ISO/IEC CD 21838-1-Top-Level Ontology initiative (https://www.iso.org/standard/71954.html). Finally, it has recently been cited in the scope of the UK National Digital Twin Program, and is under

consideration for adoption at the European Project OntoCommons for Semantic Technical Documentation. The ontology is available in many formats in different levels of formalization, including in a W3C/OWL version (http://purl.org/nemo/gufo), which shall be of particular interest for helping to foster interoperability of FAIR data on the web. A query with "Unified Foundational Ontology" returns 14.600 results.

The Modeling Language OntoUML (https://en.wikipedia.org/wiki/OntoUML) is a UML profile grounded on UFO. It has been considered as a candidate for addressing the OMG Semantic Model for Information Federation RFPs, after a report of its successful use over the years by a department of the U.S. Department of Defense. Some of its foundations have influenced other modeling languages, such as ORM 2.0. It has also influenced other groups worldwide to adopt OntoUML as part of their research agenda. One example is the Centre for Conceptual Modeling (CCM) in Czech Republic (https://ccmi.fit.cvut.cz/home/), which offers OntoUML as part of their education program, training circa 70 students every year on the subject, and which maintains the OntoUML portal (https://ontouml.org/) used by organizations worldwide. Additionally, the language has been adopted by the Brazilian Federal Program on Data Transparency and Government Interoperability as a representation language for publishing public ontologies in its Persistent Ontology and Vocabulary Repository. It is currently also being adopted by the Zorg Instituut Nederland for the purpose of Information Modeling for interoperability. Furthermore, a number of competing tools have been produced worldwide for this language, including professional tools. A google query for "OntoUML" returns 48.700 results.



The OntoUML Tool Ecosystem