Scientific Journals
Maritime University of Szczecin

Zeszyty Naukowe
Akademia Morska w Szczecinie

2012, 30(102) pp. 12–17

2012, 30(102) s. 12–17

Using the Protégé environment for building ontology for automated communication system at sea

Wykorzystanie środowiska Protégé do budowy ontologii dla systemu automatycznej komunikacji na morzu

Paweł Banaś

Maritime University of Szczecin, Faculty of Navigation, Institute of Marine Technologies
Akademia Morska w Szczecinie, Wydział Nawigacyjny, Instytut Technologii Morskich
70-500 Szczecin, ul. Wały Chrobrego 1–2, e-mail: p.banas@am.szczecin.pl

Key words: ontology, knowledge representation, automatic communication, e-navigation, e-maritime

Abstract
Automatic communication between computer systems on board and ashore is a necessity. At this stage it is limited to simple exchange of information – the data transmitted in the messages. It is expected that it will take the more complex form soon, allowing the dialogue, the transmission of intentions and conducting negotiations. To make it possible, it is necessary to build suitable ontology, describing the processes of communication at sea. To apply this ontology in information systems it is necessary to present it in a proper representation. This paper presents a method of generating a representation in form of XML-Schema based on the ontology built with the use of Protégé program.

Słowa kluczowe: ontologia, reprezentacja wiedzy, komunikacja automatyczna, e-nawigacja

Abstrakt
Automatyczna komunikacja między systemami informatycznymi na statku i na lądzie jest koniecznością. Na obecnym etapie ogranicza się ona do prostej wymiany informacji – danych przesyłanych w komunikatach. Należy spodziewać się, że w niedługim czasie przybierze postać bardziej złożoną, umożliwiającą prowadzenie dialogu, przekazywanie intencji i prowadzenie negocjacji. Aby było to możliwe, konieczne jest zbudowanie odpowiedniej ontologii, opisującej procesy komunikacji na morzu. W celu zastosowania ontologii w systemach informatycznych niezbędne jest przedstawienie jej w odpowiedniej reprezentacji. W artykule omówiono metodę generowania reprezentacji w postaci XML-Schema na podstawie ontologii zbudowanej z wykorzystaniem programu Protégé.

Introduction

Safe conduct of the ship requires acquisition of navigation information. Their sources include navigation equipment and systems such as ARPA, AIS, GPS, GMDSS or Navtex. These systems enable collection, processing and sharing of information. However, the information exchange is realized in limited range. It consists mainly in the data transferring in a standardized form, including their integration (integrated bridge). The part of information is still transmitted in a verbal form by navigators and on land staff facilities. An example is the necessity of cooperation and agreeing of manoeuvres performed or intended to do. Increasing the automatic exchange of information can significantly help the navigators, both during routine voyage as well as in an emergency. After taking into account relation between the transmitted data which depends on the situation and between the concepts which occurs in the information sent in messages, the information systems of this type would gain new opportunities, such as automated dialogue and eventually negotiations. Such systems could be a part of the navigation systems to support the process of navigation, including global systems (concepts of e-maritime, e-navigation).

Solutions of this type are already applied in other fields of life, such as e-business and have been presented in several publications, including [1, 2, 3]. They give to the designers of computer systems new possibilities, which allows transferring not only simple information, but also more complex such as intentions, questions or requests, which occurs in the processes of agree and negotiations. For this purpose, ontologies of examined field and their representations are used. The representations allow use of ontologies in computer systems. The knowledge presented in the form of ontologies enables the systematic fill in, modification and verification. However, each modification of the ontology involves the need to update its representation. Shown in the literature general methods and tools for building ontologies and create its representation do not take into account the specifics of communication at sea – they do not provide sufficient techniques or tools for modeling communication processes in the sea.

Present research carried out in the field of automation of processes communication at sea are to develop an ontology of navigational information and the basis of the process of automatic exchange of messages [4, 5, 6, 7, 8]. An important issue is to develop methods for automatic creation of the representation of the ontology: automatic conversion of navigational information ontology to a form suitable for its use in the process of automatic communication between the computer systems on board and ashore. This is related to the intended systematic supplementation (expansion) of navigational information ontology. Creation of an appropriate tool will help in a convenient way to instantly and automatically generate the representations (for instance as DTD or XML Schema), suitable for use in ICT systems.

Ontology and its notations

The basis for automatic generation and interpretation of messages is to build an appropriate ontology. Ontology is a formal record of semantic concepts (objects, attributes) and relations between them allowing to describe the current reality. In the case of communication between objects, it must define all the concepts that may occur during the exchange of messages, specific relations between these concepts and provide the ability to interpret sentences constructed with the use of defined terms. The first attempts to systematize the navigational information and connections between its elements were made in the past, as exemplified by the article [9].

In recent years, a number of formats that can be used as representation of ontologies has been developed and popularized. Because, besides the possibility of recording information, equally important is the aspect of standardization, further discussion will be limited to solutions based on XML. The most popular ones are:

- RDF (Resource Description Framework) – resource description language, oriented to automatic processing;
- OWL (Web Ontology Language) – a language being an extension of RDF, designed primarily for building ontologies;
- DAML (DARPA Agent Markup Language) – another language based on RDF.

All these languages have been designed primarily to create a so-called “Semantic Web”, the

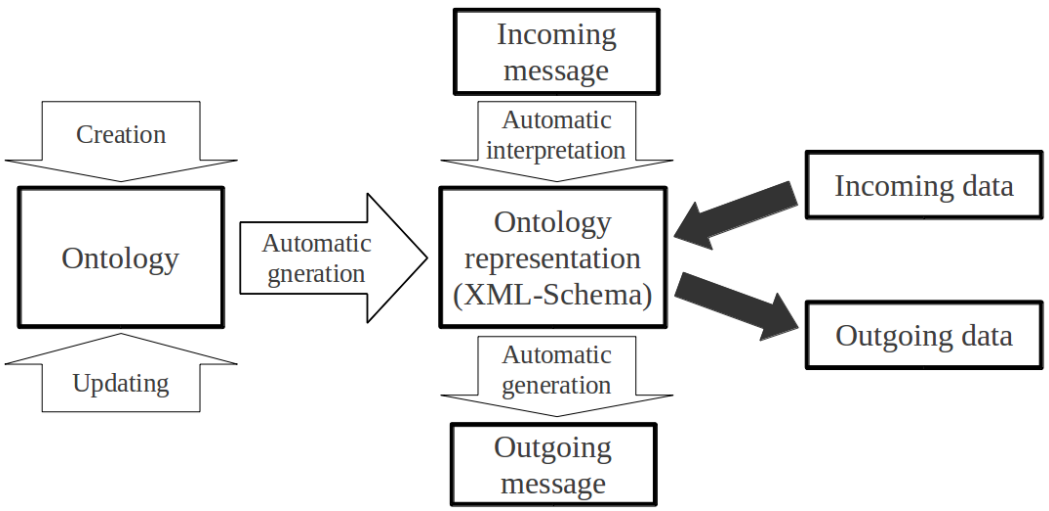

Fig. 1. Ontology and its representation in the process of communication at sea
Rys. 1. Ontologia i jej reprezentacja w procesie komunikacji na morzu

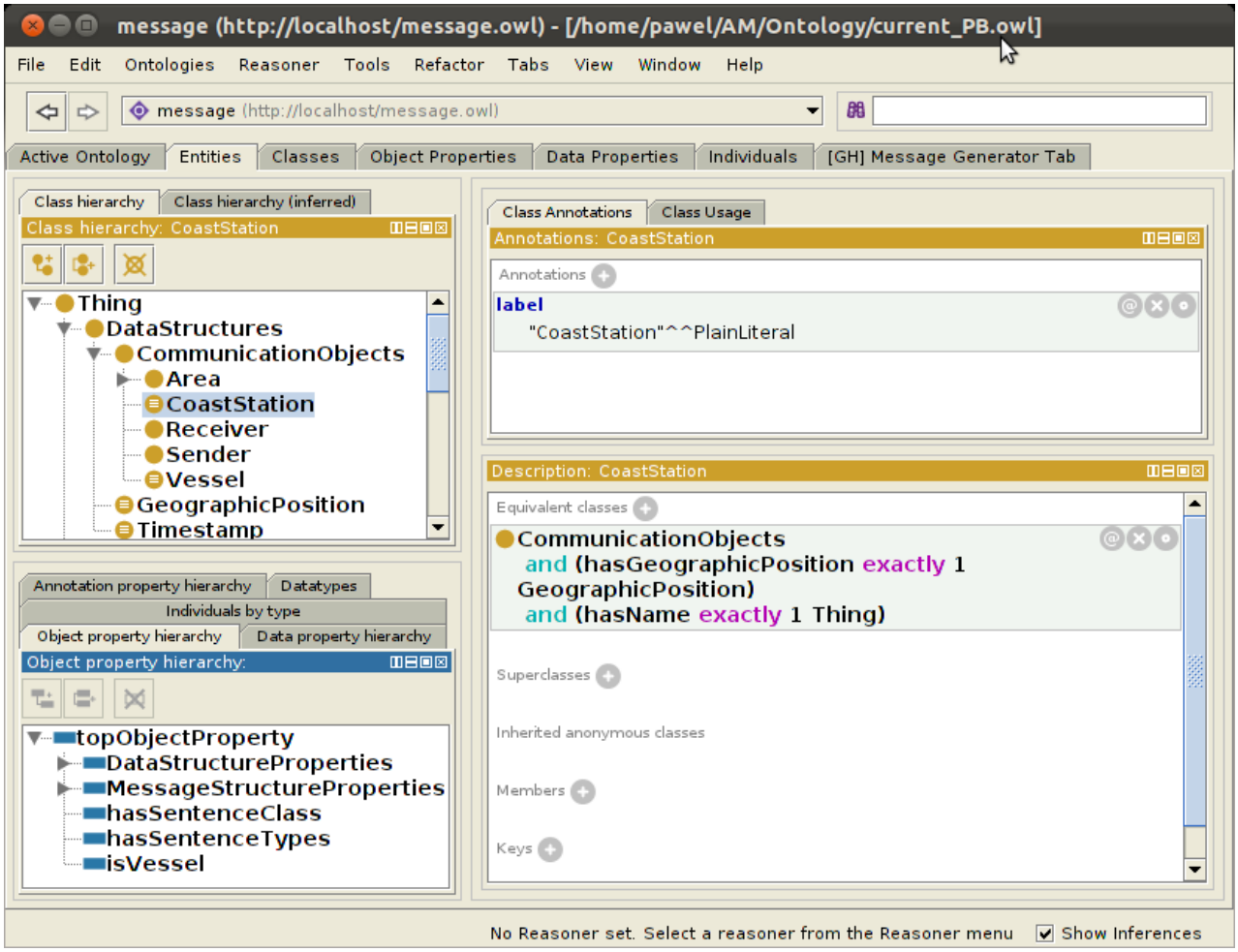

Fig. 2. The Protégé window during the process of creating an ontology of navigational information
Rys. 2. Okno Protégé podczas procesu tworzenia ontologii informacji nawigacyjnej

description of metadata contained in the Internet resources in a manner that allows the automatic indexing and analysis. However, it is possible to use them outside this application, for example to describe the ontology. As the alternative for them other simplified representations can be used, such as the XMS-Schema or DTD. They provide an opportunity of simple use in a wide range of systems, however they are associated with the risk of loss a part knowledge. Figure 1 shows a diagram showing the relation between ontology and its representation.

Using the presented above representation languages and formats, it can be build an ontology in a direct way, for which can be used even a simple programming, or XML editor. However, much more convenient solution, that gives the possibility of free manipulation of data, without the need to focus on the formal side (such as the way of XML tags description), is the use of dedicated tools to create an ontology, for example an open platform Protégé (Fig. 2). This is a highly customizable package that provides several tools to facilitate the construction of an ontology, such as graphical editors for ontology, entities, classes and objects (which constitute the ontology), and any possible connections between them. It offers two popular formats of ontologies: a frames and OWL. To ensure the widest possible compatibility with other programs and technologies, it was decided to use the program Protégé in the OWL version, the more that besides the OWL standard it also supports the RDF standard. Not without significance was the fact that for this package open application programming interface (API) for Java language is available, so it can be easy to create programs using the built ontology. It is possible to integrate these programs with the main window of Protégé system, and thus to have in one place all the tools for both the construction and completion of ontology, as well as to handle various tasks using the ontology.

Schemas as a basis for messages generation and dialogue

With the help of languages and tools provided in the previous chapter an ontology of navigational

communication can be built and then used to generate and interpret messages sent between vessels. Considering the variety of hardware and software used in navigation systems, there is no possibility of creating a single program that uses prepared ontology. It is possible to use the existing systems (eg The Protégé), which due to the possibility of extension gives an opportunity to form an appropriate interface and use them to make the ontology available to the navigation systems. However, the main disadvantage of this approach is that software to handle an ontology is an additional complex program involved in information processing, and thus another element of potential failure. Therefore, it is necessary to strive to simplify processing of the ontology, even if it means the use of simplified representations.

Solution allowing to use the ontology, while not being dependent on editing and sharing software, is the use of properly prepared representations. It should be noted that some simplifications are acceptable in comparison with the accurate representation of the navigational communication ontology, but prepared representations should still contain a sufficient amount of knowledge that enables the automatic interpretation of incoming messages and automatic generation of outgoing messages. Construction and completion the navigational communication ontology will continue to take place using the software supporting the process of creating ontologies such as Protégé. Also, this software will be used by an additional program that will automatically generate the appropriate representations on the basis of the ontology. They in turn will be used by the navigation systems of vessels involved in the automatic communication process. In figure 1, a schematic showing the relation between ontology and its representation can be observed on various stages of construction and updating of ontology, by generating its representation to handle the process of interpretation and generation of messages. As the representation format for schemas was selected XML-Schema. This is because it is a standard format, supported by W3C consortium, so there are a number of independent tools for edit it without the use of software for ontology, and over it. It is a standard used in the definition of various types of documents. Because currently all the information appearing among others in the process of communication are interpreted and used by humans, also there should be possibility of interference in the automatic communication process. Use of exactly this representation (XML-Schema) gives possibility for easy creation of communication forms used by humans who later join to the dialogue between automatically communicating systems.

It should be noted that the schema stored in this form is not intended as complete replacement of the navigational communication ontology – such approach could result in loss of information. The schema is only a simplified picture of the ontology which allows the efficient generation and interpretation of messages. If in the process of communication will become changes resulting in the need to modify or extend the ontology, then such an operation will take place always using the full ontology and using appropriate tools, and then, on the basis of the updated ontologies will be generated new versions of the schemas.

Generating an ontology-based XML-Schema

So far, the generation of the representation of navigational information ontology in most cases took place in a manual or semi-automatic manner. Using the appropriate tools, however, it is possible to carry out the process of generation of the representation automatically. As a basis for further work Protégé environment has been selected. This was motivated by convenience of its use during the construction of ontology and above all the possibility of simply expanding its capabilities by attaching user's plugins written in Java for example. Not without significance is the fact of access to the entire source code of the environment. Use of a programming interface documentation allows the simple construction of next plug-ins carrying out tasks operating on ontology. One of those tasks is the schema generation in the form of XML-Schema, used later in the automatic communication between the objects to generate and interprate messages and also by people who might be a party in the communication process to create a message in a form understandable to machines.

When creating the XML-Schema generator several problems were encountered. The most important is not fully documented API (Application Programming Interface – Application Programming Interface) in Protégé environment – part of the functions has not been described at all or their descriptions have significant errors. This is probably due to intensive development of the environment which unfortunately results mainly in the lack of documentation. However, these problems are possible to bypass due to the open source code of the environment and its APIs, and to development tools such as the programming environment (in this case Eclipse), which usually suggests at least the syntax and data types of inputs for most of the functions.

In addition to essentially technical and programming issues, there were also problems arising from the characteristics of the ontology itself. The most important of these is the higher complexity of the ontology compared to the generated schema, which is not able to transfer certain properties. In this case, it is necessary to use simplifications and replacing some of the connections with the nested structure of an XML document. This situation may lead to danger of looping an algorithm generating schema. To avoid this, it was necessary to develop additional algorithms that detect dangerous places, and solve arising problems.

XML-Schema generator was written in Java using the Protégé API. In this way, the defined ontology can be easily used and moving respectively on its structure it can create the appropriate tags that make up the XML document. Since the XML--Schema generator was developed as a plugin for Protégé program, it is visible directly in the window of this program and fully integrates with other parts of it. This allowed for a very simple selection of ontology elements that are incorporated into the generated schema – it is enough to indicate in the main window the entire ontology or a part of it, and a schema will be generated automatically. Generating schemas for parts of the ontology their size can be reduced and provided adequate object to only those parts of the ontology that concern them.

Example of use

The developed generator was used to convert the communication process subontology to form of XML-Schema. This enabled the use of the chosen representation for the processes of communication between ships. This solution gives the possibility to dialogue between vessels as in the example precisely presented in [8]. Two vessels Alpha and Beta are on opposite courses as in the situation shown in the figure 3.

According to the rules of COLREGS [10], both vessels should pass with a port sides, but the rules allow the possibility of a starboard sides passes. In such cases, it is necessary to negotiate the manoeuvre. In the case of voice communication, the navigators conducting both ships communicate and agree the action. When for example a vessel Alpha has already passed the point of safe conduct of the turn to the right, the navigator conducting it should suggest the possibility of a pass with starboard sides. Used here language and phrases should be clear to both sides and lead to the development of clear manoeuvres.

In the case of automatic communication, it is possible to use an ontology that describes the terminology used during the communication, or a schema which represents the ontology. They contain clearly defined concepts that make up the messages and appropriate connections between them, allowing unambiguous interpretation of messages generated with the aid of them. In this situation, the Alpha vessel's system (initiated by the navigator or automatically) generate the appropriate XML message that is received by the system of Beta ship, where it will be clearly understood. Navigator who leads the Beta ship will immediately have complete information about the intentions of the Alpha ship and will be able to respond by agreeing to the proposed manoeuvre, or proposing a different solution.

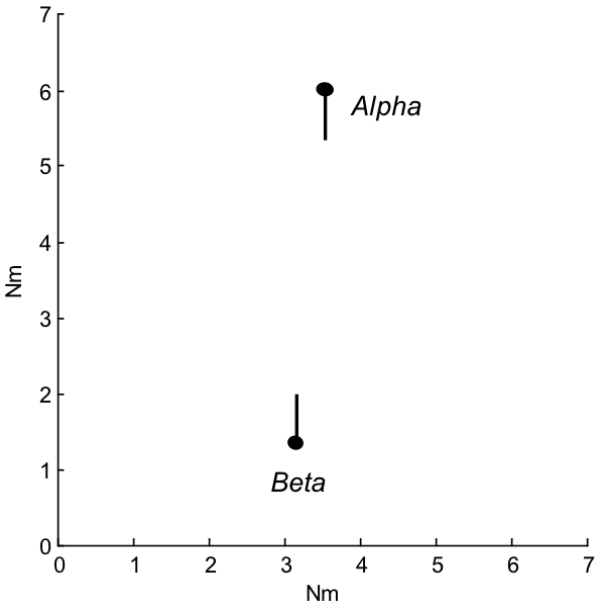

Fig. 3. The situation of the Alpha and Beta ships meeting [8]
Rys. 3. Sytuacja spotkania statków Alfa i Beta [8]

It can also be imagine a scheme like above, when at least one of the meeting units is fully autonomous vehicle. In such a case clear communication of the planned activities is crucial for safety. If a human being can correctly interpret even a very unclear statements, that even the best machine can read them incorrectly. The use of an appropriate schema to generate a message substantially increases the probability of transmission of information in an understandable way for the automatic system.

Conclusions

Automatic communication between computer systems on board and ashore is a necessity. At this stage it is limited to simple exchanges of information – data that is sent in the messages. It is expected that soon it will take the form of a more complex form, allowing the dialogue, communication of intentions and conduct of negotiations.

To make this possible, it is necessary to build a suitable ontology, describing the processes of communication at sea: appearing concepts and the detailed connections between them. Record of navigational knowledge in the form of navigational information ontology allows for its systematic update, modification and verification. Althrough, there are tools that help to build an ontology and then use it for example to generate and interpret messages, but due to their specificity they can not be used in all conditions, such as in embedded systems (because of hardware and software limitations). The solution is to generate appropriate representation based on ontology: documents (schemas) describing the relevant connections in simplified form, which can be used for example in embedded systems.

This paper presents a method of generation schemas based on the ontology which was built with the use of the Protégé program. The presented method of generation of ontology representation enables automatic conversion of navigational information ontology to a form suitable for its use in the process of automatic communication between the computer systems on board and ashore.

References

1. BEAM C., SEGEV A.: Automated Negotiations: A Survey of the State of the Art. Wirtschaftsinformatik, vol. 39, 1997, 263–268.
2. PAUROBALLY S., TURNER P.J., JENNINGS N.R.: Automating negotiation for m-services. Proc. of the IEEE Transactions on Systems, Man, and Cybernetics (Part A: Systems and Humans), Special issue on M-services, 33(6), 2003, 709–724.
3. KARP A.H.: Rules of Engagement for Automated Negotiation. Proc. of the First IEEE International Workshop on Electronic Contracting (WEC'04), San Diego 2004, USA, 32–39.
4. PECHMANN P.: Reprezentacja znaczenia komunikatu w języku polskim za pomocą ontologii. Metody Informatyki Stosowanej, 1/2011, Gdańsk 2011.
5. PIETRZYKOWSKI Z., CHOMSKI J., MAGAJ J., NIEMCZYK G.: Exchange and Interpretation of Messages in Ships Communication and Cooperation System. Advanced in Transport Systems Telematics, Ed. J. Mikulski, Publisher Jacek Skalmierski Computer Studio, Katowice 2006, 313–320.
6. PIETRZYKOWSKI Z., MAGAJ J., CHOMSKI J.: Sea-Going Vessel Control in the Vessel Communications and Co--Operation System. Scientific Papers, Silesian University of Technology, Transport, 51, Katowice 2003, Proc. of the 3rd International Conference Transport Systems Telematics, 2003, 455–462.
7. PIETRZYKOWSKI Z., MAGAJ J., NIEMCZYK G., CHOMSKI J.: A sea-going vessel in an intelligent marine transport. Scientific Papers Silesian University of Technology, Transport, 45, Katowice 2002, Proc. of the 2nd International Conference Transport Systems Telematics – 2002, 203–213.
8. PIETRZYKOWSKI Z., HOŁOWIŃSKI G., MAGAJ J., CHOMSKI J.: Automation of Message Interchange Process in Maritime Transport, TransNav 2011, Gdynia.
9. KOPACZ Z., MORGAŚ W., URBAŃSKI J., Information of Maritime Navigation; Its Kinds, Components and Use. European Journal of Navigation, vol. 2, 3, Aug 2004, 53–60.
10. RYMARZ W.: Podręcznik międzynarodowego prawa drogi na morzu. Trademar, Gdynia 1995.