Ontological Reasoning as a Tool for Humanitarian Decision Making

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ABSTRACT

We propose an OWL/SWRL enabled ontological environment which can play a role in reporting and decision making in Humanitarian Crises (HC). We use (5WH): WHO, WHAT, WHERE, WHEN, WHY and HOW, as the main vehicle for gathering information for decision making. We implement the semantics of (5WH) through OWL models and perform reasoning with SWRL rules, in order to support decision making and create more efficient Humanitarian Response (HR). Our case study shows the feasibility of the proposal and its outcome.

Keywords

Humanitarian Crises, Humanitarian Response, Decision Making, OWL/SWRL enabled ontologies, Reasoning.

INTRODUCTION

HCs, disasters or catastrophes are all names which refer to the situation in which a massive number of human lives are in danger of death or injury due to natural or man made causes (Darcy and Hoffman, 2003b). Many countries can not deal with HC, therefore they appeal to the international community to intervene and help in mitigating the catastrophe (HPG, 2006). However, making decisions on HOW, WHEN, WHERE and WHY to intervene is a complex task and decision makers often compromise between the urgent nature of actions in HC and the slow pace of the decision making process (FEWSNET, 2001; Charny 2004; Margesson and Taft-Morales, 2010). The speed of decision making highly depends on information availability, accuracy, and reliability (Morrison and Cohen, 2005; Bharosa and Janssen, 2009).

In this paper we illustrate our work in progress, which show how we can support the decision making process in HR through Semantic Web technology and improve its efficacy. We center the decision making in HR on "WHO does WHAT, WHERE, WHY, WHEN and HOW" (5WH) during HC. By answering questions such as *"who should intervene in an HC and why", "how should we help a population in an HC in terms of deploying available funds and goods"* or *"where should we allocate donor funds considering the scale of HCs, policies of donors and victims and cultural background of people involved in HCs*", we could support decision making and increase the efficiency of HR. The idea of using (5WH) in HC has been taken from the (Shamoug and Juric, 2011a) and from the framework which secures information sharing and decision making in HC (Shamoug and Juric, 2012). A shorter version of the (5WH) model based on 3Ws has been used for coordination by the United Nations (UNOCHA, 2006) and are used as concepts in news styles, police investigations and research in general (Sibun, 1997). In this paper we propose the ontological model named 5WH_ONT, based on (5WH) and the reasoning processes, performed upon 5WH_ONT, to support decision making during HC. We illustrate our proposal through a case study and its implementation with OWL/SWRL enabled ontologies.

In the next section we give a brief background on management of HR in HC. In the Proposal we introduce the 5WH_ONT model based on (5WH) and object properties, which strengthen the semantics of 5WH_ONT. In the section which follows we show a case study which illustrates the reasoning upon the 5WH_ONT as a support for decision making. We comment on the results and related works in the final section.

THE BACKGROUND

The management of HR to HC is organized through three levels: Donation, Organizational and Operational levels (UNOCHA 2001) (Shamoug and Juric, 2011a). The *Donation level* consists of a set of governments, organizations, and individuals who have interests in HR. They have the power of deciding how much

funds/goods they are willing to donate for a particular HC. The decision is based on factors which range from the type of required assistance, individual preferences, policies of countries where donors reside, to political decisions of the local and central governments, and the amount of data available (Darcy and Hofmann, 2003a; Walker and Pepper, 2007; UN, 2007). The *Organizational Level* houses international agencies and bodies which have direct impact on HR and range from UN organizations (WHO, UNICEF, WFP, and UNHCR) to charities and aid agency such (NRC, Oxfam and MSF). Their decision making is based on data available from analytical reports and any type of data or information available at locations where the HC arose. *The Operational level* consists of local and international bodies and governmental agencies of countries affected by HC which respond to HCs on the ground. They are divided into Sectors and Locations. Sectors are prescribed by the Donors, UN, Red Cross, and NGOs (Sphere, 2010).

THE PROPOSAL: 5WH_ONT OWL MODEL AND ITS CONSTRAINTS

Decision making in HC happens at any levels of management of HR, as described above and it is dependent on our ability to answer "questions" illustrated in the Introduction, before anyone can be involved HR. We propose answers these questions are obtained through a reasoning process imposed on 5WH_ONT, i.e. we make decisions based on reasoning upon information on WHO does WHAT, WHERE, WHY, WHEN and HOW" (i.e. upon the 5WH_ONT model given in Figure 1) during HC.

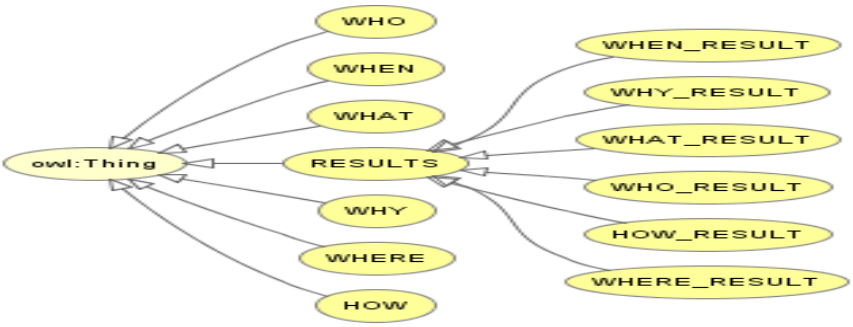

Figure 1. The 5WH_ONT Concepts

The WHO class consists of humanitarian organizations, i.e. Actors A_i, which provide services, to the victims of HC. This class may store the semantic related to the roles and interests of United Nations, Red Cross, Donor States, NGOs, and Governments, who work on the three levels of HC: Donation, Organizational and Operational Levels. WHAT class stores the semantic of two categories of Sectors (S_i): life saving and life improving, with the priority given to the life saving sectors. The WHEN class models the time factor, i.e. responses of actors and their duration in HC. The response refers to the readiness of anyone from the WHO class to respond to a HC, and readiness of Locations (L_i) from the WHERE class to receive the assistance from them. The WHERE class hosts locations (L_i) which may be grouped around regional, national, community, and municipality, where affected population resides. WHY class stores the semantic of the *reasons of interventions* ($R_1, \ldots, R_t$). Victims of HC i.e. people in locations (WHERE) and actors (WHO) may not necessarily share the same understanding of *reasons of intervention*. However, it is possible to model 5WH_ONT to find the "common reasons for intervention" rather than forcing people to "understand each other". The HOW class stores the semantics of "means and tools" ($M_1, \ldots, M_t$) for HR, which are available/affordable by actors in HC.

Table 1 summarizes relationships between the HOW, WHEN, WHY and WHAT classes and a pair of WHERE/WHO classes. WHO and WHERE classes are "related" to WHAT, WHEN, WHY and HOW classes through a set of object properties: *"sector of intervention", "preferred_duration", "reason_of_intervention" and "mean_of_intervention"* . Range and domains for properties in Table 1 are self explanatory.

5WH_ONT also contains individuals which are actors (A_i) such as USAID, DFID, WFP, UNICEF, UNFAO, UNOCHA, UNDP, Concern, GOAL, MSF, and Oxfam in the WHO class and locations (L_i) such as Haiti, Somali, Sudan, Ethiopia, DRC, CAR, Pakistan, Afghanistan, Sri Lanka, Yemen, Morocco, Peru, Bolivia, and Chile in the WHERE class. If we wish to find individuals from the HOW ($M_1, \ldots, M_t$) and WHERE (L_i) classes, which agree on the reasons for intervention WHY ($\{R_1, \ldots, R_t\}$) by the WHO class (A_i) we tie HOW class with WHERE and WHO classes through the object property *mean_of_intervention* which uses HOW ($M_1, \ldots, M_t$) as a range of values and WHERE (L_i) and WHO (A_i) as domain. This is a preparation for securing successful reasoning upon 5WH_ONT.

Domain	Object Property	Range Values	Range Class
WHO, WHERE	sector of intervention	Food, Health, Water, Sanitation, Education, Non Food Items, Hygiene, Electricity, Protection, Agriculture, Shelter, Nutrition (Sectors S_1, …, S_l).	WHAT
WHO, WHERE	preferred duration	Immediate Response, Late Response, Long Term Response, Short Term Response (Time)	WHEN
WHO, WHERE	reason of intervention	Hunger, Flood, Security Threat, Drought, Earthquake, Tsunami, Genocide, Poverty, Diseases Outbreak, Pollution. (Reasons R_1, …, R_t})	WHY
WHO, WHERE	mean of intervention	Funds, In-kinds, Human Resources, Administrative, Military, IT, Medical, Political, Logistics (Means {M_1, …, M_t})	HOW

Table 1. Object Properties for 5WH_ONT

THE REASONING: CASE STUDY

Let us assume that we had various locations (L_i) and different types of HC: a civil war in Sudan, earthquake in Haiti, hunger in Somalia and flooding in Pakistan. A decision maker should be able to choose which one of humanitarian organizations (A_i), out of possibly hundreds of them, should be deployed in which location (L_i). Therefore our question: "*WHERE (L_i) can we deploy USAID (A_i) which is interested in delivering a HR"* can be answered through the reasoning process by running the following six SWRL rules:

Rule 1: *WHO(?A) ^ sameAs(?A, "USAID")* → *WHO_RESULT(?A)*
Rule 2: *WHAT(?S) ^ WHO_RESULT(?A) ^ sector_of_intervention(?A, ?S)* → *WHAT_RESULT(?S)*
Rule 3: *WHEN(?T) ^ WHO_RESULT(?A) ^ preferred_duration(?A, ?T)* → *WHEN_RESULT(?T)*
Rule 4: *WHY(?R) ^ WHO_RESULT(?A) ^ reason_of_intervention(?A, ?R)* → *WHY_RESULT(?R)*
Rule 5: *HOW(?M) ^ WHO_RESULT(?A) ^ mean_of_intervention(?A, ?M)* → *HOW_RESULT(?M)*
Rule 6: *WHERE(?L) ^ WHAT_RESULT(?S) ^ sector_of_intervention(?L, ?S) ^ WHEN_RESULT(?T) ^ preferred_duration(?L, ?T) ^ WHY_RESULT(?R) ^ reason_of_intervention(?L, ?R) ^ HOW_RESULT(?M) ^ mean_of_intervention(?L, ?M)* → *WHERE_RESULT(?L)*

Rule 1 extracts USAID as an *actor* who is interested in HR. Rule 2 extracts *sectors of interests* (intervention) applicable to USAID (Food, Health, Water, Sanitation, Shelter, Protection, and Nutrition). Rule 3 extracts USAID *preferred duration*, which is an "immediate response" in HC. Rules 4 and 5 extract USAID's preferred *reasons* for (Hunger, Flood, Drought) and *means of intervention* (Funds, Human Resources, IT, Logistics). Rule 6 takes the extracts stored in the WHAT_RESULT, WHEN_RESULT, WHY_RESULT and HOW_RESULT and determines exactly where USAID will be deployed. Haiti, Pakistan and Sudan are three locations (WHERE) which have the needs that can be delivered by USAID.

Rule	Class	Asserted Individuals	Object Properties	Inferred Individuals	Result Class
R1	WHO	USAID, DFID, WFP, UNICEF, UNFAO, UNOCHA, UNDP, Concern, GOAL, MSF, Oxfam.	N/A (sameAs)	USAID	WHO RESULT
R2	WHAT	Food, Health, Water, Sanitation, Education, Non Food Items, Hygiene, Electricity, Protection, Agriculture, Shelter, Nutrition.	sector of interest	Food, Health, Water, Sanitation, Shelter, Protection, Nutrition	WHAT RESULT
R3	WHEN	Immediate Response, Late Response, Long Term Response, Short Term Response.	preferred duration	Immediate Response	WHEN RESULT
R4	WHY	Hunger, Flood, Security Threat, Drought, Earthquake, Tsunami, Genocide, Poverty, Dis. Outbreak, Pollution.	reason of intervention	Hunger, Flood, Drought	WHY RESULT
R5	HOW	Funds, In-kinds, Human Resources, Administrative, Military, IT, Medical, Political, Logistics.	mean of intervention	Funds, Human Resources, IT, Logistics	HOW RESULT
R6	WHERE	Haiti, Somali, Sudan, Ethiopia, DRC, CAR, Pakistan, Afghanistan, Sri Lanka, Yemen, Morocco, Peru, Bolivia, Chile.	sector of interest, preferred duration, reason of intervention, mean of intervention	Haiti, Pakistan, Sudan	WHERE RESULT

Table 2. Asserted and Inferred Individuals in the 5WH_ONT in the Case Study

RELATED WORKS AND CONCLUSIONS

We could not find any related work which uses OWL/SWRL enabled ontologies as a support to decision making in HC. However, we have found a few attempts to exploit the power of OWL/SWRL environment in HC which may be relevant for us. Truptil et al. (2009) use OWL and SWRL to create a metamodel when building "system of systems" which could help heterogeneous information systems to interoperate together during HR operations. Such a "holistic" perspective in addressing the heterogeneities aims to answer all possible questions we may have in HR. Their ideas overlap with the role of our framework (Shampug and Juric, 2012), which addresses heterogeneities between data repositories held at (A_i), (L_i) and (S_1, … S_n) sources. Gwenzi (2010) uses

OWL/SWRL in order to interoperate different geographical data sources and enhance spatial web search in HC. However, they, like many other authors, who use Semantic Web technologies, still rely on SQWRL and SPARQL to retrieve the static content of their ontologies and extract knowledge from various sources (Smart et al., 2010; García, 2011). Our solution uses OWL/SWRL to perform inference, and answer questions important in decision making. We have been encouraged to use our OWL modeling and SWRL reasoning because it is possible to juxtapose interests and preferences of actors in HC with existing profiles and histories of various HC (Shamoug and Juric, 2011b; Edmond et al., 2010) for the purpose of decision making. Predicting answers from historical experiences is possible through semantic web technology, because it allows converting elements of HC and HR into ontological individuals. Finally, we run our reasoning in order to extract answers to all questions we may have by matching locations (WHERE) profiles with actor (WHO) profiles (Shamoug and Juric, 2011b; Bénaben, 2008).

This paper is a snapshot of our work in progress, which should ultimately automate the decision making for HR during HC. We have shown a simplified and practical example of HR, where information and data collected during HC, can be interpreted and used for that particular purpose. Our idea of using the Semantic Web technology and OWL/SWRL enabled ontologies in particular, for describing and manipulating the semantic of HC, proved to be a good starting point towards the automation of decision making. More work should be done in terms of (a) extending the ideas from this paper towards all possible situations in HC and creating a generic reasoning process for supporting any type of decision making for HR and (b) incorporating the solution from (a) into a mobile and wireless software application or Apps, which can be run at any place and time, on any device, and whenever access to relevant data and information, essential for decision making, are available. It is feasible to convert any repository we may find at any level of decision making in HC into the 5WH_ONT model and populate its individuals with appropriate data from the repositories. We also aim to place our software solution from (b) within the framework (Shamoug and Juric, 2012) which addresses the issue of data sharing and interoperability across various information systems which exist in HC.

REFERENCES

1. Bénaben F., Hanachi C., Lauras M., Couget P., and Chapurlat V. (2008) "A Metamodel and its Ontology to Guide Crisis Characterization and its Collaborative Management", *Proceedings of the 5th International Conference on Information Systems for Crises Response and Management*, Washington DC, USA
2. Bharosa N. and Janssen M. (2009) "Reconsidering information management roles and capabilities in disaster response decision-making units" *Proceedings of the 6th International ISCRAM Conference*, May 2009, Gothenburg, Sweden.
3. Charny, J. R. (2004) "Upholding Humanitarian Principles in an Effective Integrated Response " Ethics International Affairs, Vol. 18, pp. 13-20.
4. Darcy J. and Hofmann C. A. (2003a) Humanitarian needs assessment and decision-making, *Briefing Paper No. 13*, HPG, Overseas Development Institute, London, UK
5. Darcy J. and Hofmann C. A. (2003b) According to need? Needs assessment and decision-making in the humanitarian sector, *Briefing Paper No. 15*, HPG, Overseas Development Institute, London, UK
6. Edmond J., Raschid L., Sayyadi H., and Wu S. (2009) "Exploiting Social Media to Provide Humanitarian Users with Event Search and Recommendations", *Proceedings of the 6th International Conference on Information Systems for Crises Response and Management*, Gothenburg, Sweden
7. FEWSNET, Famine Early Warning Network (2001) "Worsening Crisis in Sudan" Food Security Update, USAID Publications, http://pdf.usaid.gov/pdf_docs/ Pnada626.pdf (accessed on 01.02.2011).
8. Fitrianie, S. and Rothkrantz, L. J. M. (2009) "Computed Ontology-based Situation Awareness of Multi-User Observations", *Proceedings of the 6th International Conference on Information Systems for Crises Response and Management*, Gothenburg, Sweden
9. García, L. E. R., Garcia, A., and Bateman, J. (2011) "An Ontology-Based Feature Recognition and Design Rule Checker for Engineering", *Proceedings of the 10th Intern. Sem. Web Conference* , Bonn, Germany
10. Gwenzi, J. (2010) *Enhancing Spatial web search with Semantic Web Technology and Metadata Visualisation*, Master's thesis, International Institute for Geo-Information Science and Earth Observation, Enschede, The Netherlands, 2010
11. HPG, Humanitarian Policy Group (2006) "Humanitarian Response to Natural Disasters" *HPG Briefing Paper*, May 2006, Overseas Development Institute, ODI: London.
12. INTERNEWS (2010) "Humanitarian Reporting in Pakistan: Journalists' Handbook",

http://www.internews.org/pubs/pakistan/Humanitarian Reporting_Journalists Handbook_Pakistan_.pdf (accessed in 10.11.2011)

13. INSEAD (2005) "Managing Information in Humanitarian Crises: UNJLC Website", *http://www.insead.edu/facultyresearch/centres/isic/011HRG.pdf* (accessed on 03.11.2010).
14. Kataria, P., Juric, R. (2010) Creating Semantics From User Inputs Through Ontological Reasoning, *Proceedings of the 15th International Conference on System Design and Process Science*, University of Texas, Dallas, USA.
15. King D. J. (2005) "Humanitarian Knowledge Management", *Proceedings of the 2nd International Conference on Information Systems for Crises Response and Management*, Brussels, Belgium
16. Margesson R. and Taft-Morales M. (2010) "Haiti Earthquake: Crisis and Response" *CRS Report for Congress*, Congressional Research Service: Washington D. C.
17. Morrison C. T. and Cohen P. R. (2005) "Noisy information value in utility-based decision making" *Proceedings of the 1st international workshop on Utility-based data mining*, pp.34-38, August 21-21, 2005, Chicago, Illinois.
18. Pettersson U. (2009) "Sharing Knowledge: How to Highlight Proven Experience in the Swedish Armed Forces", *Proceedings of the 6th International Conference on Information Systems for Crises Response and Management*, Gothenburg, Sweden
19. Shamoug, A. and Juric, R. (2011a), "Addressing Interoperability though the Semantics of Information Highway in Managing Responses in Humanitarian Crises" *Proceedings of the 8th International Conference on Information Systems for Crises Response and Management*, Lisbon, Portugal.
20. Shamoug, A. and Juric, R. (2011b), "Decision Making in Humanitarian Crises Based On OWL/SWRL Enabled Ontologies" *Proceedings of the SDPS 2011 Conference*, Jeju Island, South Korea.
21. Shamoug, A. and Juric, R. (2012) "Framework for Knowledge Inference in Decision Making During Humanitarian Crises", to appear on *Proceeding of Workshop on Knowledge Management Capacity in Africa*, KMCA2012, 4-7 January 2012, Khartoum, Sudan
22. Sibun P. (1997) "Beyond Dialogue: The Six W's of Multi-party Interaction", Association for the Advancement of Artificial Intelligence: AAAI Technical Report SS-97-04, *www.aaai.org/Papers/Symposia/Spring/1997/SS-97-04/SS97-04-027.pdf* (accessed on 15.06.2011).
23. Smart, P. R., Russell, A., Liang, S., Shadbolt, N. R., Booth, C., Briscombe, N. and Rankin, A. (2009) Using Semantic Technologies to Improve Information Exploitation in Military and Civilian Application Contexts. In: *Knowledge Systems for Coalition Operations*, Southampton, UK.
24. Sphere, The Sphere Project (2010) *Sphere Handbook: Humanitarian Charter and Minimum Standards in Disaster Response*, Sphere Project, Geneva, Switzerland.
25. Truptil, S., Benaben, F, and Pingaud H. (2009) "Collaborative process design for Mediation Information System Engineering", *Proceedings of the 6th International Conference on Information Systems for Crises Response and Management*, Gothenburg, Sweden
26. UN, United Nations (2007) *Global Symposium+5: Information for Humanitarian Action*, Geneva, Switzerland 22-26 October 2007. Geneva: United Nations.
27. UNDP, United Nations Development Programme (2009) Sudan Threat and Risk Mapping and Analysis Project, *http://www.sd.undp.org/doc/CRMA/CRMA brief (March 2011).pdf* (accessed on 10.11.11)
28. UNOCHA, United Nations Office for Coordination of Humanitarian Affairs (2001) Structured Humanitarian Assistance Reporting, *http://www.humanitarianinfo.org/imtoolbox/08_Data_Standards/Reference/SHARE/Unicef_Share_Mar01.pdf*
29. UNOCHA, United Nations Office for Coordination of Humanitarian Affairs (2006) Guidelines for OCHA Field Information Management, *http://www.humanitarianinfo.org/imtoolbox/2006/01_Info_Mgt_Overview/2006_Guidelines_For_OCHA_Field_Info_Mgt_v1.1.doc* (accessed on 04.11.2010).
30. Walker P. and Pepper K. (2007) The state of humanitarian funding, *Forced Migration Review*, 29, 2007, 33-35, University of Oxford: Refugee Studies Centre, Oxford, UK.