Addressing Interoperability through the Semantic of Information Highway in Managing Responses in Humanitarian Crises

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ABSTRACT

We propose an Information Highway (IH) which addresses interoperability in software systems supporting Humanitarian Crises (HC) and consequently enables efficient decision making at any level: operational, organizational and donor levels. We model our IH by (a) manipulating the semantics stored in knowledge of data repositories, which are interwoven in everyday activities of managing responses to HC and (b) understanding the meaning and the purpose of requests for data retrievals issued in such environments.

Keywords

Humanitarian crises, Interoperability, Semantics, Taxonomy

INTRODUCTION

Hazardous situations in human environments, which are not prepared for dealing with them, may end in HCs which range from drought, flooding, famine and hurricanes to wars, earthquakes and volcano eruptions (Sphere, 2010). The correct information, which is either collected or created HCs, is essential in managing aid, saving lives and bringing such environments back to their normal state (UN, 2007). The UN Emergency Relief Coordinator, Sir John Holmes, says that "information is very directly about saving lives. If we take the wrong decisions, make the wrong choices about where we put our money and our effort because our knowledge is poor, we are condemning some of the most deserving to death or destitution" (UN, 2007: 41). It is expected that in such environments, information is of a heterogeneous nature. It is created in a variety of circumstances, collected through a plethora of devices and technologies and used by different actors, ranging from governments and aid bodies to international and local organizations (UNFPA, 2010). The amount of information created and stored in systems which support responses to HCs is enormous. Data and information are very often scattered across locations, managed by different bodies and obviously heterogeneous from many aspects: data structures, data models, platforms which host them and software applications which manipulate them.

In this paper we propose the creation of an IH amongst various parties involved in responses to HCs. An IH can be seen as a software architectural solution, which enables dissemination of correct and appropriate data, as a support in decision making when responding to HCs. We propose modeling of an IH through the manipulation of the semantic stored in the environments which are affected by and responsible for decision making in HCs. This will enable us to understand, during a particular HC, which spectrum of data and reports we need to have for making decisions, who has relevant data, where it is stored, in which format, how we can access and use it.

In general, decision makers use two different types of data: primary data, directly collected from the field, and secondary data, collected from external sources (INSEAD, 2005). At the same time we have to address three different aspects of data processing in software systems which support HCs:

a) The benefits of exploiting software technologies in pervasive computational spaces of environments affected by HCs and in domains where all parties involved in responses to an HC operate;
b) The way software environments, which allow the dissemination of any format of data and reports across all actors and operational levels of systems for supporting responses to HCs, enable efficient and successful decision making, thus saving lives and resources;
c) Possibility of ad-hoc creation of an IH for any type of HC, which is based on (i) the semantics of data repositories stored in environments affected by the HC, and (ii) the semantics of requests issued by various

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parties involved in HC, which secure an adequate response to the HC.

There are many factors which determine the type of IH we may create. They range from policies and political decisions of aid organizations, donors and governments, to efficient exchange of information essential for decision making and prompt response to HC (INSEAD, 2005). From the software support perspective, it is obvious that the essence of achieving a) – c) above is in securing

(i) adequate data sharing across multiple operational environments involved in responses to HCs,
(ii) interoperability of data repositories and applications created upon such repositories and
(iii) existence of modern software technologies which enable understanding of the role, purpose and content of primary and secondary data, collected or generated in environments affected by or involved in HCs.

However, if we want to promote the idea that the IH, depicted in c) above, would be able to deliver (i)-(iii), then we should model our IH by manipulating the semantics stored in data, reports, and HC environments, which are interwoven in everyday activities of managing responses to HC. The most important aspect of manipulating the semantics should be the understanding of meaning and the purpose of requests for data in such environments. Our proposal should deal with (i)-(ii), which are pre-requisites for the existence of an IH. If we really wish to share data during HCs and manage requests for data and reports issued by various parties, we have to address the interoperability problem. Our IH should guarantee the sharing of data and reports regardless of their formats, location where they are generated or stored and who "owns" them. Thus interoperability in our IH means accessing relevant data at any time and sharing it across any levels of activities and parties involved in HCs.

The paper is structured as follows. In the Background we describe the problem domain, through different levels of management of responses to HCs. In the Problem section we show the flow of information within the current structure of managing responses to HCs and highlight its deficiencies in terms of securing prompt decision making. Our Proposal section explains the role and benefits of the IH with excerpts from the semantic model built within the IH, which ultimately secures more intelligence in systems for HC. We overview related work and conclude in the last two sections.

THE BACKGROUND

The management of responses to HC is organised though three different levels (UNOCHA 2001), which is illustrated in Figure 1. It addresses (a) The nature and purpose of different *levels* of activities involved HCs, (b) the role of command and report lines, as mechanisms for initiating responses to HC and managing the flow of information within the current system and (c) points where decision making takes place across all levels.

Levels of Activities in Responses to HC

The Donation level consists of a set of governments, organisations, and individuals who have interests in making donations for HCs. They have the power of deciding how much funds or goods they are willing to donate for a particular HC. The decision is based on many 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). They also use Analytical Reports $\{AR_1, \dots AR_r\}$ (e.g. media reports, academic publications and references) which are either in the public domain or generated for purposes of managing the HC. These include archives, public statistics, crises history, demographical studies etc (Darcy and Hofmann, 2003b; UNFPA, 2010). *The Organisational Level* houses international agencies and bodies $\{O_1, \dots O_p\}$ which have direct impact on organising response to HCs. They range from organisations under UN umbrella (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 $\{AR_1, \dots AR_r\}$ created for a particular instance of HC 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 $\{A_1, \dots ,A_m\}$ which respond to HCs on the ground. They are always divided into Sectors $\{S_1, \dots S_k\}$ and Locations $\{L_1, \dots L_q\}$, where each location may contain more than one sector. Sectors are prescribed by the Donors, UN, Red Cross, and NGOs (Sphere, 2010; UNFPA, 2010).

Report and Command Line

There is an interconnection between these three levels where actors at the top level use the "command line" to envoy their response to the lower levels and vice versa. The command line is also used to send the orders, explain policies, and respond to earlier requests. Thus the command line is the *decision making* pathway. The quality, accuracy, and value of any decision taken, at any level, highly depend on the quality, accuracy, and value of the information provided to decision makers (Darcy and Hofmann, 2003b). The channel available to convey information to the decision makers during HC is what is called the "report line" (UNOCHA, 2006). It starts at the grass root level where actors in the operational level combine data from primary and secondary sources and report them to the organization level, which in turn reprocesses the information coming from operational level and also adds some information to it from other secondary sources. Finally, the donation level receives this information, reprocesses it, and takes strategic decision in light of it (Darcy and Hofmann, 2003b).

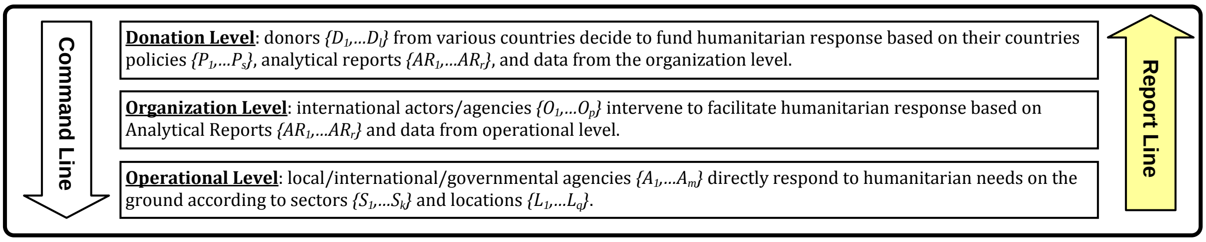

Figure 1. Current Levels of Activities for supporting responses to HC

Decision Making

The management of responses to HCs is dependent on various decision making processes, which happen at each level and which are based on various data and information available at a particular level (IASC, 2010). At the Operational level, decision making is equivalent to the initiation of direct assistance in localities affected by HCs, in terms of reaching people, i.e. responding to humanitarian needs on the ground. This decision is based on the primary source of data from the ground field, within various sectors and localities affected by the HC.

At the Organizational level, decision making has a form of "deciding on intervention", i.e. it initiates and facilitates the response to the HC. For example, international actors and agencies $\{A_1, ... A_m\}$ must justify their decision that an HC exists and initiate the beginning of intervention, as a part of the international response to affected people and countries. Their decision is based on various analytical reports $\{AR_1, ... AR_r\}$ available publicly, or created nationally and internationally and information from the Operational level.

At the Donation level, decision making is carried out on the type and amount of funding that donors can offer. Their decision is based on information from the Organisational level, and secondary source of data, such as analytical report $\{AR_1,...AR_r\}$, donor's policies, their local and government legislations $\{P_1, ...P_s\}$.

THE PROBLEM

Figure 2 shows current data and information flow across all levels, which follow the Report line from Figure 1. In other words, we concentrate on the impact of the report line to data flow in the current system. It is expected that at the operational level, the main source of data has been collected from the people directly affected by the HCs. Data is collected according to various sectors $\{S_1, \dots S_k\}$ and locations $\{L_1, \dots L_q\}$. Decision making and tasks at the operational level also depend on a publicly available Analytical Reports $\{AR_1, \dots AR_r\}$. The organizational level receives various reports from the operational level through the report line, (such as camp populations, gaps in humanitarian assistance, or coverage of humanitarian assistance) and uses secondary source of data $\{AR_1, \dots AR_r\}$ to feed its decision making and generating its own reports. The donation level uses some analytical reports $\{AR_1, \dots AR_r\}$ from the organizational level, but its main source for decision making is often based on donor preferences, relations and government policies and legislations $\{P_1, \dots P_s\}$.

We highlight below anomalies in the flow of data and information in the current system:

1. There is no *free* flow data: some data sources are available only to certain actors and agencies.
2. The response line in Figure 2 has a strict flow. It is impossible to skip levels when sending reports to interested parties, therefore it may delay decision making, particularly at the donation level
3. Decision making at the donation level, is one of the most important in this chain, but it may be delayed, because donors may not be able to access relevant information on time.
4. Decision making at the organisational and donation level is always based on secondary data, i.e. no original data from the sectors and locations affected by the HC is available for them. This does not necessarily mean that organisational and donation levels get incorrect information. It may mean that the information they receive might not have been processed, or prepared appropriately for their decision making.

5. It is obvious that if any aid organisation or actor appeared at two levels: operational and organisational, then the information they have (even from their own archives) may affect the flow of information through the report line. In such cases, the preparation of primary source of data for reports might not be controlled and done according to reporting policies of each level.
6. We also show in Figure 2 that there is no horizontal reporting between actors working in different sectors or locations at the operational level. The same is true for organisation and donation levels.

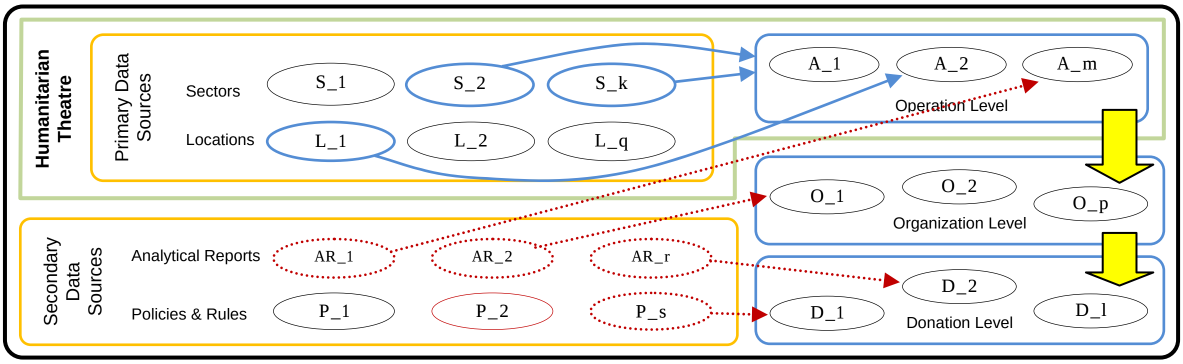

Figure 2. Current model of data flows in HC

THE PROPOSAL

In Figure 3 we give different modes of accessing and processing data stored within the current system of managing responses to HC. Therefore the essence of our IH (blue solid and brown broken lines) is in

a) connecting all primary and secondary data sources with all actors involved in the system and
b) allowing current reporting through the existing report line to enrich the amount of data and reports needed by actors at each level for their individual decision making.

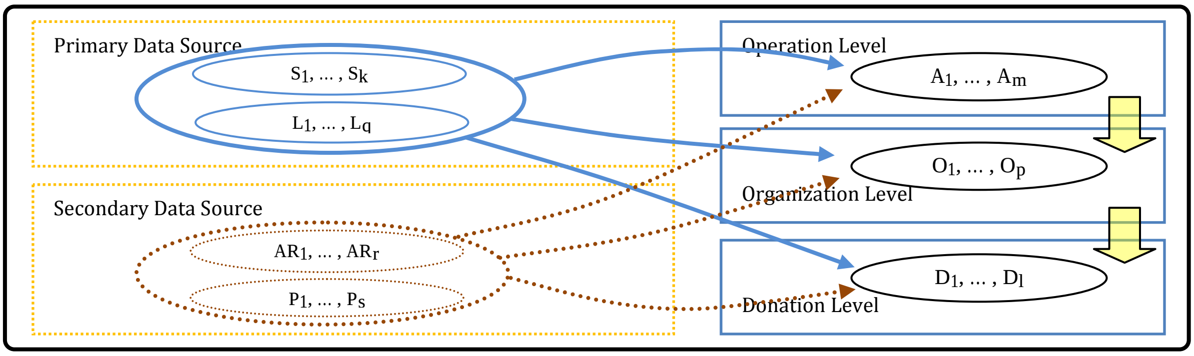

Figure 3. The proposed model of IH in HC

Accessing data from remote locations, even by agencies and donors that were NOT involved in the process of generating the data in HCs, does not necessarily mean that we compromise the security, correctness and accuracy of the data. Software engineering solutions, which control access to data, and which also allow remote access to any type of data repositories, have been common in distributed software systems since the mid-90s. However, the issue of data ownership, business politics, and business strategies is always an obstacle in designing software solutions similar to our IH. The fear that, by allowing access to your own data by someone outside your own operational environment will result in the loss of your data, has always been an obstacle to sharing data across software environments. Furthermore, we have to deal with heterogeneities of data repositories, software applications built upon them and platforms which host them. Building an IH as shown in Figure 3, will require the preparation of environments which can take heterogeneities into account, resolve them and perform retrievals across all levels and by all agencies, organizations and donors.

The Role and Benefits of the IH

The benefits of using an IH are obvious

1. Each actor has access to both primary and secondary data – at any level;
2. We improve decision making at any level, by allowing access to data outside levels, and not waiting for the report line to deliver adequate report(s);
3. Each level can dynamically generate its own reports in real time, by accessing primary sources of data. Thus we may increase the type and number of generated reports which are tailored for a particular level;
4. We eliminate the dependency between levels. We do not eliminate the report line, but we facilitate access to original data, thus enhancing the decision making process and suitability of reports created for each level;
5. Each actor may have a choice between using readymade reports from the adjacent levels and creating their own reports, which in turn can be from the primary and secondary source of data!

The Semantics of IH

An ad-hoc creation of an IH should be based on understanding the semantics which lies behind any request imposed upon sources of data across levels which manage responses to an HC. In other words, any solution which secures (i)-(iii) from the Introduction should be based on "knowledge" of:

- The role of all actors $\{A_1, ...A_m\}$ involved,
- Type, format and accessibility of data sources available at any level (with Sectors S_j and Locations L_k) and
- The nature (format, locations, mode of access) of additional information, such as Analytical reports AR_j and Policies P_k.

The bullets above illustrate the complexity of semantics behind any instance of the IH. Knowing *types, formats* and *modes of accessing* heterogeneous data sources is essential in achieving interoperability in such environments. The bullets above also highlight the need to understand the roles of actors and the nature of their requests in order to respond to HCs, which also helps in addressing how to secure correct data retrieval at any level and overcome heterogeneities which may exists across them. If we wish to claim that our software architectural solutions, behind the IH, will address all the above, then we must find a mechanism of modeling and manipulating the semantics of any instance of IH, according to requests imposed by actors in a particular HC. These requests for retrieval of data and reports across levels will determine the nature of heterogeneities we need to address, to secure sharing of data and reports and ultimately achieving interoperability.

We propose to place the semantics of an IH into an ontological environment which makes provision for:

(i) describing the semantics of the environment, essential for creating the software architectures behind IH, stored in ontological concepts and
(ii) performing reasoning upon ontological concepts in order to create the best possible instance of the IH for a particular request imposed by actors involved in managing responses to HCs.

(i) and (ii) above will directly answer any interoperability question we may have, as described earlier in this section. In order to address (i) above, we propose a taxonomy from Figure 4, which can easily be transformed into ontological concepts and their constraints, which in turn will enable reasoning in order to utilize (ii) above.

Figure 4 models the semantics of an IH based on the purpose and roles of levels of operations and data sources essential in responses to HC. Its basic concepts are self-explanatory and divided into very well known What, Who, Where and Why in HCs. The most relevant concept, in terms of accommodating the semantics of our IH, is Coordination (sub-concept of "What"), which is elaborated in Figure 5. It allows modeling of the "meaning" of a complete environment which manages responses to the HC: all actors involved in the HC, primary and secondary sources of data needed by all actors; impact of reporting and direct accessing to primary source of data by all interested parties and purposes of issuing requests of retrievals across all levels. In Figures 4 and 5 we can not show the impact of all these concepts on each other. Without a full scale ontological implementation of taxonomy from Figures 4 and 5 we can not show how inter-relations between taxonomical concepts affect the creation of an IH. However, we can demonstrate through a simple scenario which kind of reasoning we can impose upon such concepts and how such reasoning can affect the implementation of particular instance of IH.

The Scenario

United States Agency for International Development (USAID) $\{D_i\}$ has \$10 million USD as a one year budget to be spent in Haiti $\{L_i\}$ for humanitarian purposes. Meanwhile, the United Nations World Food Programme (WFP) $\{O_i\}$ needs 500,000 metric tons of food $\{S_i\}$ to be distributed for affected population in Haiti $\{L_i\}$. On the other hand, MSF $\{O_i\}$ has a health programme $\{S_i\}$ that needs \$10 million USD to cover some primary health activities to be held in Haiti $\{L_i\}$. At the same time, Oxfam $\{O_i\}$ has to build 900,000 temporary shelters $\{S_i\}$ for Haitian refugees in The Dominican Republic $\{L_i\}$. The decision maker in USAID needs to know which one of these requests has priority. This is dependent on conditions that the request (a) must match US government policies and regulations $\{P_1, \dots P_s\}$, (b) it must reflect the true facts on the ground $\{L_1, \dots L_q\}$, (c) it should belong to the same sectors of interest for USAID $\{S_1, \dots S_k\}$, and (d) it should be compatible with the secondary data sources $\{AR_1, \dots AR_r\}$ such as population of affected areas, media reports, demography, history of the crisis, and other activities help by other donors $\{D_1, \dots D_l\}$.

Manipulating the Semantics of IH

If the semantics from the taxonomy in Figures 4 and 5 are translated into ontological environments, built with Semantic Web technologies, then we will be in a position to reason upon the knowledge stored in such environments, in order to draw conclusions and make decisions. We will be able to answer questions, such as:

- Where is the data which is appropriate for our decision making stored?
- Which type of data repository (database, documents, reports) do we need in order to make decisions?
- Which data access mechanisms are available for retrieving primary data outside our working environment?
- Are we able to make decisions before we create additional reports, i.e. are the existing reports available from the report line sufficient for our decision making?
- Is our decision correct in terms of following our government policies, activities of other donors in the same HC and taking into account the newest data collected from locations on the ground?

The taxonomy in Figures 4 and 5 shows major concepts and their hierarchies with emphasis on "Coordination" sub concept which embraces a hierarchy sufficient for storing semantics essential for creating reasoning mechanism in order to answer questions in the bullets above. However, a full scale reasoning mechanism should include a range of constraints imposed on the main taxonomical concepts, which strengthen the existing semantics and describe all relationships we may have across the taxonomical concepts.

In order to detail them, we need:

(i) a full scale implementation of ontological concepts, transferred from the taxonomies above, possibly using OWL/SWRL enabled ontologies,
(ii) a set of data type and object properties in OWL, which can further describe the semantic of ontological concepts and relationships between them and
(iii) a set of SWRL reasoning rules which will give answers to various competency questions we may have, as bulleted earlier in this section.

Therefore the software architecture behind our IH in principle cerates ontological elements and populates them with ontological individuals as in (i). We then run a specific set of constraints which may say: "Donor D_i *has_ health_programme* (OWL object property) S_i that needs *"$10 million USD"* (OWL range value for an data type property defined upon concept S_i) to cover some primary health activities to be held in "Haiti" (*individual of a concept*). The next step is to run SWRL rules, as in (iii) which may answer any question from the scenario, such as "which one of requests for helping in HC takes priority".

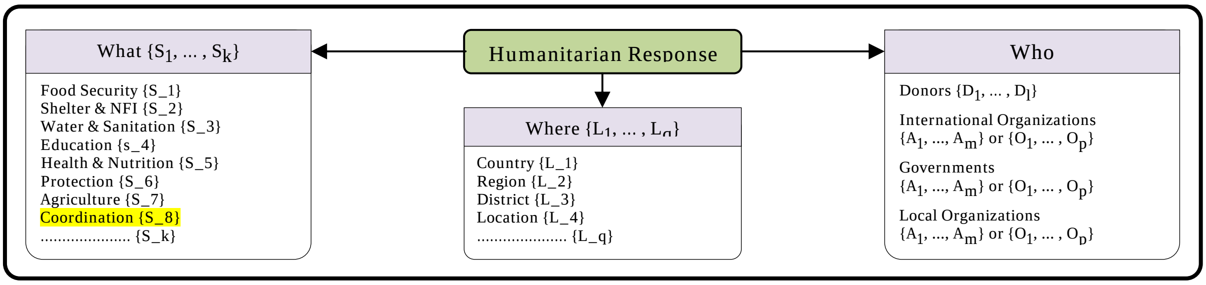

Figure 4. Taxonomy of Humanitarian Response

It is important to note that a full scale implementation of a particular instance of our IH is the subject of a separate publication. In this work we illustrate that "*deciding on the best possible instance of an IH*" will depend on reasoning we perform upon the semantics of the environments which need an IH. An instance of IH will be created with the help of Semantic Web technologies and OWL/SWRL enabled ontologies in particular, which give us reasoning mechanisms for manipulating semantics of environments of HC. However, a full scale solution will always be a software engineering application which manages retrievals across heterogeneous data sources. This must be backed up with the results of our reasoning which specify (a) which data source can be accessed and how, (b) which reports are relevant for an actor and why (c) which format of the results of retrievals we expect. Finally, we use OWL/SWRL enabled ontologies to match ontological concepts (i.e. their individuals) and infer more knowledge (i.e. answers to questions) as a consequence of ontological matching. For more information on our software engineering solutions which deal with inference mechanisms built upon OWL/SWRL enabled ontologies we refer readers to our earlier publications (Kataria and Juric 2010b).

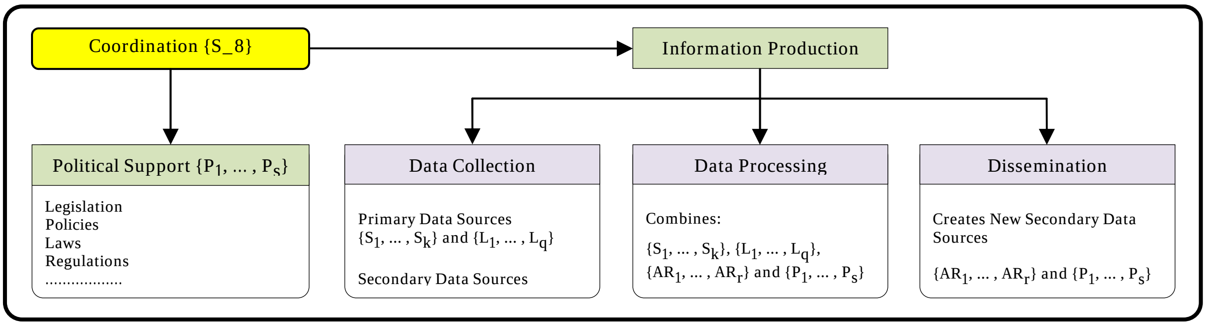

Figure 5. Taxonomy of Humanitarian Coordination

RELATED WORKS

In this section we briefly overview initiatives from the information systems and software engineering community, which have been addressing the interoperability problem since the 90s. We omit the review of solutions on decision making, dependent on data from heterogeneous domains and data sources. This has not only been done deliberately for reasons of brevity. There are currently no solutions in decision making which either use Semantic Web technologies or address both heterogeneity and decision making at the same time.

Interoperability of software systems has been in the focus of interest and research on how to deal with the problems it rises for at least three decades. The problem of software and system interoperability can be viewed from various perspectives, because it has always been triggered by heterogeneities of platforms, applications, data repositories, which bring up issues of interoperability requirements and its mechanisms that range from integration and data sharing to software interoperability standards and models. They all require semantic and schematic data interoperation and data sharing i.e. they need interoperation across heterogeneous data sources, variety of problem domains and software applications built within them, and the Internet. Shared and interoperable databases and software applications are essential in many problem domains: from software applications in business, management, public and healthcare sector to simulation modelling, decision sciences, business intelligence and information and knowledge management. Initiatives for resolving heterogeneities from the early 90s, where examples and practices of federation (Sheth and Larson, 1990; Colomb, 1997) and mediation (Wiederhold, 1999) in data intensive software applications, such as databases, did not bring any long term interoperability solution (Juric et al., 2004; Juric and Beus-Dukic, 2005). Standardisation initiatives across problem domains, with the appearance of XML, made an impact on the way we exchange data and information and also opened doors to web services. With the maturity of component technologies such as JEE and .NET and their impact on service oriented software architectures, we started looking at the problem of interoperability without relying on integrations of data sources or applications in order to address growing number of types and levels of heterogeneities. Thus, data sharing has become a reality by simply deploying technologies which allow accessing and processing data, wherever it is located and whoever its owner(s) is(are) (Granatir et al., 2007; Gnaguly et al., 2009). However, the semantic web initiative (W3C, 2004) has given a new approach to solving the interoperability problem, through commercialization of semantic web technologies, XML and the development of languages and interactive tools for supporting semantic interoperability, such as RDF, OWL, SWRL, Protégé, Jess etc. We have experimented with the efficacy of semantic web technologies when resolving heterogeneities in modern software systems by (i) understanding and modelling the semantics of the environment where heterogeneities occur (Kataria and Juric 2010b), (ii) modelling user's involvements in such environments (Katria and Juric 2010a) and (iii) reasoning upon our modelling concepts in order to achieve (i) and (ii) (Kataria and Juric, 2009).

The work of Rodríguez et al. (2010) shows a solution for supporting decisions in Non-Governmental Organisations (NGO) when responding to natural disasters. They offer a data-based, two-level knowledge methodology which assesses multiple disaster scenarios, using SEDD as a knowledge base system. They avoid traditional and existing decision support systems which proved to be of unrealistic complexity, difficult ad very often impossible to implement. Ding et al. (2010) focuses on oceanic warning system and deals with the problem of high dimensional and dynamic oceanic data which is difficult to process reasonably and to use for any kind of forecasting and analysis. They proposed an integrated framework of data processing which contains data quality control and data cleaning and filtering, based on fuzzy c-means algorithm, greedy clustering algorithm and data processing method based on maximum entropy for OWS. The work of Gong (2003) highlights very important issues of post-crises domestic procurement affected by missing links in various business cycles, which cause gaps and broken chains within UNDO mandate. The paper offers long-term solutions to the linkages between aid-oriented and economic-development-oriented issues. An excerpt form their solutions suggests to integrate all relevant information sources form the national stakeholders, UN agencies and NGOs regarding humanitarian assistance, in order to secure adequate business platforms and successful procurements. Maiers et al. (2005) explores issues and challenges inherent in developing an effective ICT within humanitarian relief and NGO sectors. One of their most important claims is that any ICT solution should facilitate Inter-organisational communication, increase co-ordination and interoperability while maintaining organisational autonomy. The work of Truptil et al. (2010) proposes mediation as an answer to building information systems which help to co-ordinate responses to HC. Their ISyCri project aims to provide an information system in charge of (i) information exchange, (ii) services sharing and (iii) behavior orchestration based on mediation. Cai et al. (2005) advocate a group interface for geographical information system, featuring multimodal human input, conversational dialogues, and "same-time, different place" communications among teams. This is their answer to the management of HC which requires collecting geographical intelligence and making spatial decisions through collaborative efforts among agencies and task groups.

CONCLUSION

This paper overviews current problems in HC reporting, which are triggered by inaccessibility of data essential for efficient and timely decision making. The power of modern software systems and the way we collect, create and process information in the 21st century should have an impact on our way of thinking when enabling data sharing in complex systems such as responses to HCs. Our idea of allowing access to primary and secondary data to all interested parties in the HC does not represent a big innovation per se. It is a simple and natural answer to the ongoing problem of reporting and making decisions across heterogeneous operational, and donation levels. It can also be implemented with modern software technologies which recognise the specificity of data and application distribution in systems that support HCs. However, the novelty in our proposal is in (i) and (ii) from the section on IH. Whenever we have requests for data or report retrieval or generation, imposed on primary and secondary sources, by any of the actors involved, the instance of the IH will be created for that particular situation. However, the semantics stored in the environments which generate IH and the semantics of relationships between data sources, stored in ontological models, will help to manipulate knowledge in them through reasoning, which in turn creates the best possible instance of an IH for a particular request.

Ultimately, the best instance of an IH will support decision making at any level by securing timely and accurate data. It will also allow access to primary data for all: donors, at the political level, through aid organisations at the administrative level to field workers as operational forces in managing humanitarian response.

Our proposal may influence and enrich many current initiatives on responses to HC, such as:

- The final report on Global Symposium 5+ (UN, 2007) because our ideas promote and secure timely and reliable information for anyone involved in responses to HCs;
- Emergency Information Interoperability Framework Incubator Group Charter (W3C , 2009) because our way of modelling the semantics of IH takes into account the nature and purpose of different *levels* of activities involved HC, the role of all actors and types of request for retrievals imposed by them. All these factors may enrich their Information Interoperability Framework and perception of roles in which information systems are used by emergency managers.
- OCHA Guidelines for information Management in Humanitarian Context, (UNOCHA, 2005) may benefit from our ideas of resolving interoperability through an IH which can become a part of OCHA's Principles of Humanitarian Information Management and Exchange.
- Global Pulse program (UN, 2011) in terms of enriching their global system architecture for its real-time data & analysis technology platform. Any of our sources within the IH may become legitimate parts of their own global system architectures for performing any type of analysis. This is the best example where data sharing may enhance activities which are outside the immediate need for responses in HC.

We also believe that a full scale implementation of an instance of IH, in terms of giving services for retrievals across data sources in environments affected by HC, can be linked to the UN portals such as United Nations Data (UN Data, 2011), and United Nations Data API (UN Data API Project 2011).

We are currently implementing ontological models based on taxonomies from Figures 4 and 5, which will allow us to add expressivity when defining semantics of an IH by following (i) and (ii) from the section on IH. This will lead us towards the exact development of software architecture behind the IH and clear specification of reasoning mechanisms which would guarantee the best possible instance of the IH. The next step would be to address (i)-(iii) from the Introduction within any instance of IH. This solution would depend on the choices of technologies used in the creation of primary and secondary data, technologies used to implement the architecture behind the IH and technology needed for manipulating the semantics in ontological environments.

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