USE OF INFOSTRUCTURE FOR DISASTER: TOWARDS DEFINITION OF INFOSTRUCTURE

Aliza Abdul Latif[1], Noor Habibah Arshad[2],and Norjansalika Janom[3]

[1]*Universiti Tenaga Nasional (UNITEN)), Malaysia, aliza@uniten.edu.my*
[2]*Universiti Teknologi MARA, Malaysia, habibah@tmsk.uitm.edu.my*
[3] *Universiti Teknologi MARA, Malaysia, norjan@tmsk.uitm.edu.my*

ABSTRACT. Infostructure' is used in multiple disciplines and it carries different meaning. The variety of meaning of this term makes it hard to be applied to a specific discipline. Different definition exists and this paper is an extension work of building the definition for 'infostructure' to be used specifically in the area of disaster management. The earlier work had analysed existing definitions of infostructure from various disciplines, and similar definitions was searched from selected databases. In this paper, the work of building the definition is continued by analyzing the selected definitions to extract common elements and to establish the basic characteristics of infostructure tailored to disaster management. Based on these existing definitions, this paper presents the exhaustive and consistent definition for infostructure which are contrasted in 4 cases, selected from different countries that experienced different type of disaster.

Keywords: information sharing, disaster management, coordination

INTRODUCTION

Infostructure has been used in describing the infrastructure of information that is used in various disciplines. According to Latif and Arshad (2015), the term infostructure can be applied in any disciplines that are using information systems in managing their information, and it need a proper infrastructure in dealing with information. The paper also stated that there is no standard, agreed definition; instead there are varieties of definitions, which look at Infostructure from different areas, including health, telecommunication and military (Latif & Arshad, 2015).

Using etymological analysis in finding the definition for infostructure is not suitable due to the structure of the word. The name infostructure is formed from two words: info, which originates from the word information, means characteristics of the output of a process, resulting from a particular process that uses inputs (Aliakbarian et al., 2006); and structure, which refers to the aggregate of elements of knowledge in their relationships to each other, as suggested by Merriam-Webster Dictionary. Following this approach, authors such as Jens Pohl (2004) affirm that infostructure 'is a creation of a communication environment that provide connectivity among all entities in support of an effective coordinated response'. However, to adopt the etymological significance as definition is too discriminatory, considering variety of definitions provided across different disciplines.

The objective of this article is to form a suitable definition to describe infostructure that is focused specifically for disaster. In order to obtain this definition, existing definitions and usage of infostructure will be analyzed. The first stage was to collect infostructure definition across disciplines that was gathered from six databases, which includes ACM, IEEE, ScienceDirect, SAGE, SpringerLink and Emerald. This search has resulted in 170 documents, and 10 originals definition were selected from these documents. The selection must fulfil the criteria of having both information and certain infrastructure which may include technology elements. However, this has been covered in the earlier work of proposing the definition of infostructure, in the article by Latif and Arshad (2015). This paper will continue the work by identifying elements and characteristic of infostructure from the selected definition, as it will allows us to identify elements to fulfil infostructure tailored to disaster; and to formalize an incipient theoretical base for infostructure for disaster.

METHODOLOGY

The methodology used to obtain the definition for infostructure to be applied for disaster follows two stages; the creation of an exhaustive definition based on commonly detected elements; and the testing of its validity. Before these two stages are conducted, the gathering of definitions via a systematic review of the literature was conducted (Latif & Arshad, 2015).

Analysis/Preparation

In creating the definition for infostructure, this study will consider the work of Tatarkiewicz, which were applied in the work of Estelles-Arolas (Estelles-Arolas & Gonzalez-Ladron-de-Guevara, 2012) in creating the definition of crowdsourcing. Using Tatarkiewicz technique (Tatarkiewicz, 1980), definitions are collected from all other authors and those which were focused on particular manifestations were set aside. This was done as all the definitions could not be a total reconstruction of the concept and only certain features were took into account while ignoring the rest of it. The next stage in creating the definition that combines all the other definitions was obtained through the union of sentences referring to the intention and effect of the concept, which in this article, is focusing on the concept of infostructure for disaster.

In Tatarkiewicz approach, he was using the concept of diffferentia specifica that has been mentioned in the writing of a Trotskyist political philosopher, Alex Callinicos. The term differentia specifica refers to differences in species that make them distinct and able to be classified, which can be applied in obtaining the definition of infostructure and separating it from other definition retrieved from the review of literature.

Elements designated by Tatarkiewicz as differentia specifica are obtained from the collection of definitions of infostructure. These include elements whose characteristics differentiate infostructure that tailored to disaster from other disciplines.

The elements designated as differentia specifica are transformed from the author's points of view into a conceptual perspective. In this way, the final components of the definition are obtained that will suit its use in the disaster research area.

Verification

The infostructure definition will be validated using two approaches used by Vukovic (Vukovic, 2009) and Aliakbarian et al. (Aliakbarian et al., 2006). In the work of Aliakbarian et al. (Aliakbarian et al., 2006) to verify the definition proposed for 'neighbourhood P2P', the definition is applied to four cases to check if all the elements of the proposed definition are

fulfilled. In Vukovic (Vukovic, 2009) it introduced the development of a general-purpose crowdsourcing platform. The developments of this platform need to fulfil certain capabilities that led to the categorization of the existing crowdsourcing platforms. The selected crowdsourcing platforms are then evaluated against the set of identified features using a proposed taxonomy.

DISCUSSION

This section described the identification of elements and characteristics that were obtained from the results of the earlier work; proposed definition; and proposed definition verification.

Preparation

Three documents are revised and analysed in identifying the common elements of 'infostructure', from which four characteristics are extracted constituting the differentia specifica.

About the info:

(a) who create and own it;

(b) what does it represent or contain;

About the structure:

(c) what it has to do;

(d) the medium used.

Each characteristic are analysed and the results are described below, together with the conclusion that relates the results towards the discipline of disaster:

(a) Who create and own the information?

Majority of the documents revised have agreed that the information belong to at least two main principal player, which are the government or private enterprises (Blanning, Bui, & Tan, 1997). Some authors do state that the information are mostly created by businesses or government that rely on ICT in providing electronic services, either through e-business or e-government initiatives (Chan, Lau, & Pan, 2008).

Based on the sources consulted, most of the information are created to support transactions between government and their citizen. These information may be used in daily transactions among these entities, as ICT was a vital key in communication. The information obtained from the citizen may be used in serving the nation in the current digital economy (Chan et al., 2008).

Conclusion - Who create and own the information?

Initially, information are used in facilitating the business transactions for e-commerce, which later transformed to support the e-government (Chan et al., 2008). It cater to the need of the citizen in dealing with the government and the private sectors. Information are passed among all the entities involved, helping them to make accurate and better decision making.

In the event of a disaster, inputs that are received may be in the forms of task flows, resources, information, decisions and responders. All of these can be considered as information that are being transferred among agencies involved during a disaster. This can be demonstrated by Haiko Van Der Voort (Voort & Bruijn, 2009), which stated the fire disaster in Schiphol Detention Complex was caused by the outdated information about the available gates to the

area. Due to the obsolete information, the firefighters were delayed in finding the right gates to help the victims and caused 11 casualties.

Information used during a disaster are based in hierarchical coordination approach, which is carried out under rigid control following an intra-agency authority structures (Bharosa, Lee, & Janssen, 2009). The major strategic decisions containing the vital information to start the operations will be made at the highest echelons, commonly the government and are filtered down, passing through to the lower echelons, consisting of all disaster related agencies.

(b) What does it represent or contain?

With regard to what the information represents, it can be divided into two categories – one more general and one specific to ICT.

The general tendency is information can be considered as primary asset that is produced, retrieved and processed to support for more rapid and accurate decision-makings capabilities. Data acquired over time can evolved into general patterns, principles or rules that can be applied in any tasks.

The specific tendency of information, as described by Hanna (2010) is the technical component of e-development that need policies and regulations to govern the telecommunication aspect of it. By having this infrastructure, it enables the sharing of knowledge and information among various actors in the society.

Conclusion - What does it represent or contain?

In principle, infostructure can be described as information collection, storage, presentation, analysis, interpretation, which overall can helps for better explanation, planning and forecasting.

According to Comfort et al. (Comfort, Ko, & Zagorecki, 2004) when a major disaster occurs, the interactions among agents engaged in disaster response operations and the patterns of communication among all related agencies create the dynamics of the response process. Inputs obtained from these interactions and communication, will produce output which we consider as information. It is a common denominator in all activities involved throughout the entire phases of a disaster (Bui, Cho, Sankaran, & Sovereign, 2000). It can be in the form of magnitude of disaster, resources available, knowledge or skills possessed by the agents and equipment needed.

It is important to highlight that infostructure does not only include physical components of interrelated systems. It also may contain elements of human resources, organizational and administrative structures, policies, regulations and incentives. It was mentioned by Scott (Scott & Mars, 2013) that all of these elements are necessary in facilitating a fully integrated and sustainable use of ICTS and services in providing support to a chosen discipline, which in our case is disaster management.

(c) What it has to do?

All the definitions obtained highlight the role of government in creating information as a medium to communicate with their citizen. Other stakeholders such as businesses or individuals also rely on information in making decision or provide them to certain entities to get support or facilitate their tasks.

This characteristic can be considered as one of the most important in obtaining the definition of infostructure, as it describes the role of infostructure. Pohl (2004) mentions how it is being used in intelligent software systems to provide countermeasures for security threats, and Uddin (Uddin, Peters, & Haque, 2004) talks about how governmental agencies use infor-

mation to respond to particular crisis. While Chan et al. (Chan et al., 2008) specify the role of information structure is to create wealth from emergence of employment opportunities based on the product and services created from infostructure.

Conclusion - What it has to do?

This characteristics indicate that information will need to have a structure that provide support in delivering content and resources to all the stakeholders involved. Most of the literatures mentions that there is a need for the adoption of modern systems of ICT in catering to the demands of the citizens, which is demonstrated in Chan et al. (Chan et al., 2008). It dictates that to be practically useful, the information content will have to be put together with an ICT infrastructure in forming a good infostructure.

In the event of a disaster, theoretically, if responders have perfect information, the responsible agencies find victims and assist them immediately. Disaster management will deals with a lot of processes that involves with flood of information that need to be collected and stored. Later, this data will be interpreted and analysed to support the communication process throughout all the phases in a disaster: mitigation, preparedness, response and recovery. Most of the problems arise during a disaster is the result of improper decisions made based on inadequate or obsolete information.

As indicated by Uddin (Uddin et al., 2004) agencies involved in a disaster will respond to a particular crisis but require a coordinated efforts across multiple agency jurisdictions. Various studies that have been carried out (Bharosa et al., 2009), (Dawes, Cresswell, & Cahan, 2004; Uddin et al., 2004) provides evidence that poor information sharing and coordination during a disaster response has a negative influence on collective decision makings and action.

ICT and the information attributes it produces appear to be a good solution in disseminating warnings and information to the public during a disaster. It helps disaster communication and can be an effective method in informing the right people at the right time. However, proper understandings on the information and communication technologies are crucial in solving the crisis and disaster situations. Chiu et al.(2009) point out that most researches is focusing on knowledge sharing and decision coordination in multiple organizations, which show how infostructure is suitable to be used as mechanism to support information sharing and coordination.

(d) Medium used

Referring to the definitions obtained from various sources, as stated in A. Latif and Arshad (2015), there is no distinct definition for structure of medium needed for information. Based on the definitions of Wallace and Choi (2011) it stated that an information structure is the relationship between decisions and availability of information. However, in other definition by Mori (Dean, 2004) infostructure need to contain technical components that may include data formats and protocols that are essential for interoperability and the integration of different applications and services. Lastly, Noseworthy (2004) refer to infostructure as a system of computers and communication networks that electronically interconnect facilities, equipment and related stakeholders to facilitate the exchange of information.

Conclusion - Medium used

The focus of ICT in disaster management is to facilitate coordination that specifically revolves around the network or data required. Ianella et al. (Iannella, Robinson, & Rinta-Koski, 2007) indicates that ICT can provide a bigger role in disaster coordination at the information level. Typically in a disaster, all agencies involved will need to make life-dependent decisions based on available resources or information that need to be coordinated to hundreds of disparate groups.

Information is a valuable and critical asset during disaster operations as it is needed to increase response effectiveness for cooperation and coordination during a disaster. Information and resources are essential for a disaster management and will require technology to facilitate the existing processes in managing them during emergencies. It will enable greater efficiency and improved decision making for all the agencies involved in disaster operations throughout the entire phases.

Communication infrastructure is one of the essential components in sharing real-time information as well as local knowledge and experiences, and this component must depend on agreed policies and regulations to induce the supply and demand for much needed telecommunications.

Integrating infostructure definition

Based on the undertaken analysis on all four identified characteristics and combining the previous partial elements, a definition that covers infostructure specifically for disaster management has been created. It achieves the previously mentioned objectives of the study, to create a specific usage of the term infostructure in the area of disaster management and formalizes a theoretical base through the reduction of semantic confusion. The definition is as follows:

Infostructure is information created that follow certain hierarchical coordination approach that include soft structures elements, promoting information sharing by delivering content and resources to stakeholders via a coordinated approach, equipped with ICT infrastructure including systems and communication technology. Information created may be in the form of task flows, resources, decisions, procedures, standards, values and rules created in the event of a disaster. Information created and used during a disaster are based on hierarchical coordination approach that starts at the highest level, typically a government passing through to all disaster related agencies. It can be described as information collection, storage, presentation, analysis, interpretation using interrelated systems, and may include elements of human resources, organizational and administrative structures, policies, regulations and incentives. It provides support in delivering content and resources to all the stakeholders involved in a disaster, which may require proper coordination and sharing of information. The formation of it needs to have a combination of information content that is equipped with a proper ICT infrastructure. Technology is essential in developing it, which include component of communication to enable information sharing that is governed by agreed policies and regulations.

Verification

The definition will be applied to selected scenario of disaster, based on several documents obtained from online databases, assessing the four characteristics of the definition (Vukovic 2009; Aliakbarian et al., 2006). To this end, '+' will be assigned to a characteristic that clearly appears and '-' to those characteristic that do not appear.

The assessment of each characteristic is presented in Table 1. The selected cases are reviewed from existing literature on disaster management that highlights on information that include Ianella (Iannella et al., 2007) (framework for crisis information management system in Australia), Asama (Asama, Hada, Kawabata, & Noda, 2009) (development of advanced robots and information systems for disaster response in Japan), Syahriar (Syahriar & Prihantoro, 2008) (identification of role of ICT in tsunami warning systems in Indonesia) and Lu and Yang (Lu & Yang, 2011) (identifying information exchange in virtual communities during earthquake in China). All cases selected are from different countries that had experienced with any types of disaster as to show that term infostructure can be applied globally in any disaster.

The characteristics of the definition, to be evaluated in each scenario, have been mentioned in earlier section:

(a) there is an entity who create and own infostructure;
(b) there exists a task with identified elements;
(c) it deliver content and resources;
(d) it must have technology element.

According to Table I, all of the selected cases clearly fulfil all four characteristic of infostructure. For example, in Ianella (Iannella et al., 2007) case, information is created and owned by an entity (the emergency management community which consists of the Australia government and related disaster agencies), a task (to exchange information for coordinated action and capability sharing), it deliver content and resources (conveying emergency warnings, resource and task management) and it have technology element (use new information-level technologies to cover all phases of crisis management).

Table 1. Verification of the Definition

Document	a	b	c	d
Ianella, 2007	+	+	+	+
Asama, 2009	+	+	+	+
Syahriar, 2008	+	+	+	+
Lu and Yang, 2011	+	+	+	+

CONCLUSION

The term 'infostructure' is a term considered in its infancy, which undergo rapid evolution and used in various disciplines. Following the analysis of a group of academic articles, it has been shown that no distinct definitions exist for infostructure, clearly illustrating there is no standard definition for it.

This article provides a narrow definition of infostructure as it is tailored to the discipline of disaster management. Through the analysis of all the authors' definition, four characteristics common to any infostructure were found; the creator and owner of it; the task together with necessary elements; it need to deliver content and resources; and it must have technology elements. For each one of these elements an analysis based on the collected definitions was undertaken and a conclusion that relates the results towards the discipline of disaster was formulated, attempting to make each element relate to the area of disaster while trying to maintain the accurateness of the definition as well. The coordination of these conclusions has allowed the creation of a global definition of it that is tailored specifically to disaster management.

REFERENCES

Latif, A. A., & Arshad, N.A. (in press), Understanding and Building the Definition for Infostructure in Disaster Management. *Int. Conf. of Information Management, 2015*.

Aliakbarian, S. (2006). Neighbor definition in P2P networks. 2006 International Conference on Communications, *Circuits and Systems Proceedings*, 3, 1562–1565. doi:10.1109/ICCCAS.2006.284969

Asama, H., Hada, Y., Kawabata, K., & Noda, I. (2009). Information Infrastructure for Rescue Systems. In *Rescue Robotics* (pp. 57–69). Springer London. doi:10.1007/978-1-84882-474-4_4

Bharosa, N., Lee, J., & Janssen, M. (2009). Challenges and obstacles in sharing and coordinating information during multi-agency disaster response: Propositions from field exercises. *Information Systems Frontiers,* 12(1), 49–65. doi:10.1007/s10796-009-9174-z

Blanning, R., Bui, T., & Tan, M. (1997). National information infrastructure in Pacific Asia. *Decision Support Systems*, 21, 215–227. Retrieved from http://www.sciencedirect.com/science/article/pii/S0167923697000304

Bui, T., Cho, S., Sankaran, S., & Sovereign, M. (2000). A framework for designing a global information network for multinational humanitarian assistance/disaster relief. *Information Systems Frontiers,* 1(4), 427–442. Retrieved from http://link.springer.com/article/10.1023/A:1010074210709

Chan, C. M. L., Lau, Y., & Pan, S. L. (2008). E-government implementation: A macro analysis of Singapore's e-government initiatives. *Government Information Quarterly*, 25(2), 239–255. doi:10.1016/j.giq.2006.04.011

Chiu, D. K. W., Lin, D. T. T., Kafeza, E., Wang, M., Hu, H., Hu, H., & Zhuang, Y. (2009). Alert based disaster notification and resource allocation. *Information Systems Frontiers,* 12(1), 29–47. doi:10.1007/s10796-009-9165-0

Comfort, L., Ko, K., & Zagorecki, A. (2004). Coordination in Rapidly Evolving Disaster Response Systems The Role of Information. *American Behavioral Scientist*, 48(3), 295–313. doi:10.1177/0002764204268987

Dawes, S. S., Cresswell, A. M., & Cahan, B. B. (2004). Learning From Crisis: Lessons in Human and Information Infrastructure From the World Trade Center Response. *Social Science Computer Review,* 22(1), 52–66. doi:10.1177/0894439303259887

Dean, K. (2004). Thought Leaders: Essays from Health Innovators. In K. Dean (Ed.), Cisco Systems.

Essay, A. N., & Aesthetics, I. N. (n.d.). A History of Six Ideas an Essay in Aesthetics Melbourne International Philosophy.

Estelles-Arolas, E., & Gonzalez-Ladron-de-Guevara, F. (2012). Towards an integrated crowdsourcing definition. *Journal of Information Science*, 38(2), 189–200. doi:10.1177/0165551512437638

Hanna, N. K. (2010). *e-Transformation: Enabling New Development Strategies*. New York, NY: Springer New York. doi:10.1007/978-1-4419-1185-8

Iannella, R., Robinson, K., & Rinta-Koski, O. (2007). Towards a framework for crisis information management systems (CIMS). *Proceedings of the 14th*. Retrieved from http://nicta.com.au/__data/assets/pdf_file/0007/8638/TIEMS-Paper-Draft-Final.pdf

Lu, Y., & Yang, D. (2011). Information exchange in virtual communities under extreme disaster conditions. *Decision Support Systems*, 50(2), 529–538. doi:10.1016/j.dss.2010.11.011

Noseworthy, T. (2004). Advancing Electronic Health Records in Canada: Why, How and Key Learnings of Potential Value to China. In *IDEAS Workshop on Medical Information Systems: The Digital Hospital (IDEAS-DH'04)*, 129–132. IEEE. doi:10.1109/IDEADH.2004.5

Pohl, J. (2004). Intelligent Software Systems for the New Infostructure.

Scott, R. E., & Mars, M. (2013, January). Principles and framework for eHealth strategy development. *Journal of Medical Internet Research*. doi:10.2196/jmir.2250

Syahriar, A., & Prihantoro, E. (2008). Roles of Information and Communication Technology in Tsunami Early Warning Systems. In *e-Indonesia Initiative 2*, (Vol. 2008, pp. 21–23). Retrieved from http://iatt.kemenperin.go.id/tik/fullpaper/fullpaper121_Ary Syahriar_dan_Pariatmono.pdf

Tatarkiewicz, W. (1980). *History of six ideas: an essay in aesthetics*. Berlin: Springer.

Uddin, N., Peters, R., & Haque, A. (2004). Community Preparedness and Response Model in Digital Environment for Protecting Critical Infrastructures. *Towards a Vision for Information ...*, 1–9. Retrieved from http://ascelibrary.org/doi/abs/10.1061/40704(2003)53

Voort, H. V, & Bruijn, H. D. (2009). Competing Perspectives on Tragedy. *IEEE Technology And Society Magazine*, 28–36. doi:10.1109/MTS.2009.934160 28

Vukovic, M. (2009). Crowdsourcing for Enterprises. *2009 Congress on Services - I*, 686–692. doi:10.1109/SERVICES-I.2009.56

Wallace, S. W., & Choi, T.-M. (2011). Flexibility, information structure, options, and market power in robust supply chains. *International Journal of Production Economics*, 134(2), 284–288. doi:10.1016/j.ijpe.2009.11.002