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Published in:
13th International Conference on Industrial Engineering (IIEC 2017)

Published: 01/01/2017

Document Version
Accepted manuscript including changes made at the peer-review stage

Please check the document version of this publication:
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Link to publication

Citation for published version (APA):

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A Process Aware Information System to Support Agility in Relief Operations

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Abstract

Agility is a key characteristic in relief operations, as rapidly respond to needs is a crucial requirement to survive people during disasters. This requirement should be supported by relevant information systems that enhance agile inter-operations. This paper intends to describe how a process aware information system (PAIS) can support agile collaborative disaster relief processes. In doing so, we describe an overview of a PAIS to provide a comprehensive view on different components of an information system that can be used within disaster relief operations. Challenges to realize the described PAIS are discussed within business, process, service, and data interoperability issues. In this way, the paper provides a well-established basis for future research to develop concrete information systems that can be used in real-life disaster relief operations.

Keywords:

Introduction

Due to the rise of frequency and intensity of disasters [1], relief operations receive an increasing attention at recent research [2]. Relief operations address all activities within a value chain that intends to aid people in their survival during disasters [3]. Agility is a key characteristic in relief operations, as rapidly respond to needs is a crucial requirement to survive people during disasters [4]. An agile relief operation should be able to rapidly handle all related demand chain and supply chain activities. More precisely, it should be able to sense expected relief services in different affected points and rapidly orchestrate relevant resources - including material, food, equipment, and rescue personnel - to provide expected services. Shaping agility in relief operations requires handling dynamic inter-operations among different parties that collaborate within virtual organizations/teams [5–7]. Virtual organizations/teams refer to short term collaborations among parties that should act together in order to respond to a specific need. This necessitates using relevant information systems that support agility by providing information and process reach and richness to manage dynamic inter-operations [8]. Process-aware information systems (PAISs), which have been evolved to support flexibility and dynamism for business processes [9], can support agility in relief operations. The relevance of PAISs in support of relief operations has been repeatedly addressed in previous research [10–12]. However, more research is necessary to explore how agile inter-operations among collaborating parties within relief operations can be enhanced by using PAISs that can support flexibility in business processes. In this way, this paper intends to address how PAISs can support agility in relief operations. More precisely, we intend to explore emerging approaches and technologies as well as challenges in the context of PAISs that can enhance agility in relief operations.

In this paper, we firstly describe the approach that is used to delineate an overview of a PAIS to support agile inter-operations. Then we describe an overview of a PAIS, in the form of a highly abstract and highly aggregated architecture, which can support agile inter-operations in the context of relief operations. We discuss on challenges relating to the realization of the described PAIS. The paper is concluded by addressing future research that should be conducted in order to realize the delineated PAIS.

Approach

A PAIS to support agility in relief operations should be able to handle dynamic inter-operations among parties that dynamically collaborate within emergent virtual enterprises [13]. From a collaboration structure point of view, in the context of relief operations, a virtual enterprise is formed from different parties that collaboratively provide a specific
relief service. Parties collaborating within a formed virtual enterprise should be able to handle dynamic processes to provide expected services. In this way, a PAIS should be able to fulfil two fundamental requirements:

- Formation of process-centred dynamic virtual enterprises that support inter-organizational collaborations among relevant parties;
- Managing dynamic inter-organizational processes among parties collaborating within a virtual enterprise;

We conduct a top-down and a bottom-up approach to develop an overview of a PAIS that supports agility in relief operations, see Figure 1. The top-down direction relies on the refinement of the relevant reference architectures that support managing dynamic inter-organizational processes within virtual enterprises [14, 15]. The refinement of the relevant reference architectures is based on the requirements of a PAIS in the context of relief operations identified in [16]. The bottom-up direction aggregates concrete components of PAISs that are developed in relevant contexts. In doing so, we use concrete architectures that have been developed to support relief operations [17], as well as architectures that support agile logistics in dynamic environments [18, 19]. The overview of a PAIS to support agile inter-organizational processes in the context of relief operations is described in the next section.

**An overview of a PAIS to support agility in relief operations**

On the basis of the described approach, the overview of a PAIS to support dynamic inter-operations in order to handle relief operations is shown in Figure 2. In the following of this section we describe its components.

**Dynamic partnering within disaster response ecosystem**

A strategic collaboration among different parties from governmental, public and private sectors is critical to handle disaster relief operations [13]. These collaborating parties need to be strategically coordinated. Strategic coordination addresses the development of collaborative response plans, in which all collaborating parties have a defined mission regarding the expected disasters. All parties that have a strategic long-term collaboration to deal with possible disasters form a disaster response ecosystem [20]. Parties collaborating within this long-term disaster response service ecosystem should be able to dynamically involve within goal-oriented instant virtual enterprises in order to respond to specific disasters [21]. Dynamic partnering to respond specific disasters is based on the accumulated knowledge about parties’ capabilities. This component addresses a semi-automated decision making to select most fitting parties to respond a specific disaster. In this way, this module addresses forming long-term strategic collaboration structures on the basis of disaster response plans, as well as dynamic short-term operational collaboration structures to support inter-operations during disasters.

**Collaborative knowledge-intensive disaster response process composition**

The coordination of inter-operations among parties collaborating within a formed dynamic virtual enterprise needs to be handled as collaborative disaster response processes. These collaborative disaster response processes should be composed at design-time within a disaster prevention phase [22]. The composition of these collaborative processes should be based on relevant knowledge about coordination patterns in relief operations, as well as knowledge on provided services by different parties collaborating within a formed virtual enterprise. The composed disaster response processes are stored within a process repository. This process repository can be handled in a centralized or a decentralized manner. In a centralized structure a focal party is responsible to compose collaborative disaster response processes. In a decentralized structure, each party within the disaster service ecosystem composes collaborative disaster response processes relating

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**Figure 1** - The approach for the development of an overview of a PAIS to support agility in relief operations
to its responsibilities during disasters.

**Global disaster response rules management**

A rule based approach is a well-established basis to handle recognized events during enacting a process [23]. This can be supported by a rule engine that aggregates and predictively monitors events that need to be considered within enacted processes [24]. The rules that handle processing sensed events can be adapted based on new facts that are recognized by using data-driven intelligent approaches [25]. Using rule based approaches to adapt collaborative disaster relief operations need to aggregate data gathered through different environmental devices, e.g. supported by IoT technologies or social media.

**Global disaster response process enactment**

This component addresses running instances of the composed collaborative response processes when a real disaster occurs. This component handles control flow among different parties collaborating within a process. This component orchestrates all services provided by different collaborating parties in run-time to co-create an expected disaster response service. A composed process can be adapted at run-time regarding the real-time events that are sensed or due to parties switched during co-creating a service. Global enactment of the composed collaborative disaster relief processes can be enacted within centralized structures, e.g. through service orchestration technologies, or decentralized structures, e.g. service choreography technologies.

**Response Coordinator**

This component addresses run-time coordination among parties collaborating within an enacted process. A primary coordination plan is developed at design-time by the process composition component. This component supports run-time coordination based on required adaptions that are necessary to respond to the sensed events. This coordination includes both supply chain and demand chain...
activities to provide a disaster response service.

**Disaster response process proposer**

In order to handle emerging issues at run-time, which have not been previously predicted at design-time, there is a need to a run-time support for developing response processes. This component provides a possibility for parties involved within a virtual organization to propose required processes to handle emerging issues at run-time. As decision making on process changes at run-time during disasters should be conducted rapidly, this component needs to be supported by relevant decision support systems that enable automated or semi-automated business process proposition.

**Dynamic interoperability adaptor**

The dynamism of interactions among collaborating parties within the formed virtual organizations can result in inconsistency of information that is exchanged among collaborating parties [26]. Dynamic interoperations among collaborating parties necessitate handling syntactic and semantic inconsistencies of information exchanged among collaborating parties [27]. This can be addressed by dynamic interoperability protocol adaptors [28]. Regarding the demand-driven nature of operations in relief operations, the interoperability adaptions need to be addressed by parties that enact service orchestrations.

**Collaborative ontology support**

Sharing information to support decision making for composing networked business processes requires forming relevant knowledge bases (e.g. in the form of process cubes) [29]. Integration of information provided by different collaborating parties within the relevant knowledge bases requires matching different ontologies [30]. A collaborative ontology can ensure consistent integration of information within the desired knowledge bases [31]. Regarding the dynamism in this context, the collaborative ontology needs to be evolved continuously to support semantic integration of new added parties.

**Challenges to realize the described PAIS**

As this paper addresses collaborative inter-operations in disaster management, we focus on interoperability challenges that should be handled to realize the described PAIS. We classify these challenges within business, process, service, and data interoperability issues. These issues are elaborated in the following of this section.

**Business interoperability issues**

Business interoperability refers to the collaboration among parties who together form a disaster relief service ecosystem. The most important challenge within this layer of interoperability is related to network governance when a disaster occurred. More precisely, coordination and adaption of operations during disasters cannot be handled easily. Decision making to determine different service providers that need to be present to handle a rescue operations should be conducted by different teams. Due to emergency requirement, a rescue team should be able to rapidly invoke required parties and coordinate them. In this way, a decentralized coordination structure is necessary for disaster relief operations. On the other hand, as predetermined collaborative disaster processes should be adapted regarding real-life occurred issues, rescue teams also should be able to adapt these processes at run-time. In this way, a distributed structure also is necessary to adapt operations within disaster relief service ecosystem. Decentralized coordination and adaption of collaborations within a disaster service ecosystem can result in difficulties to resource allocations and compliance control in operations.

**Process interoperability issues**

Due to the decentralized structure of coordination within disaster relief operations, service choreography approaches need to be used to compose and enact collaborative disaster processes. Run-time adaptions of a control flow within service choreography approaches can be a big challenge. More precisely, event-driven decision making at run-time requires a high level of intelligence at process composition and enactment phases. Meanwhile, event aggregation and event-driven decision making at run-time is another challenge within this layer of interoperability.

**Service interoperability issues**

As parties collaborating within disaster relief operations are from different contexts such as healthcare, security and rescue organizations, syntactic and semantic interoperability issues are quite expected among services composed within collaborative disaster relief processes. These syntactic and semantic interoperability issues result from the heterogeneity of services provided by collaborating parties. Dynamic and adaptive nature of operations in the context of disaster relief operations, makes it more difficult to handle these syntactic and semantic interoperability issues within composing and enacting services.

**Data interoperability issues**

Regarding the described PAIS in Figure 2, data interoperability issues are related to the collaborative ontology support and the dynamic interoperability adaptor components. Due to the autonomous nature of parties within disaster relief service ecosystem, the collaborative ontology to handle syntactic and semantic integration of knowledge shared by different parties, should be continuously evolved to address changes in collaborating parties’ metadata or new ontologies added [32]. Meanwhile, distributed nature of operations in the context of relief operations requires that all collaborating parties be aware of
the evolution of the collaborative ontology. Otherwise, semantic interoperability within service choreography scenarios cannot be addressed [33]. In addition, dynamism of process enactment at run-time requires using approaches that be able to support dynamic semantic integration of messages that are exchanged among enacted services.

Conclusions

In this position paper, we described an overview of a PAIS that can support agile disaster relief inter-operations. The main components of this PAIS were elaborated. Also, the main challenges and issues that need to be addressed to realize the described PAIS were discussed. In this way, the paper provides a well-established basis to synthesize concrete systems that can be used to support agile disaster relief inter-operations.

The challenges and issues discussed in this paper provide a clear insight for critical requirements that need to be addressed in future research. In addition, the described PAIS as well as the discussed issues can direct an architectural synthesis to bring together different relevant approaches in the context of networked, knowledge-intensive, data-centric, adaptive business processes.

References


