

# A Conceptual Service Oriented Architecture Framework for Integrated Flood Management

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## ABSTRACT

Service oriented architecture (SOA) is a platform and language-independent that guide different services to work together in order to perform business process. The benefits of using SOA such as interoperability, discoverability, loose coupling, flexibility and reliability have led previous researchers to use it as their fundamental basis in designing their software architecture framework. Previous researchers also have exploited SOA and implemented it into flood management domain to manage the complex systems that are distributed across the network. However, previous works do not provide the detail process of emergency management into their flood management framework. Therefore, this study aims to propose a conceptual SOA framework for an integrated flood management (IFM) in order to increase the effectiveness and efficiency of managing flood. Furthermore the feasibility of using SOA and the required process of flood management in order to construct the conceptual framework are being investigated by means of a comparative study. In addition, this study also suggests the Service oriented architecture Modeling Language (SoaML) as a technique to model the services for an IFM.

**Keywords:** Service Oriented Architecture, Service oriented architecture Modeling Language, Business Process Modeling Notation, integrated flood management.

## I INTRODUCTION

Service Oriented Architecture (SOA) can be defined as an architectural style or a paradigm that guide different services (individual processes and functions) regardless of different locations to perform business process and data exchange. According to Haubrock, Theisselmann, and Dransch (2007), SOA paradigm maintains the flexibility of system architecture and makes sure that different components can work together to increase system reliability. Moreover, the main technical aspect of why SOA has been widely used is that it is based on open standards such as WSDL, XML, SOAP, UDDI and BPEL (Sonousi, 2011). Furthermore, SOA also has been successfully applied in several different domains (eg., healthcare, supply chain management and e-

government portal) and it keeps getting more attention because of the capabilities that it provides.

Meanwhile, flood management is one of the domains that has cost us severely and has never been solved effectively. In practice, flood management resides in emergency management where it consists of 4 main phases which are mitigation, preparedness, response and recovery. Moreover, Li et al. (2010) stated that flood management is a complex and large system that requires several other systems (weather, hydrology, remote sensing, surveying and mapping) to work and bind together in order to provide more effective flood management system. Furthermore, in order to come out with an integrated system, previous researchers have identified that SOA has the capability of interoperable that supports the integration of information flow with diverse programming languages, database and operating system by using extensible markup language (XML) and hypertext transfer protocol (HTTP) (Li & Dong, 2006; Xinyan, 2006; HaiJin, WenJu, & Zhen, 2008).

Likewise, even though SOA is quite mature enough and has been long used in different domains but designing the service oriented system at the initial level need a specific particular language, tool and method in order to fully utilize the advantages of using SOA (Ionita, Mocanu&Ciolofan, 2013). Regarding to this purpose, Ionita et al. (2013) also have identified several modeling languages, models and views that are suitable for this purpose, such as the service view's model, the BDC view model and the reference architecture for SOA. Apart from this modeling language and views, Todoran et al. (2011) found that UML is the most commonly used modeling language to model SOA which creates visual models with a set of graphic notations provided. However, UML is not a dedicated modeling language to model the SOA. Thus the Object Management Group (OMG) has introduced the Service oriented architecture Modeling Language (SoaML) as a UML profile and metamodel for designing and modeling the services within the SOA.

Besides that, previously, there have been several research's that have used SOA in the flood management domain. The work by Niazi et al. (2011) proposed a flood management framework that uses SOA as their fundamental basis and focus on emergency response to flood management. Their

framework leverage the use of SOA in integrating several emergency response departments to facilitate different organizations for delivering emergency rescue, relief and rehabilitation services. Moreover, Demir and Krajewski (2013) also develop the Iowa Flood Information System which provides real time data to allow flood monitoring from different departments for the decision making process and make it available anytime anywhere throughout different devices. However, the works by this previous researchers do not include all the main phases of the flood management (eg., mitigation, preparedness, response and recovery). Therefore, this study aims to propose a conceptual SOAIFM framework in order to increase the effectiveness and efficiency of managing flood. In addition, the framework also suggested the use of SoaML as a mean to model the IFM services to come out with a better SOA design model.

The objective of this paper is to come out with a SOAIFM framework for an IFM and suggest the SoaML as a technique to model the services in the framework. Therefore, to achieve this objective a number of questions need to be answered in order to fulfill the need for a better SOA framework that cover all phases in flood management.

What are the components in the proposed conceptual SOAIFM framework? In order to answer this question, this study identifies the basic principles for SOA framework. The concept of SOA and the way of communication between each entity in SOA are being studies in order to provide readers the complete understanding of SOA.

What are the main phases requires for an integrated flood management? In this study all of the phases in the flood management is being identified in order to provide complete process of the flood management. The complete phases of the flood management are important as it also fits the characteristic of using SOA as the fundamental basis, which is the coarse-grained characteristic which requires a complete process to successfully complete the required services and task.

How to design a service oriented architecture framework for the integrated flood management? In order to answer this question, this study identifies how to integrate several different flood management services and come out with the centralized IFM system. This study then recognize the best approach for interoperability between flood management services so that all the required services can be effectively and efficiently communicate and interoperate. In the initial design, this study finds the way for the service provider and a service requester to successfully complete the process of providing the services required in the IFM.

Which modeling language can be used to model the services in SOA? This study identifies the

modeling languages that can be used to model the services in the proposed SOA framework. This study then will choose the best and appropriate modeling language to model the services in this proposed framework and provide the advantages of using it.

## II SERVICE ORIENTED ARCHITECTURE

Service oriented architecture is an architectural style or paradigm that guide the development of the distributed system where the components are stand-alone services. This stand-alone service can be executed from different service providers and on different computers or devices. Figure 1 explains the basic principle of SOA where it consists of three parts which are service requestor, service provider and service registry.

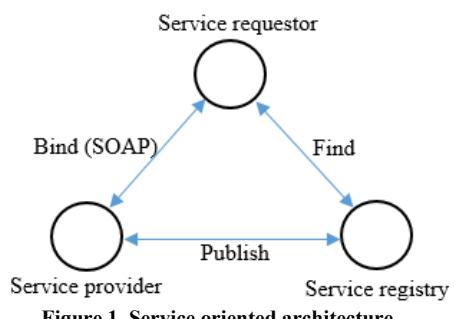


Figure 1. Service oriented architecture.

Based on figure 1, service requestor can be a software module, application or other services. This service requestor can either directly request the services from the service provider to perform the task or search the service registry for the desired services.

Meanwhile the service provider is in charge to register a new service and provide all the information about this new service in the registry so that other users can use it. This service provider also publishes and implements the web services to make them available on the network.

The service registry performs its role as a broker for a web service where it provides the description of the services in WSDL language. This service registry also is a searchable directory and a central place that responsible for finding and publishing a new service. The main function of service registry is to store the services and publish it so that the services can be used by service requestor.

### A. Business Process Modeling and Notation (BPMN)

Business Process Modeling Notation (BPMN) was developed by the Business Process Management Initiative (BPMI) and officially published in 2004. White (2011) identifies that BPMN provide easily and readily understand the notations to all ranges of business stakeholders that includes the end users, which maintain and manage the business process, technical developers that

implement the business process into a real life system and the business analyst that prepare the initial draft of the business processes.

BPMN originally was developed partially based on the UML activity diagram in order to symbolize the business process graphical layout. According to Chinosi and Trombetta (2012), business process in BPMN is represented by a graphical notation which is Business Process Diagram (BPD). The standard that has been defined for BPD are categorized into four main clusters.

- i. Swim lanes (lanes, pool).
- ii. Connecting objects (messages, association and sequences)
- iii. Artifacts (groups, annotation, data).
- iv. Flow object (activities, events, and union nodes).

### B. Service oriented architecture Modeling Language (SoaML)

According to Ionita et al. (2013), there are several modeling languages, models and views that are suitable for modeling the services in SOA. The identified modeling languages, models and views are such table 1 below:

**Table 1. Modeling Languages, Models and Views**

Modeling language	Components
Service view model	Quality of service, quality of management, business, transformation, component, data and infrastructure views.
BDC view model	Business analysis, service design and service composition views.
Reference architecture for SOA from OASIS	Business via services, realizing SOA and owning SOA.

Apart from this modeling language and views, Todoran et al. (2011) found that UML is the most commonly used modeling language to model SOA which create visual models with a set of graphic notations provided. However UML is not a dedicated modeling language to model the SOA thus the Object Management Group (OMG) have introduced the Service oriented architecture Modeling Language (SoaML) as a UML profile and metamodel for designing and modeling the services within the SOA.

According to Sadovskyh et al. (2010), SoaML is the extension of the UML that support a wide range of SOA modeling requirement such as service implementations, individual service interfaces and specification of system of services. Furthermore, Todoran et al. (2011, citing Bezivin et al., 2010; Amsden, 2010) also have found that SoaML support SOA by modeling the services at a higher level of abstraction without concerning the lower level of

technological details. Moreover, Delgado et al. (2010) stated that SoaML realize the transformation of the business processes into services by transforming the Business Process Modeling Notation (BPMN) model into SoaML thus simplify the understanding and communication of business needs. In addition, previous researchers have also identified that the evolution of BPMN into BPMN 2.0 have introduced a semantically rich modeling language which can be further explored in order to fully utilize the use of SoaML (Correia& Abreu, 2012).

### III FLOOD MANAGEMENT

According to Schanze (2006), flood management is an engineering centered-approach that focuses on reducing the flood problem and the effect of flooding to society by applying the “absolute protection” paradigm. Flood management also resides in the emergency management where it consist 4 main phases which are mitigation, preparedness, response and recovery. Table 2 below describes the 4 phases that are required in completing all the process of managing flood.

**Table 2. Flood Management Phases**

Phase	Activity
Mitigation	Activities that prevent any emergency, reducing the chances of emergency and reducing the effect of emergency
Preparedness	Preparation and plan to handle the emergency event and activities that aid the response and rescue operation.
Response	Activities that handles the rescue operation to save life and properties. Turning the preparedness plan into action.
Recovery	Activities that include the action of turning back the emergency situation to normal and safer condition.

Previously, the traditional flood management was developed in an isolated system which are large and complicated that contain lots of modules and subsystems (Xiaoliang et al., 2009). Furthermore, Demir and Krajewski (2013) also stated that the traditional flood management approach have limited capabilities in information and data sharing. Moreover, Xia and Pahl-Wostl (2012), also suggest that an urgent transformation from the traditional flood control to the Integrated Flood Management (IFM) approach is needed in order to deal with the complexities of the flood management system. In conjunction with this problem, the IFM approach can be seen as an alternative solution in order to solve the everlasting flood problem. According to Demir and Krajewski (2013), they specified that the structure of IFM allow other local institutions and states to simply build a similar operational system to share

information, flood related data and knowledge to all stakeholders.

Additionally, as a matter of fact, in order to come out with the integrated system, previous researchers have identified that SOA has the capabilities of interoperable that support the integration of information flow with diverse programming languages, database and operating system by using extensible markup language (XML) and hypertext transfer protocol (HTTP) (Li & Dong, 2006; Xinyan, 2006; HaiJin, WenJu, & Zhen, 2008). Table 3 below show several previous works that focus on using SOA in their IFM system.

**Table 3. Flood Management**

Title, Author, Year	Description
Towards an integrated flood information system: centralized data access, analysis, and visualization, Demir and Krajewski, 2013	<ul style="list-style-type: none"> <li>Develop the Iowa Flood Information System which provide real time data to allow flood monitoring from different departments for the decision making process and make it available anytime anywhere throughout different devices.</li> <li>Focus on providing the data and information related to flood and does not cover the whole flood management process.</li> </ul>
The Urban Flood Common Information Space for Early Warning Systems, Balisa et al., 2011	<ul style="list-style-type: none"> <li>Applying SOA into their Urban Flood Common Information Space, a framework facilitating the creation, deployment and reliable operation of early warning systems.</li> <li>This work only focus on early warning system rather than the whole process of flood management</li> </ul>
Service Oriented Architectural Framework for Pakistan's Disaster Emergency Response (in relation with flood), Niazi et al., 2011	<ul style="list-style-type: none"> <li>This framework apply SOA as fundamental basis to integrate several flood management system.</li> <li>This work focus only on response services.</li> </ul>
Service-Oriented Architectures for Natural Disaster Management, Haubrock et al., 2007,	<ul style="list-style-type: none"> <li>The author proposed a more flexible approach based on SOAP web services (the use of SOA) and Business Process Execution Language (BPEL) as the language for specifying the controlling instance.</li> <li>Their proposed work does not focus specifically on flood management.</li> </ul>

#### IV THE IMPLEMENTATION OF SERVICE ORIENTED ARCHITECTURE IN FLOOD MANAGEMENT

Service oriented architecture has been widely accepted in different domains and flood management has been one of the domains that can benefit a lot by applying SOA in their architectural framework design. The complexities of the flood management system can be efficiently hided by implementing SOA and SOA also allow smooth integration between distributed flood management systems.

Apart from that Li et al. (2010) stated that flood management requires coordination and integration of multiples services from different departments such as remote sensing, mapping, surveying, and hydrology in order to perform all the tasks needed to effectively manage the flood. In addition to this matter, SOA can offer the flexibility of integrating different services because of its loose coupling and interoperability characteristic. By combining and integrating different services, a new flood management system can be developed thus reducing the effort and time to start from the scratch. This newly developed system based on SOA concept also can extend and improved the legacy system thus providing a better version of flood management.

According to Sonousi (2011), SOA is based on the open standard such as WSDL, XML, SOAP, UDDI and BPEL. This characteristic allows flood management to be platform independent, thus giving the freedom of using a variety of devices across the network. The advantages of being interoperable and platform independent also means that developers can easily change or improve certain services without effecting the whole flood management system.

#### V METHODOLOGY

According to Marcos (2005), the process of doing a research consists of six phases. The identified phases are identification of research problems, establishment of hypothesis, methodology identification, resolution, verification and validation process, analysis of the result and conclusion. This study focuses on establishment of hypothesis where this phase concentrates on describing the architecture of the system. This study also provides an integrated flood management framework and suggests the modeling language that is suitable to model the services in SOA.

In this study, the feasibility of using SOA and the required process of flood management in order to construct the conceptual framework are being investigated by means of a comparative study. The first stage of this study is the requirement identification. This study identify the main component for SOAIFM which are the SOA

requirements and flood management requirements. All of the basic concepts and basic principles of SOA are being studied in order to fully understand the requirements needed to construct a SOA framework. This study also identifies flood management requirements as it is also important to properly develop effective and efficient flood management system that covers all the processes.

After the requirements identification, this study moves to requirement analysis where the identified requirements are bound together to construct SOAIFM framework. This requirement analysis is vital as it is purposely done to integrate the distributed flood management services based on the 4 phases of flood management. The requirement analysis also responsible to ensure that all the services within SOAIFM can smoothly communicates between each other.

The final stage of this study is that this study also looks into SOAIFM design. This study focuses on how to model the services for SOAIFM so that all business and system stakeholders can easily understand the SOAIFM framework architecture. To provide both understandings for business and system stakeholders, SoaML has been identified capable to deliver the intended purpose.

## VI DISCUSSION

Flood management is not a new problem that has affected us severely but however it has never been solved effectively. There also have been numbers of studies that have been done by the previous researchers but this problem has never seemed to fade away. Table 3 shows the works done by the previous studies that are related to flood management. Their proposed works aim to solve flood management problem by applying SOA in their framework. However their works do not cover the 4 phases in flood management, which are mitigation, preparedness, response and recovery. Feng and Lee (2010) stated that these 4 phases (mitigation, preparedness, response and recovery) are important to reduce the loss of life and property. Moreover, Leppäniemi (2012) work also stresses that mitigation, preparedness, response and recovery processes are needed for the dynamic event of an emergency situation.

As shown in table 3, previous works focus more on solving specific problems in flood management, providing real time data and monitoring and works on general natural disaster. Lack of research that cover the whole 4 phases in flood management may become the main factor of ineffectiveness in flood management. Therefore this study proposed a conceptual SOAIFM framework that identifies the 4 phases of flood management in order to increase the effectiveness and efficiency of managing flood.

## VII PROPOSED CONCEPTUAL SOAIFM FRAMEWORK

Figure 2 describes the proposed conceptual SOAIFM framework for flood management. Generally, the flood management services are scattered around across the network and different platform. This service is provided by different responsible flood management organization and departments. All of the services are then will be identified and categorized into 4 phases in flood management, which are mitigation, preparedness, response and recovery. All of these phases are important and required in order to provide complete services in flood management so that an effective and efficient flood management system can be developed. All of the identified and categorized services that are distributed will then be integrated into one stop IFM system.

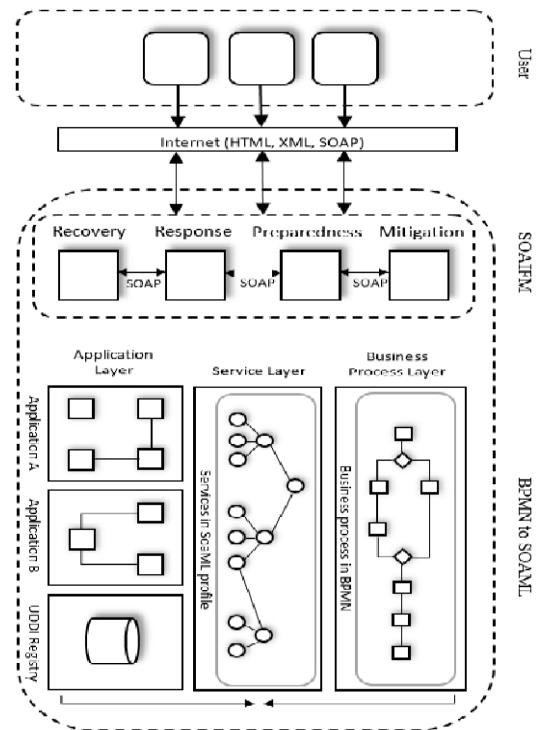


Figure 2. Proposed conceptual SOAIFM framework

User can connect to the IFM using the internet where IFM will then connect them to the flood management services. The communication within the IFM will be done through SOAP while the outside communication of the system will be done by embedding the SOAP messages into HTTP. This proposed conceptual SOAIFM framework follow the standard of the SOA in order to utilize the benefits of using it.

The identified service requirements based on the 4 phases of flood management then will be modeled using SoaML where it transforms the business process in BPMN into service model. This process of transformation and mapping the BPMN

into SoaML is important in order to align business requirements and IT system implementations. Moreover, SoaML also helps all ranges of business and system stakeholders to have a better understanding about the system architecture (Elvesaeter et al., 2010).

## VIII CONCLUSION AND FUTURE WORKS

This paper has proposed a conceptual SOAIFM framework that applies SOA as their fundamental basis. The benefits of applying SOA have been explained in this paper where SOA can be used to integrate the distributed services from different platform and location to come out with one stop flood management system that offer the whole phases of flood management services. Furthermore the proposed conceptual framework also recommends that in order to have an integrated flood management, the whole phases of flood management should be identified first in order to increase the effectiveness and efficiency of managing flood.

Besides, this framework also suggests SoaML as the modeling language that is suitable to model the flood management services. This flood management model can help in providing the business and system stakeholders a clearer view on the processes and services that are needed in an integrated flood management.

Future work will include the identification of each service for all 4 phases required in flood management. Moreover the sustainability aspect that are close related to flood management and SOA also will be further explored in order to come out with a reliable and better flood management system.

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## REFERENCES

Chinosis, M., & Trombetta, A. (2012). BPMN: An introduction to the standard. *Journal of Computer Standards and Interfaces*, 34(1), 124-134.

Correia, A., & Abreua, F. B. (2012). Adding Preciseness to BPMN Models. *International Conference on Health and Social Care Information Systems and Technologies*, 5, 407-417.

Delgado, A., de-Guzmán, I. G., Ruiz, F., & Piattini, M. (2010). From BPMN business process models to SoaML service models: A transformation driven approach. *2nd International Conference on Software Technology and Engineering*, 1, 314-319.

Demir, I., & Krajewski, W. F. (2013). Towards an integrated flood information system: centralized data access, analysis, and visualization. *Environmental modeling and software*, 50, 77-84.

Elvesæter, B., Panfilenko, D., Jacobi, S., & Hahn, C. (2010). Aligning business and IT models in service-oriented architectures using BPMN and SoaML. *Proceedings of the First International Workshop on Model-Driven Interoperability*, 8, 61-68.

Feng, Y. H., & Lee, C. C. (2010). Exploring development of service-oriented architecture for next generation emergency management system. *24th International Conference on Advanced Information Networking and Applications Workshops*, 557-561.

HaiJin, Z., WenJu, L., & Zhen, K. (2008). Supply chain simulation: collaborative design system based on SOA: A case study in logistics industry. *Proceedings of World Academy of Science, Engineering and Technology*, 29.

Haubrock, S., Theisselmann, F., Dransch, D. (2007). Service-oriented architectures for natural disaster management. In: Proceedings of the Joint CIG/ISPRS Conference on Geomatics Solutions for Disaster Management, CIG/ISPRS Joint Conference, Toronto, Conference CD.

Ionita, A. D., Mocanu, M., & Ciofolan S. N. (2013). Modeling with SoaML applied for warning and water management services. *19th International Conference on Control System and Computer Science*, 624-627.

Leppäniemi, J. (2013). Domain specific service oriented reference architecture case: Distributed disasters and emergency knowledge management. *International Journal of Computer Information Systems and Industrial Management Applications*, 4, 43-54.

Li, B., Liu, J., Zhao, R., Sun, L., & Shi, L. (2010). Information management for flood prevention service work. *International Conference on Information Society (i-Society)*, 50, 55, 28-30.

Li, Y., & Dong, B. (2006). Supply chain information sharing system based on SOA. *Logistics technology Journal*, 7, 217-220.

Marcos, E. (2005). Software engineering research versus software development. *SIGSOFT Software Engineering Notes*, 30 (4), 1-7.

Niazi, W. L. K., Arif, F., Ahmad, F., & Jamil, A. (2011). Service oriented architectural framework for Pakistan's disaster emergency response (in relation with flood). *2nd International Conference on Software Engineering and Service Science*, 457-460.

Sadovsky, A., Desfray, P., Elvesæter, B., Berre, A.-J., Landre, E. (2010). Enterprise architecture modeling with SoaML using BMM and BPMN: MDA approach in Practice. *6th Central and Eastern European Software Engineering Conference (CEE-SECR)*, 79, 85, 13-15.

Sonousi, A. A. A. (2011). Sapphire: A service-oriented architecture for a personalized open-source health information research exchange. <http://books.google.com.my/books?id=hzpoMwEACAAJ>

Schanze, J. (2006). Flood risk management: A basic framework in flood risk management. In Schanze, J., Zeman, E., & Mar'salek, J. (Eds.), Springer, 1-20.

Todoran, I., Hussain, Z., & Gromov, N. (2011). SOA integration modeling: An evaluation of how SoaML completes UML modeling. *15th IEEE International Enterprise Distributed Object Computing Conference Workshops*, 57-66.

White, S. A. (2011). BPMN 1.0 business process modeling notation. OMG final adopted specification, on BPMN website, 2006. <http://www.bpmn.org> (May 2011).

Xia, C., & Pahl-Wostl, C. (2012). Understanding the development of flood management in the middle Yangtze River. *Journal of Environmental Innovation and Societal Transitions*, 5, 60-75.

Xiaoliang, G., Bin, H., & Guoli, W. (2009). Study on integration management of web-service based flood control consultation system. *International Conference on Web Information Systems and Mining*, 336-341.

Xinyan, L. (2006). Using SOA to design a public logistics service platform. *Journal of Computer Systems and Applications*, 11, 33-37.