Abstract

The purpose of this paper is to provide a theoretical framework for Maritime Informatics from a service-oriented ecosystem view. We propose to go beyond the traditional service provider-user dyad view to provide a richer understanding of Maritime Informatics using a case study. Relying upon the Service-Dominant (S-D) logic framework, this paper presents how this service-oriented ecosystem view helps multiple stakeholders configure value by integrating dispersed data and information in the context of e-navigation. The S-D dominant logic provides insights to investigate network-oriented, information-oriented, or experience-oriented service ecosystem with Maritime Informatics. We apply the Service-Dominant logic to analyze a case study of Korean initiatives on e-navigation for enhancing our understanding of Maritime Informatics.

Keywords (Required)

Maritime Informatics, e-navigation, service-dominant logic, ecosystem, stakeholders

Introduction

In the globally interconnected era, the world marine shipping industry serves an important role in connecting industries and markets all over the world. The dynamic flows of information and logistics have called for Maritime Informatics (MI), which allows for interactive information and communication across multiple stakeholders. Specifically, the International Maritime Organization (IMO), the United Nations agency specialized in the safety and security of shipping and the prevention of marine pollution, attempts to improve the IT standard of the marine shipping industry, providing an efficient way of communication and collaboration (IMO Website: http://www.imo.org/en/OurWork/Safety /Navigation/Pages /eNavigation.aspx, 2015).

In addition to dynamic flows, another challenge to the maritime industry is inherited from layered values of multiple stakeholders and their value network of marine industry. The maritime industry consists of numerous groups of stakeholders with diverse interests including port authorities, shipping industries, insurance companies, ship owners, crew members, police, coast guard, and others. In this context, the global shipping industry allows them to connect one another through a complicated value network. The role of IT has been paid a great deal of attention because it functions as an enabler connecting dispersed data and information across place, time, and people.

In response to the escalating demand on marine informatics and communication infrastructures, the IMO initiated the e-navigation Strategy Implementation Plan (SIP) in 2014. The goal of this program is to provide the global maritime community with the e-navigation technology and a set of service guidelines.
by 2019. The focal points of the plan are to improve safety of navigation, and to establish standardized information systems to address challenges of the current systems including incompatibilities between vessels and an increasing level of complexity (IMO, 2014). To achieve this goal, an e-navigation should be equipped with collaborative and user-friendly bridge systems, standardized and automated information sharing solutions, reliable, resilient and integrated bridge equipment and navigation information, integration and graphical presentation of available information, and an improved communication method of Vessel Traffic Service (VTS) (IMO website, 2015).

The notion of e-navigation relates the outstanding concept of modern industry; the service- and information-oriented industry. As a matter of fact, the IMO defines the e-navigation as a comprehensive information system that conducts “the harmonized collection, integration, exchange, presentation and analysis of marine information on board and ashore by electronic means to enhance berth to berth navigation and related services for safety and security at sea and protection of the marine environment (IMO Website, 2015).” The the e-navigation, therefore, can be regarded as a service-oriented information system heavily relying on MI.

For decades, the international community has been discussing global information and technology standards in an effort to improve domestic and international shipping efficiency. In this process, an e-navigation may play a central role of MI when it supplies integrated quality information and facilitates real-time information exchange among actors. The value created by MI and the e-navigation can be escalated when it takes account of maritime industry’s ecosystem along with the dynamics of how actors can create value with this service. This paper is to examine informatics-based e-navigation systems from a service-oriented ecosystem perspective, and to introduce a case study for enhancing our understanding of the proposed theoretical paradigm.

In line with IMO’s initiative, countries, including Denmark, Sweden, and the U.S. among others, have launched the e-navigation development projects. In the same vein, the Korean Ministry of Oceans and Fisheries (MOF) established a budget of $160 million to support R&D projects and to develop the marine telecommunication infrastructure in 2015. If all goes as planned, Korean e-navigation is expected to launch in 2019. Using the data from the MOF’s project, this paper offers a service-oriented framework of the e-navigation.

Our objective is to propose a conceptual framework of the e-navigation that may become a platform of marine information analytics. This paper provides a meta-theoretical foundation of marine navigation systems based on S-D logic.

**Theoretical background**

The deployment of maritime IT requires hardware, software, network/telecommunication, and data management technologies. Although maritime information systems are becoming popular in practice, technologies adopted by the industry are technologically behind because of the lack of inexpensive high bandwidth communication on the ocean and the limited functionality of the current marine IS supporting data integration processes (Kocak 2014).

Langlois argued that using technology “is not an end-product but a means to an end or to a variety of ends” (Langlois 1992, p. 46). In this respect, the current marine IT doesn’t succeed in not only fulfilling the needs of diverse stakeholders but also in meeting fundamental requirements in relation to the efficiency, safety, and sustainability of the industry (Watson et al. 2010). The conventional Marine IT framework is rooted in the dyadic view between a traditional service provider and a user, which may be limited to dispersed data and information from various stakeholders and their complex value network. In this context, we propose a service-based ecosystem view in the context of e-navigation. Since e-navigation is a service engendered by IT integrating dispersed data and information from multiple stakeholders, we introduce the Service-Dominant logic framework rooted in a service-based ecosystem view for enhancing our understanding of e-navigation.

**The e-navigation as Service**

The fundamental notion of the e-navigation is to provide an information service to improve performance of the marine industry as a part of the Green Information Systems (Green IS) initiatives (Watson et al.
Green IS aims to communicate and collaborate among “a set of people, processes, software, and information technologies to support individual, organizational, or societal goals (Watson et al. 2010, p. 24).” The goal of Green IS entails efficiency, safety and sustainability (Watson et al. 2010), and these can be embodied in the context of shared responsibilities thanks to communication and collaboration among actors in the service network. First, efficiency may imply enhanced performance of a service network by the reduced information transaction cost resulted from dispersed data and information across multiple stakeholders (Takabi, Joshi, and Ahn 2010). Second, the safety of the service network entails security and privacy, which can be accomplished by managing the platform with relevant expertise as well as engaging user-friendly interfaces. This makes efficient security management and threat assessment possible (Takabi et al. 2010). Third, sustainability involves “social responsibility for the future generations who will bear the consequences of excessive consumption of scarce resources and environmental degradation (Watson et al. 2010, p. 24).”

The design of the e-navigation, therefore, needs to be based on a service-oriented framework connecting dispersed data and information across place, time, and people. The current design of maritime IT has centered on an actor-focused value chain (e.g., port, shipping company, insurance company, ship owner, crew members, police, and coast guard) that is merely the suboptimality of the entire marine industry eco-system (Kocak 2014). To address this challenge, Lusch and Nambisan (2015) argue that, beyond the conventional views rooted in a service provider-user dyad, a new perspective centered on a service-dominant network is appropriate.

In this paper, we view a service as an application of knowledge and skills (Vargo and Lusch 2008). To this end, we argue that the e-navigation should be conceived as a service that is to be positioned at the center of the marine ecosystem. The service ecosystem view emphasizes value creation processes across actors who acquired a diverse set of knowledge and skills.

Understanding e-navigation through a Lens of S-D Logic

The concept of e-navigation can be viewed as a service-oriented service system hinging on MI. We consider e-navigation as a type of MI systems because this informative service allows interactive information and communication across multiple stakeholders. The goal of e-navigation is to configure value in the context of a complex value network. Specifically, IMO entails key functions of e-navigation, such as collaborative and user-friendly bridge systems, standardized and automated information sharing solutions, reliable, resilient and integrated bridge equipment and navigation information, integration and graphical presentation of available information, and an improved communication method of Vessel Traffic Service (VTS) (IMO website, 2015). This conceptualization is consistent with Service-Dominant (S-D) logic paradigm, a mental model to explain network, information, and value-driven IT-enabled service network and its value configuration with multiple acting stakeholders.

Since e-navigation emphasizes value creation and IT-driven data and information integration, the S-D Logic can provide a theoretical insight because it explains how actors of service network use their resources including data and information, to cocreate values in terms of resource liquefaction, resource density, and resource integration (Lusch and Nambisan 2015). From this perspective, the e-navigation is not only a technology product, but a technology-based service (Langlois 1992). It can further function as a service through which actors in the marine shipping industry collaborate and communicate.

Figure 1 portrays how the components of MI including actors, resources, and IT configure values on service ecosystem, service platform, and value cocreation. According to Lusch and Nambisan (2015), actors acquire a set of resources, and perform three main roles; bringing resources, discovering resources, and configuring value with resources. In this process, IT serves a critical role for actors and resources to configure value by enabling, exchanging, and integrating resources. All these processes take place across three levels including service ecosystem, service platform and value cocreation.

In the context of the e-navigation, the service network of marine stakeholders (including IMO, local government, research institutes, marine industries, and domain individuals) interact to accomplish shared goals, such as efficiency, safety, and sustainability, which is a series of value configuring processes in a self-contained and self-adjusting manner (Lusch and Nambisan 2015). The e-navigation platform can be translated into a modular system that comprises hardware and software components and facilitates data and information exchanges through technical interfaces. Value cocreation occur at the
ecosystem of e-navigation. This includes a series of processes and activities to integrate information from various sources and incorporate technologies, policies and domain knowledge into the e-navigation service ecosystem.

Value configuration is executed at each acting stakeholder level when they actually use the service rather than just purchase the service. The value of IT as an enabler of service ecosystem can be implemented when it is applied to value-in-use rather than value-in-exchange. In other words, conceptualizing the e-navigation as a service platform brings a new perspective to advance our understanding beyond the traditional 4P (product, promotion, price and place) framework that focuses on the value in exchange. While the traditional 4P framework emphasizes the transactional aspects of interactions between a buyer-seller dyad, the value configuration of the service dominant logic aligns with how actors of a service network configure their customized and personalized value across their diverse usage contexts (Lusch, Vargo, and O’Brien 2007).

Therefore, the concept of value configuration may provide a richer and current understanding of the e-navigation along with MI; it can be “viewed in terms of information service flows, in which the service is provided directly or indirectly through the e-navigation; promotion needs to be reoriented toward conversation and dialog with information consumers; price is replaced with a value proposition created by both parties of information service exchange; and place is supplanted with value information networks and processes (Lusch et al. 2007, p.6).” We, therefore, suggest that the S-D Logic paradigm provides a theoretical lens to advance and refine our understanding of MI.

**Reconceptualizing Value Configuration**

To conceptualize MI through the lens of S-D Logic, it is important to obtain a blueprint of value configuration at the layers of service ecosystem, service platform, and value cocreation. In the service ecosystem, IT serves as an information conduit for collaboration and communication among actors, creating an actor-to-actor network. Networked actors may establish and share worldview for efficiency, safety, and sustainability (Watson et al. 2010; Takabi et al. 2010) and mobilize their means for value configuration.

As to the service platform, IT provides modular architecture and protocols, which facilitate resource liquefaction and resource density. According to S-D Logic, resource liquefaction refers to a process decoupling of information from associated hardware or software, and resource density to a situation “when the best combination of resources mobilized for a particular situation (Lusch and Nambisan 2015, p. 160; Normann 2001).” Actors or stakeholders of the network can mobilize their resources effectively
and efficiently when modular architecture and protocols as well as rules of exchange help configure value with the “contextually relevant knowledge (Lusch and Nambisan 2015, p. 160).”

In the value cocreation layer, actors take in action for their identified roles and crystalized value-in-use, and integrate decision making processes, which is enabled by the interactive and transparent functionality of IT. In the next section, we will examine how The e-navigation adopted S-D Logic and implemented value configuration with ingredients of MI.

**Actor-to-Actor Service Network**

Figure 2 presents the actor network of the marine value ecosystem centered by the e-Navagation. This network is distinct from the traditional service provider-user dyad view. This distinction is important because the e-navigation attempts to address dispersed data and information from multiple stakeholders beyond the traditional dyadic view (Kocak 2014). Since all the actors of service can be active resource integrators, the distinction of labor between a provider and user is blurred. The actor network includes embedded relationships of actors, which facilitate exchange and collaborate through resource liquefaction and integration to configure value. Conceptualizing the e-navigation as a service, we can apply three components of MI, such as actors, their unique resources, and IT, to an examination of the e-navigation. The role of IT is crucial to exchange resources, hardware and infrastructure as well as knowledge and skills among actors. This enabling function would be consistent with what IT makes a difference for enhanced efficiency, safety, and sustainability (Lusch and Nambisan 2015).

The IMO sets up marine regulations in the aim of increasing productivity of the shipping industry. This goal can be accomplished by achieving the three objectives of Green IS; efficiency, safety, and sustainability (Watson et al. 2010; Takabi et al. 2010). Efficiency can be raised by cost reduction and attenuating the risk of crash and pollution. Safety means doing the right things and doing things right for a variety of stakeholders. Sustainability is to maintain eco-equity without compromising the essential functions and processes of the industry (Watson et al. 2010). In this process, MI including e-navigation may function as a conduit of vital rhythm for the health of entire service ecosystem and platform of the industry. It would help build and maintain productive communication and collaboration among actors by resource liquefaction, resource density, and resource integration. We, therefore, may enhance our understanding by adopting a theoretical lens of S-D Logic as portrayed above and in the next section we will examine how S-D Logic works in Korean Initiatives on Ocean Navigation Systems. Using case study provides us with a concrete understanding in the contextualized manner, which is beneficial to show how the SD-logic framework enhances the phenomenon in question (Yin 1994).
**Case in point: The e-navigation**

**Korean Initiatives on Ocean Navigation Systems**

In accordance to IMO’s initiative, the Korean government has promptly stepped forward with an e-navigation development project. The project is appropriated for the following reasons (KISTEP 2015). First, as military and political tension between South and North Korea is escalating, the e-navigation equipped with MI technologies is drawing more attention than ever. In particular, researchers have adopted various data analytics approaches to investigate and forecast the pattern of conflicts after a series of incidents on the disputed western sea borders (Ducruet and Roussin 2008).

Second, South Korea is a peninsular geographically located between China and Japan. All the neighbor countries are keen on seafood. It is critical for the countries to acquire, maintain, and develop marine natural resources and Exclusive Economic Zones (EEZ) for their competitive advantages at the national level. The concept of e-navigation will become an effective means to serve the goal of marine resource management particularly when it is connected to the Marine Spatial Planning (MSP) of the county.

Thanks to a high degree of technology awareness and collectivistic culture, the e-navigation is more likely to be adopted by Korean industries and citizens. Indeed, South Korea has been recognized as a world leader in information communication technology along with USA and Japan (International Telecommunication Union 2015). Leveraging advanced mobile technologies; South Korea can reap the benefits of pioneering e-navigation equipped with MI technologies. This specification may be a crucial first step for building world standards for better efficiency, safety, and effectiveness, which is endorsed by IMO as well as Green IS.

**Designing the e-navigation through a Lens of S-D Logic**

Figure 3 depicts how S-D Logic applies to Korean e-navigation in service design and operation. To accomplish service goals including efficiency, safety, and effectiveness, actors and their unique resources can configure values through e-navigation. It is worth noting that services that the e-navigation is to deliver are designed for goals and interactions by three service design dimensions; who are the actors, whom they know and influence, and what they know for making an impact from the service to configure value (Lusch and Nambisan 2015; Storbacka et al. 2012; Read et al. 2009).

**Actors of the e-navigation**

The objective of the project is to respond to the pressing agenda of the IMO by mobilizing leading Korean information communication technology, and, at the same time, to take a leading position on global standardization of the e-navigation. A diverse sets of organizations are participating in the project; the Korean Ministry of Oceans and Fisheries (MOF), research institutions including Korea Research Institute of Ship and Ocean Engineering (KRISO), Korea Institute of Ocean Science and Technology (KIOST), and Korea Institute of Science and Technology Evaluation and Planning (KISTEP), and IT and marine shipping industries in Korea. They formed a collaboration-based network in which each organization (or researcher), as an actor, cocreates value with other organizations (or researchers) through integrated resource and service provided (Vargo and Lusch 2011). The project was named SMART-Nav Service.

An outstanding advantage of the actor-to-actor network is that participating organizations are loosely coupled and institutionally tied. They have developed a “shared worldview” while collaborating for the past research projects. The institutional ties appeared to make it possible for the participating actors with both administrative and cultural distance to form and share common perspectives on the e-navigation program. This can be explained well by S-D logic paradigm, a mental model to explain network, information, and value-driven IT-enabled service network and its value configuration with multiple acting stakeholders (Lusch and Nambisan 2015).

**Resources of the e-navigation**

As to the main resources for the project, the MOF established a budget of $160 million to support R&D projects and to develop the telecommunication infrastructure on which the e-navigation is to operate. S-D
logic suggests that there are two types of resources; operand and operant resources (Lusch and Nambisan 2015). Operand resources for implementing the e-navigation include hardware and network/telecommunication infrastructure, which are tangible and static. Operant resources include human skill, know-how, data and information, and software, which are intangible and dynamic.

In the context of Korean initiatives on e-navigation, KRISO, the research organization that takes a leadership of the program, has already acquired extensive knowledge and experience in the related field. Specifically, KRISO, as a leading marine science and technology research institute in Korea, provides comprehensive expertise in the development of ships and ocean engineering technologies. It is important to note that KRISO’s accumulated knowledge and experience in the related areas serve a significant role to develop and implement e-navigation in practice.

**Technological Aspect of the e-navigation**

SMART-Nav is to be integrated with numerous information technologies at the service ecosystem level, and KISTEP classifies them into four categories (KISTEP 2015); core technologies, SMART-Nav infrastructure, and international standard technologies. The core technologies represent the fundamental technologies and systems including real-time vessel location monitoring system, marine emergency system, Vessel Traffic Service (VTS), and selective core component technologies of SMART-Nav. SMART-Nav infrastructure includes distributed the e-navigation operation centers, marine super-high speed LTE (Long-Term Evolution), VHF Data Exchange, satellite-linked vessel tracking systems, and digitalization of marine VHF/MF/HF. The group of technologies that the Korean team attempts to set as International technology standard comprises maritime big data, marine application and data cloud, data exchange standard (S-10S), and ocean wireless standard among many others. The technologies and systems are to be transferred and operated by various actors of the marine industry ecosystem.

SMART-Nav will offer industry actors real-time interactions. Comprehensive maritime data is to be collected, managed, and exchanged through big data system. In the service platform, IT provides cloud systems and standardized data through wireless network. In this stage, related organizations may nurture maritime information specialists to involve in resource liquefaction and resource density. To amplify the benefits of information service, data needs to be prepared in a well-defined modular architecture and protocol.

Resources of actors are important components of automated maritime intelligence systems. In the cocreation layer, actors crystalize their value based in their own interest, and improve efficiency, safety,
and sustainability can be improved by the information service provided (Watson et al. 2010; Takabi et al. 2010). At this point, the resource of actors can be at the service level with reduced risks and crashes from diverse sources. In this process, IT helps to integrate decision making at the international shipping level and deliver better performances.

Beyond the traditional service provider-user dyad, S-D dominant logic provides insights to understand the e-navigation with MI technologies for network-oriented, information-oriented, or experience-oriented qualities of service (Lusch and Nambisan 2015). The case of e-navigation can open the possibilities that we can configure value for the each actor through consistent and collaborative dematerialized dialogs. MI can be a protagonist of this narrative for more efficient, secure, and sustainable picture.

Conclusion

In this paper, we argue that the e-navigation should be designed as a service agent improving performance of marine shipping industry in terms of efficiency, safety, and sustainability. This is based in initiatives of Green IS (Watson et al. 2010) that requires an innovative perspective. The role of IT is crucial in the context of the maritime industry because it enables actors of the service network to exchange and integrate resources and configure value.

Our study offers a broadened innovative view of service and an integrated framework that concerns the dynamic nature of marine IT innovation. So far, the conventional framework of maritime information technology has been based on a service provider-user dyad view, which cannot be easily aligned with the big picture of MI (Kocak 2014). On the contrary, the S-D logic adapted in the current study provides a fundamental framework for the e-navigation SIP. It provides a foundation to explore the dynamics not just of the actor network and service exchange, but also value co-creation and service-oriented process innovation of the marine shipping industry. The concept and implementation of e-navigation are still at the infant stage. It has a great deal of potential to advance maritime information services by integrating a variety of MI technologies. It is, therefore, necessary to take into account the service-dominant innovation framework into the design of the e-navigation in the future.

We further investigated how multiple actors may co-create value not only at the individual level but also at the ecosystem level. Adopting the advanced information technologies into the shipping industry surely improve its performance at the global service level as the e-navigation based on MI improves communication and collaboration. The S-D logic paradigm can be a useful theoretical lens to research value co-creation using MI because it gives more insights on how multiple actors interact with service.

For further research, an empirical validation of the service-dominant the e-navigation framework would be desirable. The outcome result of the study may provide an insight for policy makers, business researcher, and practitioners. In addition to the e-navigation, the IMO should develop an orchestration strategy for cross-domain MI. The IMO may work the global IT industry that would continue improving the e-navigation along by incorporating innovative approaches of MI, which would advance the efficiency, safety, and sustainability of the maritime industry.

REFERENCES


