Chapter 11
Development of Data Analytics in Shipping

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ABSTRACT
Modern vessels are monitored by Onboard Internet of Things (IoT), sensors and data acquisition (DAQ), to observe ship performance and navigation conditions. Such IoT may create various shipping industrial challenges under large-scale data handling situations. These large-scale data handling issues are often categorized as “Big Data” challenges and this chapter discusses various solutions to overcome such challenges. That consists of a data-handling framework with various data analytics under onboard IoT. The basis for such data analytics is under data driven models presented and developed with engine-propeller combinator diagrams of vessels. The respective results on data analytics of data classification, sensor faults detection, data compression and expansion, integrity verification and regression, and visualization and decision support, are presented along the proposed data handling framework of a selected vessel. Finally, the results are useful for energy efficiency and system reliability applications of shipping discussed.

INTRODUCTION
The International Maritime Organization (IMO) and other respective authorities (IMO, 2007) have proposed “e-navigation”, a global vision for an international collaborative communication network, to improve the safety and efficiency in the shipping industry (IMO, 2014). The e-navigation framework can facilitate towards standardized ship navigation platforms (i.e. integrated bridge systems (IBSs) to overcome the present emission control based energy efficiency industrial challenges (Rodesth 2011). IMO and other respective maritime authorities have introduced various emission control (i.e. CO2, SOx, and NOx) regulations to develop more energy efficient ships. It is reasonable to believe that tighter emission control measures will introduce for vessels navigating in designated emission control areas (ECAs)

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(IMO, 2009) in the future. Hence, there is a need to develop appropriate ship navigation strategies to accommodate not only weather routing but also emission control and energy efficiency type applications (Perera and Guedes Soares, 2017). Furthermore, such navigation strategies can complement with the proposed e-Navigation framework by introducing intelligent decision support capabilities under IBSs. However, such intelligent decision support capabilities should be based on adequate ship performance and navigation data, i.e. “Big data.” It is an expectation that the ICT infrastructure and “Big Data” will play an increasingly important role towards digitalization of the shipping industry in the coming decade. Therefore, there is a development need for appropriate data handling frameworks to use onboard vessels and support the ICT infrastructure and “Big Data” applications.

Modern IBSs that should facilitate towards such data-handling framework often consist two separate networks for collecting ship performance and navigation data: navigation and automation systems. Such divisions in IBSs also supports various classification societies’ requirements with the navigation safety and reliability considerations. Modern IBSs are equipped with various appropriate sensors and data acquisition (DAQ) systems to collect ship performance and navigation information and that creates onboard Internet of Things (IoT) (Rodseth (2016) and Bhatt and Bhatt (2017)). Ship navigation systems may consist of the following systems: electronic chart display and information system (ECDIS), autopilot system conning, radar, and other respective sensors. Ship automation systems may consist of the following systems: power management architecture for engine and propulsion controls and other systems that relate to various engine room operations. An adequate overview of ship performance and navigation conditions is possible to observe under such IoT and the collected information (i.e. vessel performance and navigation data) and use it towards intelligent decision support capabilities. Such navigation decisions under an appropriate data-handling framework can lead to more energy efficient ships. It is a belief that an appropriate data-handling framework can also play an important role in such IoT, where effective navigation strategies depend accurate ship performance and navigation information.

This study proposes such data-handling framework to organize ship performance and navigation information under IoT (Atzoria et al., 2010). This framework collects large-scale data sets, so called “Big Data”, that should be analyzed to evaluate ship performance under various navigation conditions in onboard or shore based data centers. One should note that conventional data analysis tools and techniques might fail to capture actual ship performance and navigation conditions under such large-scale data sets. Therefore, this framework introduces several data handling layers to overcome such challenges in handling large scale-data sets in vessels. Such layers are categorized as “data analytics”, where the main contribution of this chapter is to observe ship performance and navigation conditions from the receptive data analytics. Ship performance and navigation information under such data analytics can facilitate to identify optimal vessel operational and navigation conditions, where such analytics and the respective results can also be a part of the ship energy efficiency management plan (SEEMP) (IMO, 2009 & 2012). Furthermore, the proposed data-handling framework under IoT is also an important step towards the proposed digitalization of the shipping industry.

DATA HANDLING FRAMEWORK

This section describes various data analytics to support the proposed data-handling framework under IoT. That is presented in Figure 1 and facilitated by both top down and bottom up approaches. The top