Cyber Security in the Maritime Transport

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Abstract

Maritime transport is an essential element for the economic sustainability of many regions around the world, including Albania. Especially for the countries that have access to the sea, maritime transport is the backbone of domestic and international trade. One of the challenges faced by this sector is the protection from threats and cyber-attacks. Cyber-attacks can lead to major environmental or economic disaster, even being able to cause loss of human life. Also, technological changes are being implemented by shipping companies more slowly compared to other manufacturing sectors. Therefore, this sector is easily attacked in this direction. The purpose of this study is to present the consequences of cyber-attacks on maritime transport through a map of current cyber security provisions on ships and in ports. Regarding this, the purpose of the research in this study is related to the conference topics regarding technology and information and navigation sciences. The methodology used in this scientific research is based on published literature that enables a mapping of modern methods and analysis, interpretation, and implications of cyber security within the maritime industry. Major results and implications of the study regards suggestions on raising cyber security capacities against cyber threats for the realization of safe and modern port activities.

Keywords: cyber security, maritime transport, legislation, logistics
1. Introduction

Maritime transport is an essential element for the economic sustainability of many regions around the world, including Albania. Development of the maritime industry relies on different factors, such as: global growth and improvement of its standards, investments, elimination of trade barriers, etc., that also encourage an ever-increasing dependence on the maritime industry. Especially for the countries that have access to the sea, maritime transport is the backbone of domestic and international trade.

Furthermore, in markets that require sustainable development, low costs, efficiency and, of recent growing importance, environmentally friendly operations, the maritime sector is responsible for 90% of the transport of all goods.

Recent developments in the Internet of Things (IoT), Big Data and Artificial Intelligence have enabled the migration to more digitized maritime infrastructures and, therefore, required an urgent re-evaluation of cyber security provisions. Additionally, connectivity and reliance on smart devices play a key role in motivating cybercrime such as social engineering, identity theft and spam. Protecting the integrity of next-generation maritime infrastructures is an urgent need.70

The maritime sector, as a vital part of the global economy, must be protected from cyber threats and attacks. A cyber incident can lead to a major environmental or economic disaster, even being capable of causing the loss of human life.

Technological changes are being implemented by shipping companies more slowly than other manufacturing sectors. As a result, the maritime sector is mainly suffering the risks of cyber-attacks related to this way of conceiving and managing the business.

2. Methodology

The methodology used in this scientific research is based on published literature and documents issued by the International Maritime Organization (hereinafter IMO), that enables a mapping of modern methods and analysis, interpretation and implications of cyber security within maritime transport. The purpose of the desk-based research is to collect data on: the predictions set by the IMO on cyber security in maritime transport, the role of protection from cyber risks in maritime transport, legal predictions at the national level or their absence in cybersecurity in maritime transport. The purpose of the desk-based research is to highlight the predictions and standards that must be respected in the protection from cyber risks in maritime transport.

3. Results

Cyber security in the maritime sector is the great obsession of shipping companies, as nowadays almost everything is managed through the Internet, which is the medium of relationship and transition between a company, its suppliers and its customers, prompting hackers to hack and access the data of a transport company very easily. These attacks do not only refer to economic damages, but also affect reputation and credibility when it affects the trust that the environment has in the company. Since plans are focused on reducing risks related to security, port disruption, and environmental concerns, a traditional cybersecurity assessment may not be enough.

Currently there have been several attacks on the security systems of both ports and shipping companies or businesses that import/export their goods via sea transport. Even though the use of the Internet has been significantly introduced in almost all port operations, the seaports of the Republic of Albania have a significant lack of protection against cyber-attacks and therefore become very vulnerable to cyber-attacks or cyber terrorism.

On the other hand, IMO’s response to this is issued in some guidelines, which, although they have a recommendatory character, are of particular value to be implemented by stakeholders in maritime transport. In the following, we are presenting some of them in a descriptive way.


2021. Subject to this resolution are all vessels and it requires that in their safety management systems is included cyber
risk management, in accordance with the International Safety Management (ISM) Code.

This resolution takes into account the MSC-FAL.1-Circ.3-Rev.2 “Guidelines on maritime cyber risk management” (Guidelines hereinafter). The guidelines provide high-level recommendations on maritime cyber risk management to safeguard shipping from current and emerging cyber threats and vulnerabilities and include functional elements that support effective cyber risk management. The recommendations can be incorporated into existing risk management
together with the ISM Code. The Resolution includes further recommendations as well, which can be summarized as following:

**Identify:** Define personnel roles and responsibilities for cyber risk management and identify the systems, assets, data and capabilities that, when disrupted, pose risks to ship operations.

**Protect:** Implement risk control processes and measures, and contingency planning to protect against a cyber-
event and ensure continuity of shipping operations.

**Detect:** Develop and implement activities necessary to detect a cyber event in a timely manner.

**Respond:** Develop and implement activities and plans to provide resilience and to restore systems necessary for
shipping operations or services impaired due to a cyber-event.

**Recover:** Identify measures to back-up and restore cyber systems necessary for shipping operations impaired by a cyber-event.

Resolution MSC.428(98) “Maritime Cyber Risk Management in Safety Management Systems” has since been complemented by other guidelines, notably those developed by the Baltic and International Maritime Council (BIMCO) for cyber risk management.

In particular, we mention here “The Guidelines on Cyber Security onboard Ships” - Version 4, according to which vessels and shipping are vulnerable to cyber-attacks and which is based on high-level principles, such as:

- establishment of awareness of the safety, security and commercial risks that present themselves due to a lack of cyber security measures;
- protection of shipboard IT infrastructure and connected equipment;
- system for authentication and authorization of users, to ensure appropriate access to necessary information;

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72 This resolution encourages administrations to ensure that cyber risks are appropriately addressed in existing safety management systems (as defined in the ISM Code) no later than the first annual verification of the company’s Document of Compliance after 1 January 2021.
73 It was approved by the Facilitation Committee, at its forty-first session (4 to 7 April 2017), and by the Maritime Safety Committee, at its ninety-eighth session (7 to 16 June 2017).
76 Ibid.
77 Ibid.
78 Ibid.
● protection of data that is used in the ship environment, ensuring it has adequate protection based on the sensitivity of the information;
● management of IT users, to make sure they only have access and rights to the information for which they are authorized;
● management of communication between the ship and the shore side, and
● develop and implement a cyber incident response plan based on a risk assessment.79

These guidelines lay out high-level recommendations for incorporating cyber risk management into existing safety management system (SMS) processes, enabling ship owners to protect their vessels. As of January 1, 2021, all ship owners must comply with IMO Resolution MSC.428(98) in order to continue sailing worldwide.80

4. Discussion

There are more than 50,000 merchant ships operating internationally, carrying all types of cargo. These vessels must dock at Critical Infrastructures (CI) to carry out their usual operations (ports, platforms, refineries, pipelines, power plants, etc.). Ports are one of the most important links in the logistics chain, especially in recent years, due to the tremendous growth of container shipping.

In the Republic of Albania, there are four state-owned ports open for international transport, such as the Port of Durrës, which covers about 80% of the import/export of goods in Albania, the Port of Vlora, the second port in terms of size and importance, the Port of Saranda which has mainly turned into a port for processing passengers and the Port of Shëngjin as the most northern port of Albania, which is mainly used by companies that have their activity in the north of the country.

Three terminals for the processing of hydrocarbon materials which have been built and operate under concession contracts between state institutions and private companies. These ports are Romano Port sha. and MBM Port which are in the bay of Porto Romano, Durrës and the Vlora-1 Petrolifera Italo-Albanese (PIA) terminal which operates in the bay of Vlora.

In the above ports, the possible illegal activities of cyber-crime or cyber terrorism can condition the Albanian economic and institutional activity and always cause losses for many economic actors, because of the collapse of processes and services.

5. Conclusions

Based on the above results and discussions, conclusions of this paper are as following:
● Safe and secure shipping, which is operationally resilient to cyber risks, should be supported by the increase of human capacities that cover this field and the adoption of the relevant legal rules.
● To safeguard shipping from current and emerging threats related to cyber security of processes and systems in shipping, all the actors involved should take the necessary measures based on international and national standards and best practices.
● Adoption of effective feedback mechanisms is required for effective cyber risk management.
● Adoption of new measures at domestic level (Albanian law) are required to fulfill the IMO guidelines.

References


Homomorphism in Weakly $\Gamma$-Ring

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Abstract

Many algebraic structures have been defined so far. One of them, is that of $\Gamma$-ring, which is a generalization of ring. Weakening some of the conditions of the definition of $\Gamma$-ring, it has also been defined the concept of weakly $\Gamma$-ring. An important and well-known concept for every algebraic structure is homomorphism. In this paper, the concept of homomorphism in weakly $\Gamma$-ring is introduced. Further, some simple results analogous to the theory of rings, related to this concept are extended.

Keywords: $\Gamma$-semigroup, $\Gamma$-ring, weakly $\Gamma$-ring, homomorphism

1. Introduction

The concept of $\Gamma$-ring, which is a generalization of the concept of ring, was first defined by Nobusawa in [1].

Barnes, in [2], weakened some of the conditions of the definition of Nobusawa, and defined those that he called $\Gamma$-rings, naming $\Gamma$-rings defined in [1], as $\Gamma$-rings of Nobusawa.

Based to the definition of Nobusawa’s $\Gamma$-ring, Sen in [3], defined $\Gamma$-semigroup that is called $\Gamma$-semigroup of Sen. Sen and Saha in [4], defined a generalization of $\Gamma$-semigroup of Sen, which is called a $\Gamma$-semigroup. The concept of $\Gamma$-semigroup may be obtained by that of $\Gamma$-ring, by extracting addition.

Petro and Sema, in [5], weakened further the conditions of the definition of Barnes and defined those that they called weakly $\Gamma$-rings.

An important concept for every algebraic structure is homomorphism. Thus, it is eligible extending this concept to weakly $\Gamma$-rings.

In this paper, homomorphism to weakly $\Gamma$-rings is introduced and some simple results of rings to $\Gamma$-rings, which are related to this concept, are extended.

2. Materials and Methods

Here we give some notions and present some auxiliary results that will be used throughout the paper.

Let $M$ and $\Gamma$ be two nonempty sets. Any map from $M \times \Gamma \times M$ to $M$ is called a $\Gamma$-multiplication on $M$ and is denoted by $(\cdot)\_\Gamma$. The result of this $\Gamma$-multiplication for each $a, b \in M$ and each $\gamma \in \Gamma$, is denoted by $a\gamma b$.

The concept of $\Gamma$-ring, which is a generalization of the concept of ring, was first defined by Nobusawa in [1], as follows:
Definition 2.1. [1] Let $M$ be an additive group with elements $a, b, c, \ldots$ and $\Gamma$ another additive group with elements $\alpha, \beta, \gamma, \ldots$. Assume that $a \cdot b$ is defined as an element of $M$ and $\alpha \cdot \beta$ is defined as an element of $\Gamma$ for each $a, b, \alpha$ and $\beta$. If the products satisfy the following conditions:
1. $(a_1 + a_2) \cdot b = a_1 \cdot b + a_2 \cdot b$, $a \cdot (\alpha_1 + \alpha_2) = a \cdot \alpha_1 + a \cdot \alpha_2$,
2. if $a \cdot b = 0$ for each $a$ and $b$ in $M$, then $\alpha = 0$,
then $M$ is called a $\Gamma$-ring.

An ordinary ring $(A, +, \cdot)$ may turn into a $\Gamma$-ring, if we get $M$ and $\Gamma$ to be equal to $A$.

Barnes, in [2], weakened some of the conditions of Nobusawa, by calling $\Gamma$-rings of Nobusawa the ones defined as above and simply $\Gamma$-rings those that he defined himself.

Definition 2.2. [2] Every ordered five-tuple $(M, \Gamma, +, \oplus, (\cdot)_{\circ})$, where $M$, $\Gamma$ are sets, $+$ is an addition on $M$, $\oplus$ addition on $\Gamma$, $(\cdot)_{\circ}$ is a $\Gamma$-multiplication on $M$, such that:
1. $(M, +)$ is an abelian group,
2. $(\Gamma, \oplus)$ is an abelian group,
3. $\forall (a, b, c, \alpha, \beta) \in M \times \Gamma, (a \cdot b) \cdot \gamma = a \cdot (b \cdot \gamma) \wedge [a \cdot (b + c) = a \cdot b + a \cdot c]$,
is called $\Gamma$-ring (of Barnes).

Sen and Saha in [4], defined $\Gamma$-semigroups, which may be obtained by the definition of $\Gamma$-rings, by avoiding the additions:

Definition 2.3. [4] Every ordered pair $(M, (\cdot)_{\circ})$, where $M$ and $\Gamma$ are two nonempty sets and $(\cdot)_{\circ}$ is a $\Gamma$-multiplication on $M$, which satisfies the following condition:
1) $(M, +)$ is an abelian group,
2) $(M, (\cdot)_{\circ})$ is a $\Gamma$-semigroup,
3) $\forall (a, b, c, \alpha, \beta) \in M \times \Gamma, (a \cdot b) \cdot \gamma = a \cdot (b \cdot \gamma)$,
is called weakly $\Gamma$-ring.

We notice that plain rings, $\Gamma$-rings of Nobusawa and $\Gamma$-rings of Barnes, are weakly $\Gamma$-rings, but the converse is not true.

Saha and Seth in [6] have introduced the concept of homomorphism between two $\Gamma$-semigroups, as follows:

Definition 2.5. [6] Let $(M, (\cdot)_{\circ})$ be a $\Gamma$-semigroup and $(M_1, (\cdot)_{\circ_1})$ a $\Gamma_1$-semigroup. A pair of mappings $(h_1, h_2)$, where $h_1: M \rightarrow M_1$ and $h_2: \Gamma \rightarrow \Gamma_1$, such that
$h_1(a \cdot b) = h_1(a) \cdot h_1(b), \quad \text{for each } a, b \in M \text{ and } \gamma \in \Gamma,$ is called a homomorphism of $(M, (\cdot)_{\circ})$ to $(M_1, (\cdot)_{\circ_1})$.

Let $M$ be a weakly $\Gamma$-ring and $A, B$ two nonempty subsets of $M$. Define:
$AB = \{ \sum_{i=1}^{n} a_i \cdot y_i : a_i \in A, b_i \in B, \gamma_i \in \Gamma \text{ for each } i = 1, 2, \ldots, n; n \in \mathbb{N} \}$.

Every subgroup $R$ of the group $(M, +)$, such that:
$R \subseteq M \subseteq R \subseteq [M \subseteq \Gamma]$, is called right [left] ideal of the weakly $\Gamma$-ring $(M, (\cdot)_{\circ})$.

Every subgroup $I$ of the group $(M, +)$, such that:
$I \subseteq I \subseteq I \subseteq [M \subseteq \Gamma]$, is called left [right] ideal of the weakly $\Gamma$-ring $(M, (\cdot)_{\circ})$.
is called ideal of the weakly Γ-ring $(M, +, (\cdot)_r)$.
Thus, $I$ is an ideal of the weakly Γ-ring $M$, only if it is a left ideal and a right ideal of $M$ simultaneously.

3. Conclusions

In this section, basing on what is given above, mixing them, some new results are given.

**Definition 3.1.** Let $(M, +, (\cdot)_r)$ be a weakly Γ-ring and $(M', +, (\cdot)'_r)$ be a weakly Γ'-ring. Every ordered pair of mappings $H = (h_1, h_2)$, where $h_1: M \to M'$ and $h_2: \Gamma \to \Gamma'$, such that:
1) $\forall (a, b) \in M^2, h_1(a + b) = h_1(a) + h_1(b)$.
2) $\forall (a, \alpha, b) \in M \times \Gamma \times M, h_1(aa\beta) = h_1(a)h_2(\alpha)h_1(b)$.

is called a homomorphism of the weakly Γ-ring $(M, +, (\cdot)_r)$ to the weakly Γ'-ring $(M', +, (\cdot)'_r)$.

It is obvious that every homomorphism of the weakly Γ-ring $(M, +, (\cdot)_r)$ to the weakly Γ'-ring $(M', +, (\cdot)'_r)$, is an ordered pair of mappings $(h_1, h_2)$, where $h_1$ is a homomorphism of the additive group $(M, +)$ of the weakly Γ-ring $(M, +, (\cdot)_r)$ to the additive group $(M', +)$ of the weakly Γ'-ring $(M', +, (\cdot)'_r)$, whereas $(h_1, h_2)$ is a homomorphism of the Γ-semigroup $(M, (\cdot)_r)$ to the Γ'-semigroup $(M', (\cdot)'_r)$ of the Γ'-multiplication of the weakly Γ'-ring $(M', +, (\cdot)'_r)$.

If both mappings $h_1, h_2$ are injective (one-to-one), the homomorphism $H = (h_1, h_2)$ is called monomorphism and $(M, \Gamma)$ is called monomorphp to $(M', \Gamma')$. If these mappings are both surjective (onto), $H$ is called epimorphism and $(M, \Gamma)$ is called epimorphism to $(M', \Gamma')$.

**Definition 3.2.** Let $H = (h_1, h_2)$ be a homomorphism of the weakly Γ-ring $(M, +, (\cdot)_r)$ to the weakly Γ'-ring $(M', +, (\cdot)'_r)$. The kernel of the homomorphism $h_1$ of the additive group $(M, +)$ to the additive group $(M', +)$, is called kernel of the homomorphism $H = (h_1, h_2)$, and will be denoted by $\text{Ker} H$.

Thus:
$$ \text{Ker} H = \{ x \in M : h_1(x) = 0_{M'} \}.$$ 

The image of the homomorphism $h_1$, is called image of the homomorphism $H = (h_1, h_2)$, and will be denoted by $\text{Im} H$.

Thus:
$$ \text{Im} H = \{ h_1(x) \in M' : x \in M \} = \{ x' \in M' : \exists x \in M, h_1(x) = x' \}.$$ 

**Proposition 3.3.** For every homomorphism $H = (h_1, h_2)$ of the weakly Γ-ring $(M, +, (\cdot)_r)$ to the weakly Γ'-ring $(M', +, (\cdot)'_r)$, the kernel $\text{Ker} H$ is an ideal of the weakly Γ-ring $(M, +, (\cdot)_r)$, whereas, when $h_2$ is a surjective mapping, $\text{Im} H$ is a subΓ'-ring of the weakly Γ'-ring $(M', +, (\cdot)'_r)$. 

**Proof.** $\text{Ker} H$ is a subgroup of the additive group $(M, +)$ of the weakly Γ-ring $(M, +, (\cdot)_r)$.

For each element $a, \alpha \in M$, for each element $b$ of $\text{Ker} H$ and for each element $\gamma \in \Gamma$, the following hold
$$ h_1(ab\alpha) = h_1(a)h_2(\gamma)h_1(b) = 0, $$ 

$$ h_2(\gamma \beta) = h_1(\beta)h_2(\gamma)h_1(a) = h_1(b)h_2(\gamma)0 = 0, $$

which show that $\text{Ker} H$ is an ideal of the weakly Γ-ring $(M, +, (\cdot)_r)$. 

Let $a', b'$ be two elements of $\text{Im} H$ and $\gamma'$ an arbitrary element of $\Gamma'$. Then, there exist the elements $a, b \in M$ and the element $\gamma \in \Gamma$, such that:
$$ a' = h_1(a), \quad b' = h_1(b), \quad \gamma' = h_2(\gamma). $$

The following equalities hold:
$$ a' \gamma' b' = h_1(a)h_2(\gamma)h_1(b) = h_1(ab\alpha), $$

which show that $\text{Im} H$ is a subΓ'-ring of the weakly Γ'-ring $(M', +, (\cdot)'_r)$, since $\text{Im} H$ is a subgroup of the group $(M', +)$.

Let $H = (h_1, h_2)$ be a homomorphism of the weakly Γ-ring $(M, +, (\cdot)_r)$ to the weakly Γ'-ring $(M', +, (\cdot)'_r)$, and $B'$ a subset of $M'$. Denote
$$ H^{-1}(B') = \{ x \in M : h_1(x) \in B' \}. $$

The subset $H^{-1}(B')$ of $M$, will be called inverse image of $B'$.

**Proposition 3.4** Let $H = (h_1, h_2)$ be an epimorphism of the weakly Γ-ring $(M, +, (\cdot)_r)$ to the weakly Γ'-ring $(M', +, (\cdot)'_r)$ with kernel, the ideal $I$ of $(M, +, (\cdot)_r)$. Then, a nonempty subset $B'$ of $M'$ is an ideal of $(M', +, (\cdot)'_r)$ if and only if
$$ H^{-1}(B') = B $$
is an ideal of the weakly Γ-ring $(M, +, (\cdot)_r)$ that contains the ideal $I$.

**Proof.** Assume that the nonempty subset $B'$ of $M'$ is an ideal of the weakly Γ'-ring $(M', +, (\cdot)'_r)$. Let $a$ be an
ordinary element of $M$, $b$ an ordinary element of $B = H^{-1}(B')$ and $\gamma$ an ordinary element of $\Gamma$. Since:

$$h_1(ayb) = h_1(a)h_2(\gamma)h_1(b) \in M'T'B' \subseteq B',$$

$$h_1(bya) = h_1(b)h_2(\gamma)h_1(a) \in B'T'M' \subseteq B',$$

the elements $ayb, bya$ belong to the subset $B$ and consequently $H^{-1}(B') = B$ is an ideal of the weakly $\Gamma$-ring $(M, +, (\cdot)_\Gamma)$, since $H^{-1}(B')$ is a subgroup of the additive group $(M, +)$ of the weakly $\Gamma$-ring $(M, +, (\cdot)_\Gamma)$.

The ideal $H^{-1}(B') = B$ contains the ideal $I$ of the epimorphism $H$; since we have

$$\forall x \in M, x \in I \Rightarrow h_1(x) = 0 \in B'$$

Conversely, suppose that $H^{-1}(B') = B$ is an ideal of the weakly $\Gamma$-ring $(M, +, (\cdot)_\Gamma)$, that contains the ideal $I$. Let $a'$ be an element of $M'$, $b'$ an element of $B'$ and $\gamma'$ an element of $\Gamma'$. There exist the elements $a \in M, b \in H^{-1}(B') = B$ and $\gamma \in \Gamma$, such that:

$$a' = h_1(a), \quad b' = h_1(b), \quad \gamma' = h_2(\gamma).$$

The following equalities hold:

$$a' - b' = h_1(a) - h_1(b) = h_1(a - b),$$

$$a'\gamma'b' = h_1(a)h_2(\gamma)h_1(b) = h_1(ayb),$$

$$b'\gamma'a' = h_1(b)h_2(\gamma)h_1(a) = h_1(bya),$$

that show that $B'$ is an ideal of the weakly $\Gamma'$-ring $(M', +, (\cdot)_{\Gamma'})$, since $B' \neq \emptyset$, because $I \subseteq H^{-1}(B') = B$, and $H^{-1}(B') = B$ is an ideal of $(M, +, (\cdot)_\Gamma)$, that guarantees us that $a-b, ayb, bya$ are elements of $H^{-1}(B') = B$.

References


