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CYBERSECURITY IMPLEMENTATION ASPECTS AT SHIPPING 4.0 AND INDUSTRY 4.0 CONCEPTS REALIZATION

Assoc. Prof. Dr. Vladlen SHAPO

National University "Odessa Maritime Academy", Ukraine,
E-mail: vladlen.shapo@gmail.com

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ABSTRACT

Last few years took place true jump in approaches to developing, control and exploitation of different complex technical systems. In industry, transport, energetic and so on data exchange technologies, based on Industry 4.0, IoT, IIoT, Shipping 4.0, etc. concepts are implementing very actively. In maritime branch information technologies became inextricably linked to the classical approaches and allow to perform intelligent remote control and create fully unmanned objects and complex technical systems. So, some companies have founded Unmanned Cargo Ship Development Alliance; newly developed Distributed Intelligent Vessel Components software, which provides new protocol for devices connecting and data transferring; recently created Advanced Autonomous Waterborne Applications Initiative autonomous ship research project and Maritime Autonomous Surface Ships direction.

It's possible to highlight following ship automation levels.

1. *Ship can be controlled remotely.*
2. *Ship may work in unmanned mode partly or periodically.*
3. *Ship may perform self-driving with operator help, if necessary.*
4. *Additionally to the level 3, self-driving possible without operator's intrusion.*
5. *Fully unmanned ship with the same functionality and possibilities as classic ship.*

But complexity and vulnerability for external intrusion of such ships is also growing enormously. So, in 2017 and 2018 years at least two large shipping companies were attacked by hackers and had to stop significant part of business activity and lost huge amounts. That's why the task of cybersecurity providing, including highly productive firewalls implementing, is very actual.

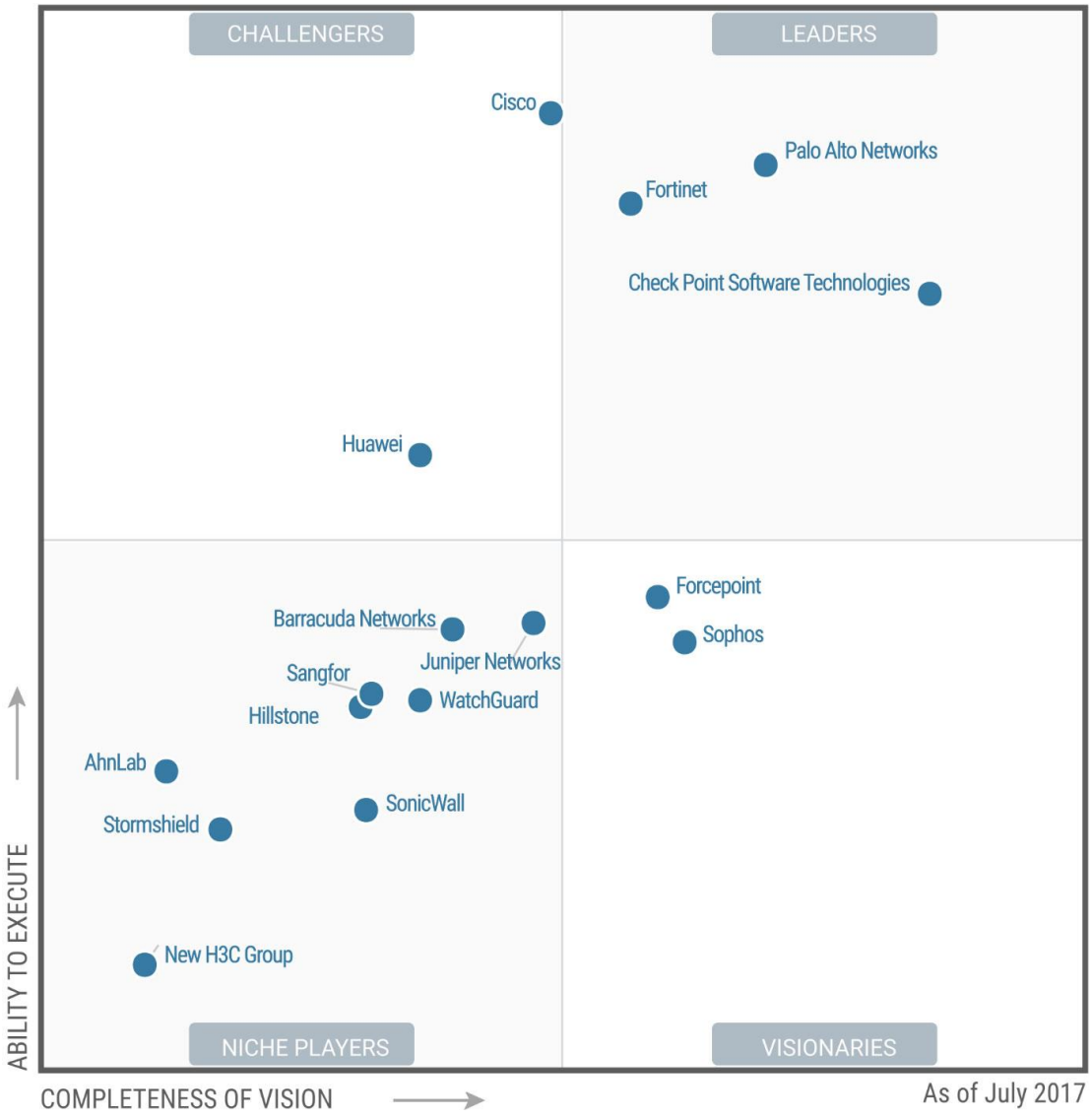
Ways of modern concepts and technologies implementing in maritime branch are briefly analyzed. Possible levels of ships' autonomy and automation with most modern technical decisions are shown. Existing problems and vulnerabilities of highly automated ships are described. Approach on vulnerabilities influence minimizing with firewalls using is proposed.

1. INTRODUCTION

Last 10-15 years it's become absolutely clear that software and hardware cybersecurity systems are very significant for of any information system operability assurance. Modern equipment in any branch of industry, transport, etc. became much more automated, complex and expensive, supporting of business processes become much more intelligent, software become much more complex and sophisticated, data flows in corporative networks (inside

separate networks and between territorially distributed subdivisions in different cities, countries and even continents) and industrial networks become enormous and still growing. Idle time of equipment, facility, information system, etc. leads to huge financial losses and these values are growing as well. For example, idle time at waterside (arrival and departure), constitute 38 per cent of the total port stay for a container ship, which cost billions of USD per year to the shipping lines [1]. So the best situation is when any complex equipment will be fully loaded 24 hours per day. Different kinds of cyberattacks or malicious software intrusion may be a reason of such problems, and implementation of firewalls for defence of information systems may significantly reduce these risks. For instance, ransomware attacks on Maersk's operations in June 2017 took nearly a month to recover and approximate losses were about USD 250 Millions [2]. In 2018 hackers attacked successfully Maersk again [3], and also were successfully attacked Cosco [4], ports of San Diego [5] and Barcelona [6, 7]. Thus different approaches on cybersecurity providing are highly necessary, and one of these approaches is different types of firewalls application.

Figure 1. Magic Quadrant for Small/medium Business and Enterprise Network Firewalls



Firewall (FW) have to control access between trusted and untrusted (internal/external) networks using beforehand created rules. FW may be a hardware (physical device, installed between the external and internal networks; more expensive but much more productive),

software (protects a single computer; will not analyzed below) that is used to prevent unauthorized program or users from untrusted network from accessing a private network or a single computer. All data from external network have to pass through the FW, which analyzes them for specified beforehand security criteria. FW is necessary to protect network in general, its separate resources from users or devices which have no corresponding rights and from malicious users and accidents that originate outside of our network.

At shaping FWs application services strategy it's necessary to understand deeply the application architectures of company. Mostly application services are network and security services (often referred to as Open System Interconnection (OSI) model levels 4–7 services or application delivery services), and also availability, performance, security, and identity and access management. Typical application services include north-south and east-west load balancing, web application firewalls, DDoS prevention/protection, application analytics/monitoring, SSL instantiation and termination.

FW can stop hackers from computer accessing; protect personal information; block "pop up" ads, invalid packets and cookies; determine which programs can access the internet. Personal FW can't prevent e-mail viruses. FW requires periodic updates to the rule sets and the software itself. In June/July 2017 have been appeared next reports (Magic Quadrants) of Gartner (Fig. 1).

Gartner is global research and advisory company providing insights, advice, tools for leaders in IT, Finance, Marketing, Sales, etc. These reports are dedicated to Unified Threat Management (UTM) – for Small and Medium-sized Business (SMB) Multifunction Firewalls and for Enterprise Network Firewalls. Most famous developers on this market are following companies: F5 Networks, Riverbed, Cisco, Fortinet, Huawei, Palo Alto Networks, Check Point Software Technologies, Sophos, Forcepoint, Barracuda Networks, Juniper Networks, SonicWall, Hillstone Networks, WatchGuard, Sangfor, AhnLab, Stormshield, H3C, Rohde & Schwarz cyber security, Untangle, Alien Vault, Algosec, etc. [8, 9]. These companies permanently develop new software, hardware and combined solutions. Main problem for end customer is to choose specific solution satisfying on performance/expenses ratio, also taking into consideration some additional characteristics like number of monitored ports (typical values are 4, 5, 7, 8), expansion slots (typical values are 1, 2), maximum number of protected nodes (typical values are 200, 450, 500, 1000, 5000), maximum throughput (typical values are 50 Mbps, 100 Mbps, 200 Mbps, 500 Mbps, 1Gbps), internal storage subsystem (typical values are 64, 180, 240 GBytes). So it's necessary to formalize procedure of firewall characteristics analyzing, calculating and choosing.

2. MAIN TEXT

The FW is very important component for modern network security. Main types of FWs are stateless and stateful FWs, transparent FWs, FWs at various levels of the network reference architectures, FWs with deep packet inspection (DPI), FWs with intrusion detection features. In addition, FWs are necessary to restrict communication to the desired patterns and communication relationships at other parts of the network. But FWs can also enlarge transmission latency and reduce network throughput, the use of a dedicated FW is not always possible. In such cases, professional network switches can also use less powerful stateless filtering rules. These rules are usually not referred to as FW rules, but to access control lists (ACL). ACLs are suited for situations when rapid filtering must take place within a network. Thus it's necessary to make optimal choice.

1. Packet filter FWs analyze each packet, entering or leaving the network, and accept or reject it, using beforehand defined rules. Packet filtering is quite effective and transparent to users, but it's difficult to configure, and it's vulnerable to IP-addresses spoofing.
2. In application gateway FWs remote host or network communicates only with proxy server, which is responsible for hiding the details of the internal network. Users work with TCP/IP applications. This is very effective but can be reason of performance decreasing.
3. Circuit level gateway works at the session layer of the OSI model. It's standalone system or a specialized application. It does not permit an end to end TCP connection and creates two TCP connections. A typical use of the circuit level gateway is a situation, when network administrator trusts the internal users. FW can be configured to support application level or proxy service on incoming connections and circuit level functions for out coming connections.
4. Stateless FWs. Communications between devices may have some states. Communication is usually initiated in 1st phase, data exchange is performed in 2nd phase, the connection is ended in 3rd phase. Stateless FWs can't react to the state of a connection nor differentiate between the various phases. Thus, it can only be determined that individual devices or applications may communicate with one another. But it can't be determined whether the participants conduct the communication according to the normal procedure. So, the FW cannot recognize or prevent any attacks resulting from anomalous protocol behaviour. Especially vulnerable devices with minimal self defence are put at risk by denial of service (DoS) attack, by which device communication interface is specially flooded and overloaded with forged or mistaken communication requests.
5. Stateful FWs. In contrast to stateless, stateful FWs can monitor the communication process of the participants and thus use the behaviour of the partners during essential communications operations, such as the initiation or termination of the connection, as the foundation for the packet filtering. Thus, attacks which attempt to communicate over connections already made can be recognized and prevented. Equally, attacks which use a known faulty connection in order to load and overload a system can be prevented. These FWs have high level of defence, may work at all 7 levels of OSI model, transparent for applications, have quite good performance and scalability. In the same time cost is also quite high. DPI FWs is subtype of stateful FWs. Stateful FW typically examines the packets in the network as deep as the header at the beginning of the packet, because it contains the information used by FW for communication state determining and monitoring. DPI also allows examination beyond the communication header all the way to the packet payload. Thus highly specialized attacks, hidden deep in the communication flow, can be discovered. DPI FWs are often implemented as additional components of a stateful packet inspection FW only for certain protocols and application purposes. DPI FW offers a high level of security, but it demands a great amount of FW computing power. It also requires a sophisticated configuration interface in order to command the complexity of it. As the result DPI FWs are applied only at certain points in the network. At that location they create a significantly stronger communications security.
6. Packet filter, screening filter. This type has following positive sides: low cost, transparency for application, high performance. But possibilities of analysis are

restricted (up to 4th OSI model level), level of defence is low and may be easily bypassed; settings FW and monitoring parameters are complex.

7. Proxy (application layer gateway). This type has following positive sides: high level of defence, working at all 7 levels of OSI model, possibilities of web filtering, e-mail checking. Negative sides: number of supported protocols is restricted, absence of transparency (it's necessary to specify at client computers proxy server address); duplicating of connections number; low performance; high requirements to proxy server productivity, bad scalability.

Additionally, to traffic filtering FWs may include content filtering, static or dynamic network addresses translation (NAT), virtual private networks (VPN) organization (site to site, point to point, point to site), intrusion detection systems (IDS), Demilitarized Zone (DMZ) organization. For traffic defense may be applied following protocols: IPSec (IP Security), Point-to-Point Tunneling Protocol (PPTP), Layer 2 Tunneling Protocol (L2TP), Open VPN, etc., which use algorithms DES (56 bit key encryption) Data Encryption Standard, Triple Data Encryption Algorithm 3DES TDES Triple (168 bits key encryption), Advanced Encryption Standard AES (128/192/256 bits key encryption). AES is newest and realized by Intel company in Core i7 processors. For execution of most of these functions high processing power is necessary. That's why it's reasonable to prefer special hardware FW solutions or in some cases application of separate stand alone computers with high productive central processors.

It's possible to highlight following criteria of FW choosing.

1. Functionality and supported functions in three main subsets: firewall/intrusion prevention system (IPS) / VPN gateway, secure Web gateway security (URL filtering, Web antivirus) and messaging security (anti-spam, mail antivirus) and also NAT, VPN, base routing system, WAN-technologies supporting, etc.
2. Number and types of necessary interfaces (DMZ, modem pools, etc.).
3. Possibilities of integration with existing equipment and software, communications between wireless and wired networks, possibilities of FW integration directly to the wireless access point.
4. Total cost of ownership (price, expenses for additional training of network administrator and his salary, technical support, licenses, expenses for two typical FW management tasks [10, 11]: the integration of a new FW in an existing network and the management of multiple FWs with network management tools) [Ismail, 12, Mohan, 13].
5. Presence of actual in close future functions: Firewall as a Service, working with private and public clouds, close integration with IaaS platforms (Amazon Web Services, Google Cloud, Microsoft Azure), Cloud Access Security Brokers (CASB) using, outgoing Transport Layer Security (TLS) inspection, Multi tiered DMZs, solutions for SaaS security, growing sophistication and more close integration of Security Information and Event Management (SIEM) systems.

Installation of new FW in existing network is pretty complex task. If FW is configured liberally, the network traffic will pass without problems, but FW will not be significant obstacle for hacker. If FW is configured too restrictively, it blocks hacker's activity, but also slows down network traffic. It's important to configure the FW to permit the desired communication and to prevent the undesirable traffic in the same time. Without a complete view of all communication relationships, the integration of a FW in an existing network is far from easy. High end FW may work in analysis mode when it analyzes the relationships between devices in a network

during a freely specified learning stage. The FW records all data exchanges between network devices without any restrictions. As a result an administrator can detect desired or undesired communication relationships quickly and easily and create a custom configuration of the FW partly or fully automatically. It saves time and enables a functional and secure configuration without time losses and failures.

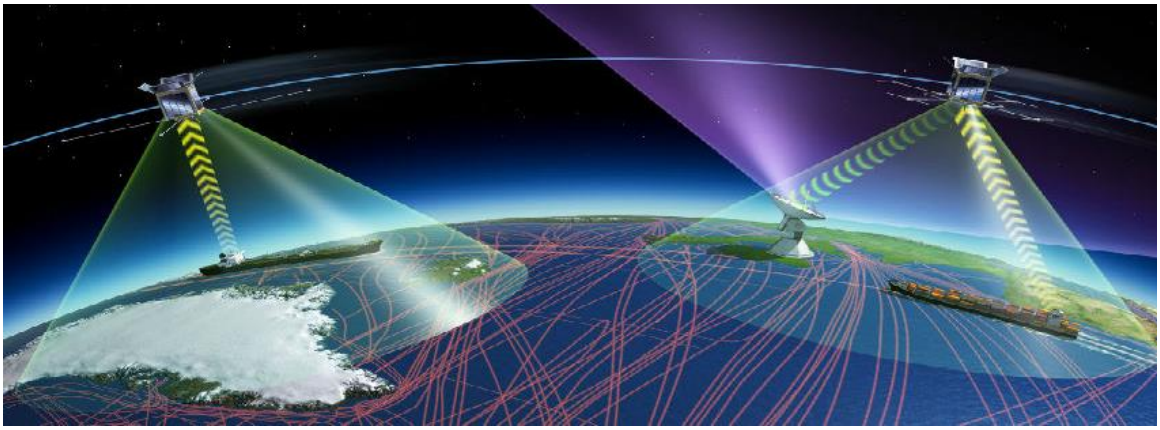
The use of multi level FW application model is very important aspect of the defence in depth. If an attacker has overcome an initial obstacle, additional FWs with more sophisticated rules can prevent further penetration. The use of multiple FWs requires additional management and configuration of these devices. Without a powerful software management tool this task is very time-consuming and may be additional reason for faults and errors. That's why it's very important that the FWs can be managed and monitored centrally by software network management tools. This approach will allow to implement standard configurations quickly on newly installed FWs, as well as making changes to the configuration. If all FWs must be configured individually, a lot of parameters must be manually entered on each FW. With software network management tool this task may be simultaneously, quickly and reliably performed for all FWs at once.

In maritime branch it's necessary to use satellite technologies to provide data exchange between the ship and land office. FW must be installed between ship's network and external network in general and Internet particularly. Most popular satellite technologies in maritime branch are Inmarsat and in last decade also VSAT.

Inmarsat provides Mobile Packet Data Service (MPDS), Integrated Service Digital Network (ISDN), Public Switched Telephone Network (PSTN) and low cost voice telephony. Real-time telemetry, Supervisory Control and Data Acquisition (SCADA) and messaging applications may be provided as well. Also 64 kbps ISDN connectivity, enabling high-speed data transfer and high quality voice, fax and video, a 3.1 kHz audio channel for the connection of analogue devices as well as low cost "Inmarsat mini M" voice telephony and fax and 128 kbps ISDN service are available.

Fig. 2 presents typical scheme of satellites application for data exchange between ship and land office.

Figure 2. Scheme of satellites application for data exchange between a ship and land office

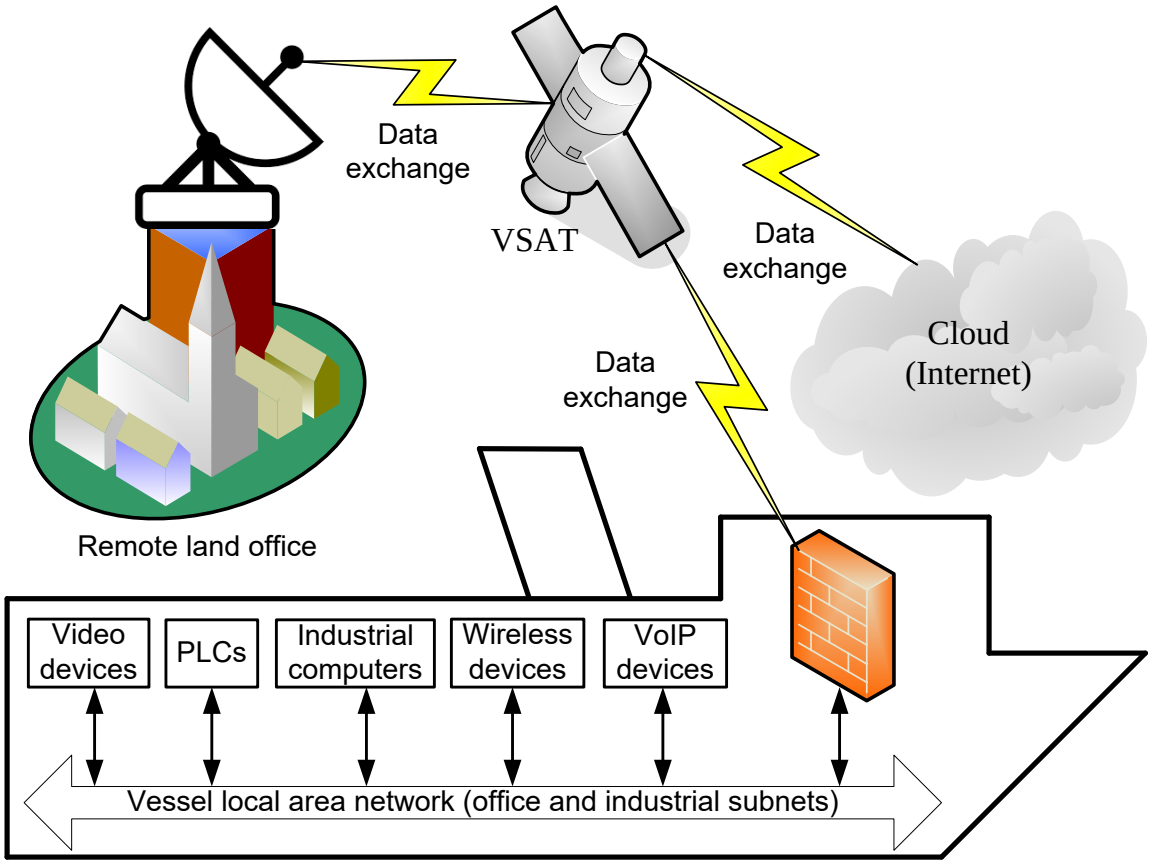


Much more modern VSAT based technologies provide multiple service options starting at 32 kbps, broadband, two-way SCADA data exchange through IP or serial interface for entire ship network. VSAT products family offers new embedded technologies including acceleration, built-in accelerated VPN, advanced QoS, high inbound bit rates, advanced encryption, improved access scheme and modulations resulting in maximum bandwidth efficiency and performance from satellite network.

Maritime operators realize VSAT possibilities by proposing higher throughput services. As a result installed number of equipment is actively growing. VSAT data rates in some segments increased from 10 Mbps in 2007 to 100 Mbps in 2013, largely driven by streaming video and bandwidth-intensive business applications. [Comsys 14]. On some ships a multi-band and multi-orbit VSAT service also provided. It worked with Intelsat, SES and Telesat satellite operators for the satellite coverage and delivers super-fast broadband service, peaked at 3.1 Gbps [15].

Fig. 3 presents scheme of data exchange between land office network (Internet) and computerized subsystems on board a ship (office and industrial networks) with satellites using.

Figure 3. Scheme of satellites application for data exchange between computerized subsystems on board a ship and land office with satellites using



In complex distributed structures (separate local area networks (LAN) in remote subdivisions or big complex campus network), among others in maritime branch, it makes sense installing of several FWs (Fig. 4) for each subdivision or workgroup as defence facility from internal attacks. Centralized FW is based on a perimeter defence model assuming attacks from outside a network. But this model fails if an attack comes from inside the network (users can connect to an internal network using wireless access, VPN tunnels, etc.). Traditional FWs typically can't effectively deal with such attacks, but a distributed FW adds one more defence layer. Also growing of internet access speeds and appearance of new complex protocols, that FWs must analyze, causes that stand alone FW may become congestion point. Distributed FWs help solve this problem by using processing power in different network points. A distributed FW is security software application, which protects the entire network and must be installed additionally to traditional FWs. Distributed FWs have following standard set of capabilities.

1. Centralized management and reporting: configuration with "push out" security policies.
2. Fine-Grained Access Control: standard FWs cannot readily accommodate without greatly increasing their complexity and processing requirements.
3. All FWs have the ability to set security policies to allow or deny access, depending on determined criteria. Distributed FWs usually also have features that guarantee the integrity of the policy during transfer.
4. Distributed FWs typically support “pull” and “push” distribution methods: pinging the central management server to check whether it’s in working conditions, then requesting its policies, and the last step is ensuring that the hosts always have updated policies at all times.

Fig. 4 presents hardware or distributed FW multiplicity application with data flows specification.

Figure 4. Multiple (distributed) firewalls implementation in complex distributed structure with variety of LANs

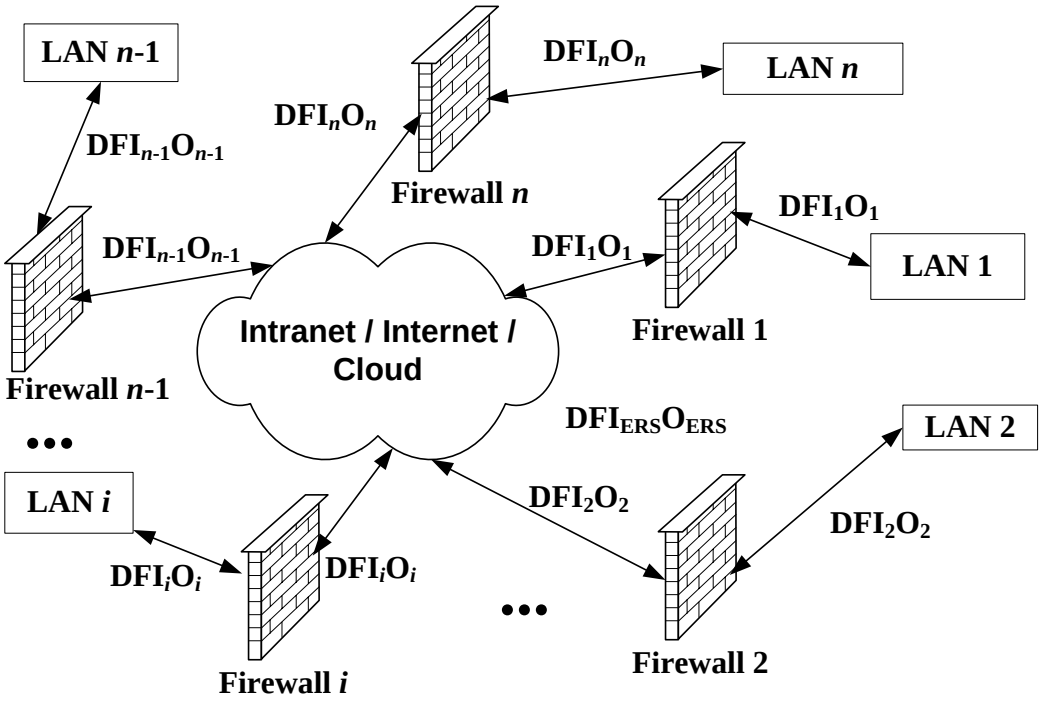


Fig. 4 contains following abbreviations: DFI – Data Flow Input, DFO – Data Flow Output.

Traditional physical and virtual FWs have started to hinder assurances of modular protection in modern network environments. Distributed FWs can work as additional fix for some new problems that arise when dealing with the challenges of maintaining a secure network in a business environment. Distributed FWs allow to maintain internal and external security with the theoretically limitless expansion properties.

Let (C_{mp}, C_{es}, C_{pn}, C_{tp}, C_{ss}) is vector of FW characteristics (any model; any manufacturer): C_{mp} is number of monitored ports, C_{es} is number of expansion slots, C_{pn} is maximum number of protected nodes, C_{tp} is maximum throughput (Gbit/s), C_{ss} is internal storage subsystem (GBytes). Then (C_{mpi}, C_{esi}, C_{pni}, C_{tpi}, C_{ssi}) is vector of FW characteristics for one of model (number i) of any manufacturer (quantity z of models in device line has to be

defined by manufacturer). Then (C_{mpil}, C_{esil}, C_{pnil}, C_{tpil}, C_{ssil}) is vector of FW characteristics for one of model (number *i*) of manufacturer number l (quantity *z* of models in device line has to be defined by manufacturer).

Let (P_{1k}, P_{2k}, …, P_{nk}, …, $P_{(z-1)k}$, P_{zk}) is vector of FW prices (manufacturer *k*, number of devices *z*). In the case when price factor is dominant and expenses for FW purchase are restricted, it's possible to choose some different models (more than 1) from device lines of different manufacturers (fig. 5). In this case will suppose that FW models of any manufacturer sorted by descending (model with the best characteristics will be placed on the top of device line, having number 1, but the price in this case will be maximum). Unfortunately, this particular approach, when expenses are restricted, is dominant in most cases. Very often it leads to wrong decision taking, discrepancy between FW characteristics and needs of concrete task at information system defense, and necessity of additional expenses, time wasting and specialists retraining.

In the general case volume of transferring data V_f and minimal demanded data transfer channel bandwidth B_f in network segment or Internet at ship information system cooperative exploitation are accordingly

$$V_{inpf} = \sum_{k=1}^{n} V_{\text{inp}k} \quad \textbf{(1)}$$

$$B_{inpf} = \sum_{k=1}^{n} B_{inpk} \quad \textbf{(2)}$$

$$V_{outf} = \sum_{k=1}^{n} V_{outk} \quad \textbf{(3)}$$

$$B_{outf} = \sum_{k=1}^{n} B_{outk} \quad \textbf{(4)}$$

where V_{inpk} – volume of data, transferring to ship network (information system) from *i*-number local or remote user; B_{inpk} – data transfer network bandwidth, demanded for data transferring from *i*-number user; V_{outk} – volume of data, transferring to ship network (information system) from *i*-number local or remote user; B_{outk} – data transfer network bandwidth, demanded for data transferring from *i*-number user.

From the technical point of view V_{inpk} is data volume, generated by control commands, and B_{inpk} is bandwidth, necessary for control commands transferring. V_{outk} and B_{outk}, generated by digital devices in ship network (information system), but it's necessary to take into account possible outgoing malicious traffic presence and detection of possible problems with FW settings.

Figure 5. Choosing of firewall characteristics
(price is point of departure, characteristics are in second order)

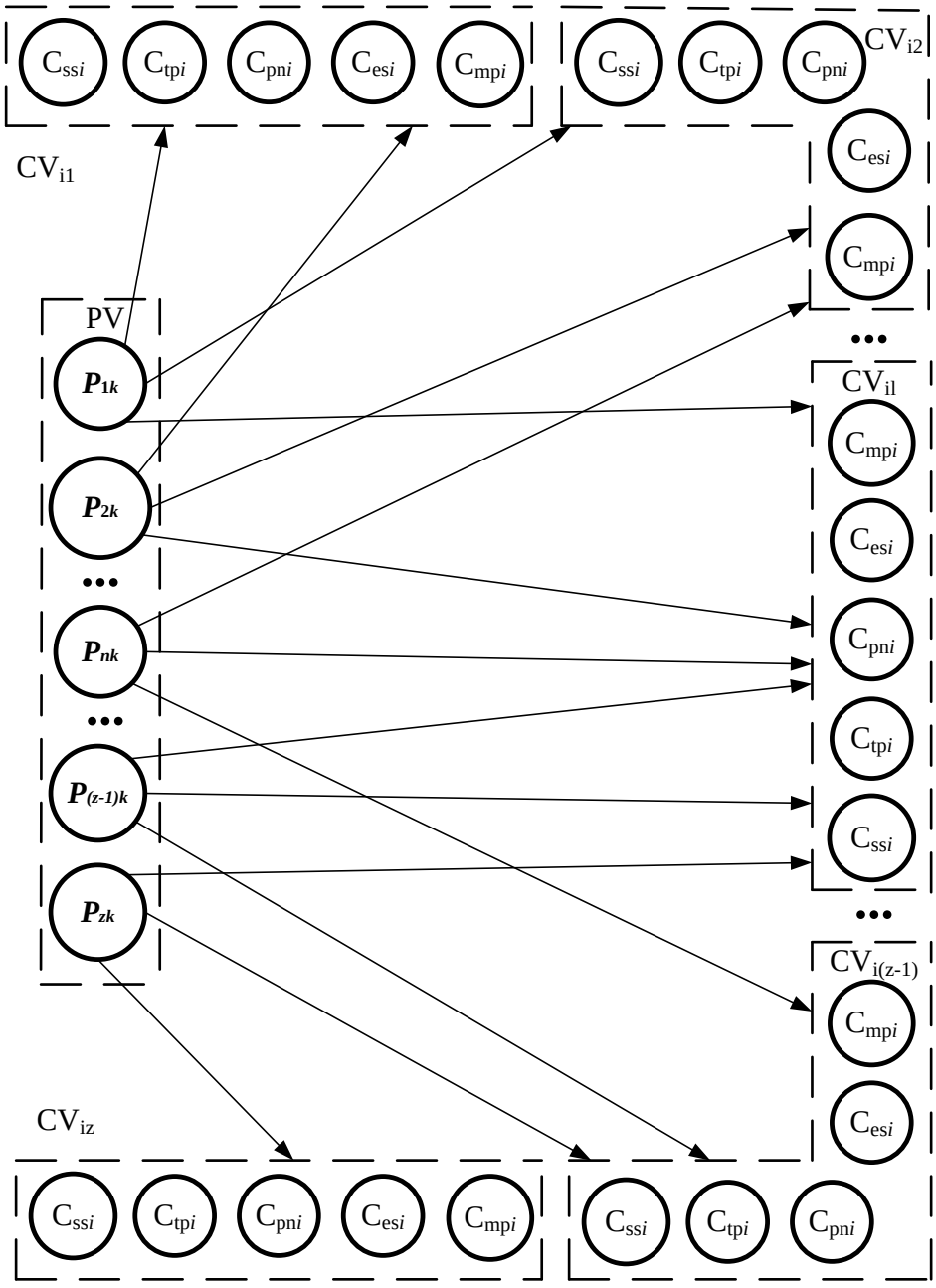


Fig. 5 contains following abbreviations: PV – Price Vector, CV – Characteristics Vector.

Situation is possible, when some same type devices transfer identical data volumes to local or cloud control computational system and create identical network segment or channel loading. In this case volume of transferring data V_f and minimal demanding network segment or Internet channel bandwidth B_f it's possible to count using following formulas:

$$V_f = \sum_{i=1}^{n} k_i V_i \quad \textbf{(5)}$$

$$B_f = \sum_{i=1}^{n} k_i B_i \quad \textbf{(6)}$$

where k_i – number of same type devices of *i*-type, which generate identical volume of data, transferring to local or cloud control computational system, creating similar network loading.

Let in the network structure there are *m* local digital devices, which transfer data to central control computational system (cloud). In this case volume of data V_{fc}, transferring to central control computational system and minimal demanding bandwidth B_{fc} of corresponding network segment or Internet channel are accordingly

$$V_{fc} = \sum_{k=1}^{m} V_{fk} \quad \textbf{(7)}$$

$$B_{fc} = \sum_{k=1}^{m} B_{fk} \quad \textbf{(8)}$$

where V_{fk} – volume of data, transferring to cloud central control computational system from local digital device number *k*;

B_{fk} – network bandwidth, demanding for data transfer from digital device number *k*.

Formulas (1) - (8) allow to calculate volumes of transferring data and necessary bandwidth between ship network and land office and to facilitate choosing of network equipment, firewall and model of cloud services taking into account performance, data transfer rate and cost aspects.

Implementation of one or more local data processing device in ship network (information system) to reduce expenses for cloud system model choosing taking into consideration following parameters: necessary processor(s) productivity, random access memory volume, data store volume and productivity and to minimize expenses for Internet channel rent. Local control computational system may be used if some users use the same network (cloud) service but simultaneously work in the same local network.

Possible also opposite situation, when it's necessary to choose concrete characteristics of FW and concrete manufacturer because of presence of already installed hardware, software, network equipment, compatibility problems, recommendations of equipment manufacturers, prepaid support service and so on.

3. CONCLUSION

Firewall role as a necessary central element in maritime branch cybersecurity providing is shown. Model on optimal firewalls characteristics choosing with taking into consideration price/productivity ratio is proposed. Mathematical expressions which allow to calculate volumes of transferring data and necessary bandwidth are proposed.

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WIRELESS SYSTEM FOR TEMPERATURE MONITORING IN A VOLCANIC AREA BY USING ZIGBEE TECHNOLOGY: INITIAL CONCEPTS AND PROJECT

Ramiro Sebastian VARGAS

PhD student Doctoral School on Material Sciences and Technologies, Obuda University, HUNGARY
E-mail: vargas.ramiro@phd.uni-obuda.hu

Lourdes RUIZ

PhD Student Doctoral School on Safety and Security Sciences, Obuda University, HUNGARY
E-mail: lourdes.ruiz@bgk.uni-obuda.hu

Maria Cristina Navas LEMA

Universidad de las Fuerzas Armadas ESPE, ECUADOR
E-mail: mcnavas@espe.edu.ec

Mustahsan SHUAIB

Miskolcs University, HUNGARY
E-mail: mustahsan.abbasi@gmail.com

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ABSTRACT

Volcanic areas in Ecuador are certainly a topic that concerns the population. National and international institutes have carried out constant monitoring to be aware of the volcanic activity. Thus, stationary monitoring equipment was installed along the volcanic belt. However, this control stations cannot really cover the whole surface. The following study describes the design of a wireless mobile equipment which constantly measures the temperature. The temperature is sent to the control station using ZigBee technology and reliable sensors. The half-duplex communication allows the user to manipulate the mobile system and observe the measured temperature in the same controller.

1. INTRODUCTION

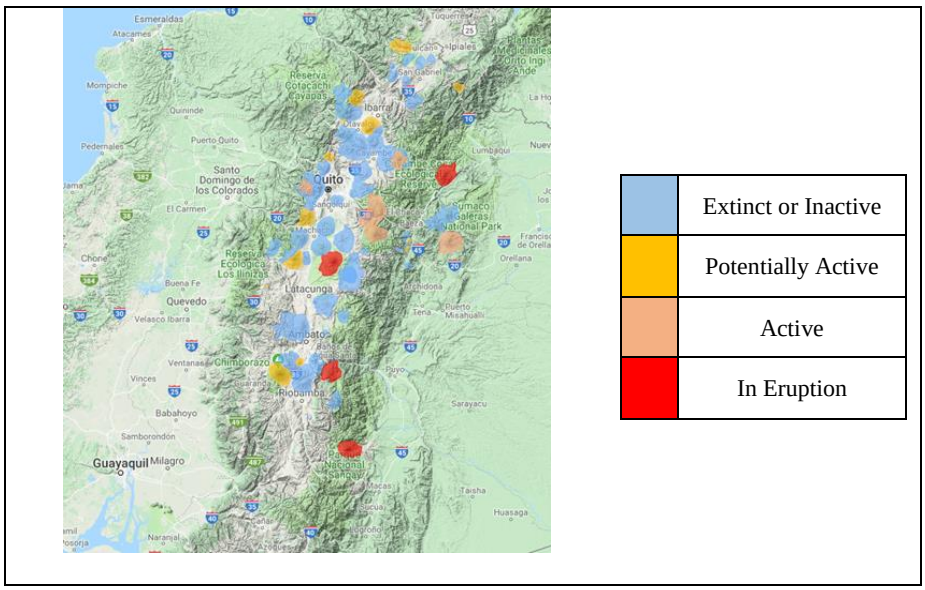
Ecuador is located in the Ring of Fire of the Pacific, which is comprised by a string of volcanoes and sites of seismic activity. Approximately 90% of the earthquakes take place in this area. Moreover, 75% of all the active volcanoes on Earth are situated in this ring. Ecuador harbors a large number of volcanoes (National Geographic, 2018). Volcanoes' classification comprised of three groups based on their eruption history. However, for the sake of practical application a fourth type is added for describing the volcanoes that have been in eruption over the last few decades.

1. Extinct or Inactive: the last eruption was more than 10000 years ago.

2. Potentially active: the last eruption was less than 10000 years ago.
3. Active: the last eruption was more than 500 years ago.
4. In eruption: had eruptive activity in 2011.

According to the Institute of Geophysics of Ecuador, it possesses 84 volcanoes, 27 are potentially active in the continental area and the Galapagos Islands (Instituto Geofisico Ecuador, 2018). Figure 1 shows the state of the volcanoes in the Ecuadorian continental area.

Figure 1. Volcano Activity classification in Ecuador continental area.



(Bernard & Andrade, 2011)

Active volcanoes are located nearby cities which imply a risk for the population and infrastructure. Recent eruptions of Guagua Pichincha, Tungurahua (1999), El Reventador (2002), La Cumbre, Fernandina (2005) and Cotopaxi (2015) clearly show the need for monitoring, designing and contingency plans (Aguilera & Toulkeridis, 2005).

Volcanic explosions not only adversely affect life on the ground but also cause serious problems in aircraft and flight operations by spreading volcanic ash and forming volcanic clouds. With the exponential growth of global population, the air traffic is growing as well; which means more dependence for moving goods around the globe. Luckily, along with all that progress, significant advancements also have been made in the field of volcanology. With the advent of the technology it has been possible to anticipate, assess and mitigate the potential volcanic hazard.

It is important to understand the distinctive concepts of 'prediction' and 'forecasting'. Prediction means a statement about a specific event that will take place within a given timeframe and is inevitable. On the other hand, forecasting denotes a probabilistic statement of a specific event to take place with certain likelihood. There are certain patterns that emerge before the explosion of volcanoes. Therefore, by recognizing and understanding those patterns an eruption and related earthquake forecast could be made.

There is a direct relationship between earthquakes (foreshocks) and the volcanic eruption. It has been noticed that earthquake frequency increases significantly before an eruption on a local level (Minakami, 1960; Klein, 1984; Rubin & Gillard, 1998; Christopher & Kilburn, 1998). However, (Jordan, et al., 2011) argued that reliable and accurate earthquake "prediction" is not reliable, except in some special circumstances. For example, a correct prediction was made when the eruption of Mount Helka in Iceland occurred in year 2000. Many

years before the main eruption, borehole strain meters were deployed within 15 kilometers around the Helka summit, to measure the strain variation. In 1991 an eruption took place, it was observed that magma was emerging from the chamber through a dyke at the depth of 6 kilometers, this observation was done by the aid of systematic strain variation and seismic data. About nine years later, in March 2000 same patterns were noticed again. Given the previous eruption records, an announcement was passed by the Meteorological Office to the Icelandic radio that eruption will start within 20 minutes and it started with the difference of 2 minutes only. Moreover, in perhaps the most famous case of volcanic eruption monitoring of Mount. St. Helens, accurate forecast was done by accurately forecasting the dome protrusion consequences (Swanson, et al., 1983).

The answer for the importance of monitoring lies in the presence of the 500 million people who live at vulnerable locations that can be affected by the eruptions (Newhall, 2000). Volcanism can also lead to the series of hazards that can be very complex for example extreme weathers, earthquakes and landslides that can all trigger together in the form of a chain reaction. The types of the volcanic hazards are mentioned in the Table 1.

Table 1. Hazard type and the related risks intensity, modified after.

Hazard	Threat to life	Risk to property	Aerial extent
Ash / pumice fall	Low	Depends on roof collapse	Varies but can spread over countries
Pyroclastic flow	Very high	Very high	Regional
Lahars /Flooding	High to moderate	High	Local/ Regional
Lava flows	Low	Very High	Local
Acid rain/ Dust	Low to moderate	Moderate	Local/ Regional

(Sparks & Aspinall, 2004)

There are about 10-20 small volcanic events happening every month around the globe that might pose a serious threat to the population and the local economy. However, the catastrophic event capable of disrupting the whole economy of the country can take place approximately every hundred years (Pyle, 1998).

Moreover, it is also necessary to understand the past behavior of a volcano with the aid of geological mapping and the rocks investigation. It is crucial to comprehend the eruption style whether it was explosive or non-explosive or it took place intermittently. Such studies can provide data for the long-term forecasts and can provide enough time to establish various zones based on the risk factor hence mitigating in advance by taking this factor in urban planning and moving existing population to the safer places.

In Ecuador the active volcanoes are monitored by different technologies including seismographs, barometers, GPS and different sensors. The type of instrumentation used in the volcano surveillance depends on the threat for the population living near the volcano [5]. The following study describes the design of a raw prototype of wireless equipment for temperature monitoring of volcanic areas using ZigBee technology.

2. METHODOLOGY

The design of the prototype was divided into two main stages for better understanding of the process:

2.1. Hardware Design

The hardware of this prototype consisted of a controller and a mobile device. A PIC (Peripheral Interface Controller) 16F628A was used as the controller, whereas a PIC 16F877A was used as the monitoring mobile device. The controller is comprised of four buttons and one 16x2 LCD (Liquid Crystal Display). Each button controls the mobile's movement direction: forward, backward, left and right. In addition, the temperature measured by the mobile is displayed in the controller. Hence, only digital inputs/outputs were needed for the controller. On the other hand, the mobile device was assembled with a linear temperature sensor LM35, two standard servo–motors and a LED (Light Emitting Diode) to assure its proper functioning. Thus, an analog input was required.

Before wiring each circuit, an electronic scheme was designed in ISIS Proteus 7.

Figure **2** and Figure 3 show the scheme of each device. Thereupon, both circuits where assembled in breadboards.

Figure 2. Mobile temperature monitoring scheme.

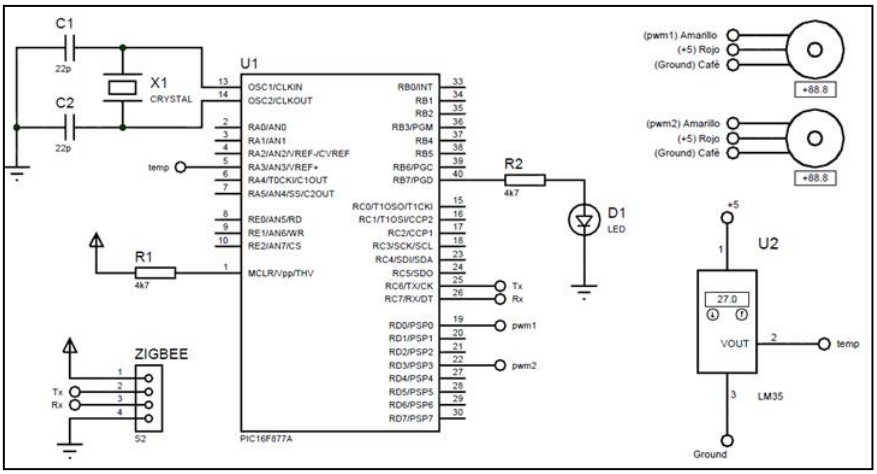
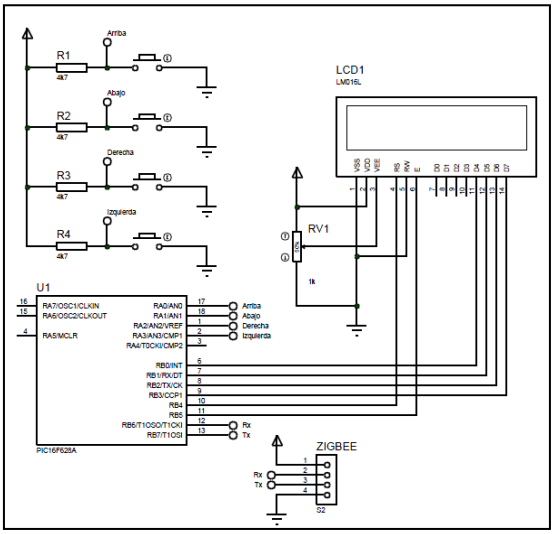


Figure 3. Controller scheme.



2.2. Network Setting

Since PIC microcontrollers were used, the communication protocol chosen was serial due to its facility to work with these devices. The physical interface was composed initially by four cables: reference voltage (+5V), ground (GND), Transmitter (Tx) and Receptor (Rx). Firstly, the communication was carried out using conventional copper wires. The controller sent only one data at a time to control the direction of the movement. Each movement instruction was considered as an independent function. Listing. 1, for instance, describes the text to be displayed in the LCD during the serial communication. Number 1 is sent as a character with a baud rate of 9600 [bit·s-1].

Listing. 1. Forward movement function - Controller.

```
dir_Forward:
LCDOUT $FE,$85,"Forward"
SEROUT portb.2,T9600,["1"]
LCDOUT $FE,$C4,"1"
```

However, the temperature sent from the mobile device was treated as a row of 4 data for a better resolution. Thus, the reception function had to save all four data into a row, convert all of them from ASCCII (American Standard Code for Information Interchange) to decimal numbers and then display the measured temperature.

The baud rate (bits per second) transmission selected for this case was 9600 after several experiments with lower baud rates. Another parameter to limit the baud rate is the characteristic of the wireless device. Once the half–duplex serial communication was synchronized, the wireless devices (ZigBee) were set to replace the copper wires.

Two ZigBee devices were used, both S2 series; one for the controller and one for the mobile device. The difference between them is the capability to work as a router and as a coordinator within a network depending on its configuration (Andersson & Thoren, 2005). For further purposes, the controller should be able to manage multiple mobile devices (mesh network).

3. RESULTS

Figure 4 and Figure 5 show the raw prototype of the controller and the mobile respectively. The communication distance reached up to 75 meters. The displayed temperature was as accurate as the temperature measured by conventional thermometers. However, since the mobile device was assembled with basic electronic components, its linear velocity was approximately 0.25 [m·s-1].

Figure 4. Controller (Prototype).

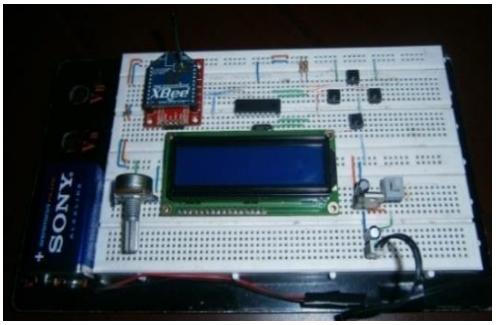
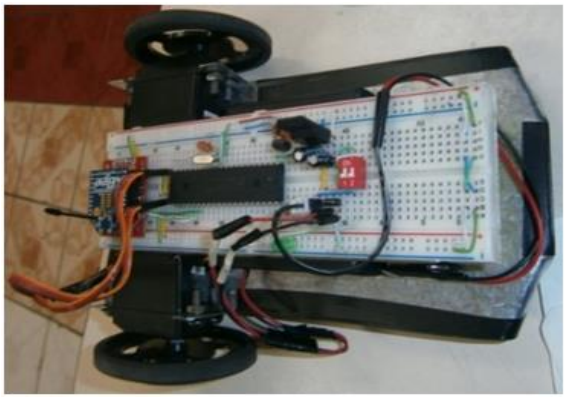


Figure 5. Mobile monitoring device (Prototype).



4. DISCUSSION

In electronic circuits there are mainly three components: power source, input and output instruments. In order to coordinate those electronic instruments, a programmable controller is usually needed. Once a device has been assembled to work efficiently, the developer could require to communicate with each device or establish a communication between them. Since a sensor is an electronic device which has to be embedded into a circuit, the options to electronically transmit its data are somehow limited. Depending on the network adaptor and the network protocol, the sensor's data could be transmitted via wireless signals or simply by using cables. Regarding wireless options, Bluetooth was highly popular before ZigBee technology appeared. One of the advantageous features of ZigBee is the capability to coordinate multiple nodes and then communicate with other coordinators to finally create a mesh network. Table 2 shows a comparison between some of most popular wireless interfaces. For this specific case of study, ZigBee was chosen due to its reasonable communication range, low cost and low power consumption.

Table 2. Comparison of wireless technology.

	ZigBee	Wi-Fi	Bluetooth
Max. speed per channel	250 kbps (2.4 GHz) 40 kbps (915 MHz)	11-300 Mbps	Max. 1 Mbps
Distance	10-75 m	100 m (indoor)	10m typical
Standard	IEEE 802.15.4	IEEE 802.11	IEEE 802.15.1
Adoption rate	Widely adopted	Extremely high	Extremely high
Unique value	Low cost, low power usage, high number of nodes	High speed mature standard	Ease of access, no configuration requirement, secure connection

(Sahoo, 2016)

Another remarkable characteristic of the proposed raw prototype is the facility to modify the hardware. Initially, a temperature measurement was effectively performed, but some other parameters can be sensed such as: humidity and vibration. By few changes in the hardware and software, the same device could read more than one variable at a time.

5. CONCLUSION

The fact that Ecuador is located in the Ring of Fire makes it extremely vulnerable to the earthquakes and volcanic hazards. Moreover, the presence of four volcanoes that have been in

eruption for the past few decades and their position just next to the population; contributes to a serious hazard. The human lives cannot be at risk. Hence, there is a need to adopt sophisticated and innovative monitoring techniques to sense the risk before it becomes a catastrophe. Although there have been successful 'forecasts' in the past but with the advancement in the technology, the accuracy can be further improved. Given the mobile nature of ZigBee, it can prove the best up to date technology that can actively monitor the surface temperature in a real-time, even in the areas that are not easily accessible. Furthermore, real-time temperature monitoring can give the clues about the upcoming events, subsequently that information can be delivered to the public that can lead to the safe evacuation of the population before any disaster. Hence ZigBee can prove to be a vital technology to gather data from an inaccessible location.

The raw prototype described above, can result in an important monitoring tool not just in Ecuador but throughout the Ring of Fire. The mobility and versatility of the features that can be added to the equipment can lead to a powerful tool for harsh environments. Moreover, the ZigBee technology utilized, enhances occupational safety by sending the data instead of requiring someone to collect it in the field.

As initially stated, the design described in this study is in its preliminary stages. For this reason, it needs to be updated and has the potential to acquire new features tailored to the monitoring needs. For instance, the servomotors implemented did not reach a required speed. The mobile device itself should cover a wide area. Thus, the mobile's speed should increase by replacing the current servo motors.

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ALGAE AND DIETARY DIETS[*]

Assist. Prof.Dr. Latife Ceyda İRKİN

Canakkale Onsekiz Mart University, School of Applied Sciences, Fisheries Technology, Canakkale, Turkey
E-mail: latifeirkin@gmail.com

Assoc. Prof. Dr. Özlem TONGUÇ YAYINTAŞ

Canakkale Onsekiz Mart University, School of Applied Sciences, Fisheries Technology, Canakkale, Turkey,
E-mail: ozlemyayintas@hotmail.com

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ABSTRACT

Algae involve several species of multicellular and macroscopic marine algae found in the coastal region between high to low tide in the sub-tidal region up to a depth where 0.01 % photosynthetic light is available. Based on their pigmentation, seaweeds were classified in to Chlorophyta (green algae), Phaeophyta (Brown algae) and Rhodophyta (Red algae). Algae are not classified as true plants. They lack an organized vascular system for absorbing nutrients. The root called the holdfast, the stem is the stripe and the leaf of the seaweed is the blade or frond. Like flowering plants, they are able to use chlorophyll to conduct the process of photosynthesis and create their own food for growth.

In marine ecosystems, macroalgae communities provide nutrition, reproduction, and an accommodating environment for other living organisms. Algae play a vital role in various aspects compared to other aquatic resources. Because of these properties, macroalgae are some of the most important organisms maintaining the ecosystem's stability. They are also excellent source of bioactive compounds such as carotenoids, dietary fibers, proteins, essential fatty acids, vitamins, minerals and important sources of medicines and fertilizers.

1. INTRODUCTION

Algae is one of the primitive life forms on Earth. They are simple water plants without roots, stems or leaves. There are primitive replication methods. The ecological role of algae is to provide oxygen as well as providing a basic step for the food chain.

Algae come in different sizes, shapes, growth forms and colors. They can be single and multicellular in salt and fresh water. They are named according to their color; Blue-green, green, red and brown algae. The colors are the result of various chloroplast pigments, including chlorophylls, carotenoids and phycobiliproteins. Algae contain chlorophyll to catch the sunlight needed to pass through the phytosynthesis.

[*] Bu makale, 27-29 Haziran 2018 tarihlerinde düzenlenen III. Doğunun Batısı Batının Doğusu Konferansı'nda sunulmuş aynı isimli bildirinin gözden geçirilmiş halidir.

Algae has been an important source of fertilizer, food and medicine since ancient times. The earliest record of using algae dates back to 2700 BC by Emperor Shen Nung (Kasimala et al., 2015). Human consumption of algae extends to the Aztec civilization in the 14th century. This type of *Spirulina* and *Chlorella*, commonly are used as a superfood supplements. The benefits of algae can play a role in prevention and treatment of diseases by various mechanisms, due to the high concentrations of minerals, vitamins, proteins and antioxidants.

People consume algae as healthy food that facilitates the elimination of heavy metals, radioactive elements, dioxins and PCBs. Algae promotes a healthy immune system, prevents thyroid disease, obesity, cancer metastases, cardiovascular diseases, diabetes, nervous system disorders, osteoporosis. Also they reduce chronic inflammation, inhibit viruses (including herpes and papilloma virus), and help regulate menstrual period.

Algae are divided into two major groups as prokaryotic (microalgae) and eukaryotic (macroalgae). Microalgae (blue-green algae, Cyanophyta) are unicellular planktonic algae, Macroalgae are according to their whips or pigmentations; Brown algae (Phaeophyta), Red algae (Rhodophyta), Green algae (Chlorophyta), Diatoms (Chrysophyta) and Flagelleta.

1.1.Brown Algae (Phaeophyta)

Phaeophyta is a protista branch, which constitutes a large part of multi-cell algae. They have chlorophyll a, c and fucoxanthine pigment. Unlike plants, brown algae store photosynthetic products not as starch, but as mannitol (manic acid alcohol), laminarin (a polysaccharide), algin (as a substance) and oil. On rocky beaches, they often live in cold and temperate waters. The number of brown algae living in tropical regions is small. In their life cycle, progeny is seen, followed by sexual and asexual reproduction. Large marine algae have distinct cell differentiation but do not carry any form of leaf, stem or body. The simplest species are in the form of branched yarns, whereas in the larger species the tallus have developed in the form of trunk and foliage and can develop in a very large size. About 1,500 species are known. They provide animals shelter for their food and eggs. They are also used in the food industry because they are rich in nutritional value.

1.2.Red Algae (Rhodophyta)

Red algae is the most advanced class of algae. They are usually filaments or leaf-shaped macro algae. This group are characterized by the red pigments. There are no differentiations in the form of leaves, roots and trunk. Algae body is wrapped with gelatinous substance. One of the most important features of red algae is that no cells, including sperm cells, carry whips.

Leaf-shaped tallus are found. By photosynthesis, they store carbohydrates in the form of fluoridean, a special starch. They may also develop in low intensity light. Unlike other algae, they can live in deeper regions. In some species, calcium carbonate is stored in cell walls. The reefs of these species, by cutting the waves, provide shelter for living creatures. Polymer-structured polymer gel, called "agar agar", is obtained from pectin-structured cell walls of them. There are also types used in the food and pharmaceutical industry.

1.3.Green algae (Chlorophyta)

The single-cell or multicell colony forming species are covering the sphere of plants. They contain chlorophyll a, b and various carotenoids (carotene, lutein, xanthophylls, pyrenoids). Chlorophyll is in green, making them look green. The cell wall consists of cellulose-containing polysaccharides in some forms. Sometimes they create "tallus" by showing partial variations. Multicellular cells do not have complex cell differentiation. The photosynthesis product stores carbohydrates in the form of starches and oils. More than 9,000 species are known. 90% of them are fresh water and 10% are in seas. They are widespread at the beginning

of spring, late summer and autumn season. They participate in lichen formation. As a result of the studies conducted, it is accepted that they are the ancestors of terrestrial plants.

1.4.Microalgae Blue-green algae (Cyanophyta)

Blue green algae, considered to be the first photosynthetic organisms of the earth and which have been around 3.5 billion years in the world, are the only prokaryotic group among the algae groups. Blue green algae, like other algae in aquatic life, take the first place in the food chain. These are living things that do not have a specific cell nucleus with a simple cell structure. Blue - green algae are as small as bacteria. They either live as individual cells or colonies. Due to their versatile metabolism, they can easily adapt to different environmental conditions. They are found in damp soils and in waters. There are no organelles and nuclei. They can do photosynthesis. When they overgrow, they reduce the oxygen of the water, cause turbidity and prevent the light from going into deep water. This can damage deep-water creatures. In addition to their biological role in ecosystem; various active ingredients, proteins, pigments, fatty acids, vitamins, antibiotics, polysaccharides and many other metabolites naturally accumulate. For this reason, this group provides economic contribution in many areas such as food, cosmetics and energy.

2. NUTRITIONAL VALUES OF ALGAE

160 species of marine algae (algae) commonly used in Far East countries, especially in China, Korea and Japan and consumed as food. Algae are very rich in carbohydrates, proteins, lipids, fatty acids, glycerol, natural pigments (beta-carotene, astaxanthin, xanthophylls, fikobilin) and amino acids (Durmaz et al., 2002). and bioactive substances (Chandini et al., 2008) with antibacterial, antifungal and antiviral properties such as polyphenols.

Algae are rich in protein, fat and water-soluble fiber, as well as minerals such as iron, magnesium, potassium and zinc, which are important in nutrition. Significantly they contain vitamins K and E, ribofilavine, thiamine, niacin. Algae's antioxidants, vitamins and pigments as well as are a rich source of polyunsaturated fatty acids (Gökpınar et al., 2001).

2.1.Vegetarian Omega-3 and DHA Source: Algae Oil

Algae oil, although not very appetizing, is actually a healthy source oil with an excellent fatty acid profile. It has more monounsaturated fatty acids than olive oil (13 grams per tablespoon compared to 9.9 grams for olive oil) and contains only 4% saturated fat compared to olive (14%), canola (7%) and coconut 7 (87%).

Algae oil contains high amounts of DHA (docosahexaenoic acid), one of the two omega-3 fatty acids we need for long-term physical and mental health.

Studies have shown that supplementation with DHA from algae oil reduces the level of triglycerides in people for heart health and is able to balance HDL and LDL cholesterol levels.

Although higher LDL was not preferred. Small and dense LDL particles predict higher risk of heart disease, while larger particles may be protective (Kasimala et al., 2015).

2.2.Benefits of Algae Oil to Our Health

Algae oil provides a healthy pregnancy. Omega fatty acid DHA is required for brain development during pregnancy.

Algae oil promotes eye health and prevents age-related macular degeneration (yellow spot disease). The retina has a high level of DHA, and the role of DHA is biophysical interactions on the cell membrane.

Algae oil has protective and supportive effects on cardiovascular health. It helps to regulate heart rate, reduces blood pressure and blood clot formation, prevents inflammation. This reduces the risk of heart attack and stroke. There are also positive effects on triglycerides and LDL cholesterol.

Algae oil has the ability to support brain power and memory. Omega-3 is the key to brain development and functions. This is another reason why algae oil is important for health. 60% of the brain is composed of fat and is supported to work with high levels of DHA. DHA helps the brain's communication cells and fights aging.

Algae oil has anti-inflammatory effect. Recent studies have shown that Omega-3 fatty acids can help to minimize symptoms of osteoarthritis and pain.

Studies show that one or two grams of algae oil supplementation per day can significantly increase levels of DHA and EPA in the blood. This dose can also help to reduce triglycerides, blood pressure and heart rate, increase HDL, control inflammation (Kasimala and Kasimala, 1983).

3. CONSUMED ALGAE AS FOOD

While 800 thousand tons of 28 million tons of seaweed produced in 43 countries are collected from nature, 94% is obtained through culture culture.

Among the edible algae, *Porphyra spp*. is one of the most famous species in Japan. Brown algae in, *Laminaria sp*. and *Underis sp*. are also used as other nutrients.

The nori used in sushi coating has been an important food in Japan for at least 1300 years. Nori rice sandwiches, boiled rice or noodles are used in flavoring and in different soups.

3.1.Foods Prepared with Algae

Nori (Purple Laver): It is an edible seaweed of *Porphyra* in the red algae branch. Most of *P. yezoensis* and *P. tenera* species are used. The product is made on the basis of the cutting and spreading process, which resembles paper manufacturing. Nori is often used as a winding material for sushi and onigiri. It is lightly fried immediately before use. Separately, when eaten alone, soy sauce is fried together with various spices. Similarly, there is also a food called Aonori prepared from green algae *Monostroma* and *Enteromorpha.*

Nori is rich in vitamin B complex, including vitamins B6 and B12. About one third of Nori is protein and one third is fiber. It contains high levels of iodine, carotene, vitamins A, C and calcium and iron. In Japan, 350,000 tons of production creates a market of over one billion dollars annually (https://www.livestrong.com/article/427504-list-of-foods-that-contain-algae/)

Ulva lactuca / Sea Lettuce: *Ulva lactuca* or Sea-Lettuce is a bright green leaf algae that is harvested in nutrient-rich waters for its delicious taste. The leaves can be flat, slender, round or oval. It can be consumed freshly as well as being mixed with pasta varieties, soups, salads, sauces and fish. When it is dried, it has been added to many recipes such as spices and flavor enhancers. It is high in protein and has nine basic amino acids. In addition, magnesium, potassium, calcium and essential vitamins (A, B, C and B12) are rich. It is rich in pigments with strong antioxidants (especially beta carotene and lutein). Beta carotene is an important antioxidant for our eye health. Lutein is an indispensable substance to repair the damage caused by UV rays of the skin. Sea lettuce contains 28% protein consisting of 9 essential amino acids, including Lysine, which is lacking in most vegetarian diets.

Wakame (*Undaria pinnatifida*): Wakame is an edible seaweed or kelp commonly used in Japanese, Korean and Chinese cuisines. It has a rare brown or dark green color. It contains fucoxanthine, a unique compound with rare medical and nutritional quality.

Wakame is a low-calorie low-fat food that contains fucoxanthine, a carotenoid with anti-inflammatory and anti-cancer effects. It is a rich source of carbohydrate and protein. The major component is water with some fiber and sugar. Most of these benefits come from the source of vitamins and minerals found in sensitive green leaves. Wakame is a good source of magnesium, calcium, iodine, iron, vitamins (A, C, E, K, D and B2) and folate. Antioxidants such as omega-3 fatty acids and lignans are also supported. In Japan, wakame is often used in soups and salads. It has a sweet taste and a bright appearance. This delicious seaweed continues to gain popularity especially in France and other countries of the World (https://www.livestrong.com/article/458681-algae-as-a-food-source-for-humans/).

Sea Spaghetti (Sea Spaghetti): Sea spaghetti seaweed (*Himanthalia elongata*) is one of the most easily recognized of all brown seaweeds. It spreads abundantly along the rocky, windy shores of the Atlantic Ocean. In autumn it develops from the disc (thallus) attached to rocks and coastline to long leaves. It grows very fast, the structure of thallus can be two to three meters long. It is usually dried or sold as pickles. In Northern Spain, the famous Spanish tortilla is used instead of green beans. Like all sea vegetables, it contains high levels of calcium, magnesium and potassium, rich in protein, fiber, vitamins and minerals. It can be eaten on its own or mixed with spaghetti. It can be cooked and added to soup.

3.2.**Benefits of Blue-Green Algae Tablets**

Blue-green algae are a living group of about 1,500 species known as rich protein sources. These plants contain carotenoids, vitamins, minerals and essential fatty acids. It has been harvested in Mexico and the Sahara Desert for a long time due to its medicinal properties.

Blue-green algae strengthens the immune system, cholesterol balancing, reduce viral infection and inhibite the effects of cancer. Blue-green algae contain antioxidants, including zeaxanthin, which can help strengthen the retina and prevent macular degeneration, which severely disrupts or destroys vision. *Spirulina* can also help to prevent the development of kidney stones caused by chemicals called oxalate (https://www.webmd.com/vitamins-supplements).

Both *Chlorella* and *Spirulina* have positive effects in lowering serum lipid levels. Also *Chlorella* and *Spirulina* have been studied for benefits of diabetic patients. According to a investigation in 2009 diabetic rats fed with *Chlorella* proved to have lower fasting glucose levels than non-fed rats.

Although *Spirulina* represents only a few species of most blue-green algae species, it is the most commonly used name for identifying edible blue-green algal groups. Widely used as 500 or 750 mg tablets. The daily dose of blue-green algae is 2000-3000 mg (http://www.businessinsider.com/algae-is-the-superfood-of-the-future-2014-6).

4. CONCLUSION

What is the most important live species in the world? When this question is asked, most of us give the answer uz human “without thinking. It is very natural that we give this answer as a member of the human species.

Algae, which continue their lives by photosynthesis, are also the reason why other living things can do photosynthesis according to the endosymbiosis theory. These species, which reproduce in oceans and stagnant waters, provide oxygen to the atmosphere by photosynthesis during the day; at night they simply break down the nutrients they produce using oxygen, which is far less than they produce.

Algae, which we describe in the oxygen cycle and in ecological relations, are also used in other fields for the benefit of humanity. As mentioned in our previous study, algae can be used as an alternative in energy production.

They can also be used as fertilizers. Especially in Far Eastern cuisine, it is put into meals. In addition, their use is also possible to control the excessive growth of some species (https://gaiadergi.com/hayatimizi-alglere-borcluyuz/).

Algae with their enormous contribution to the atmosphere of the world, serves to enable us to reproduce the vitality and to create today's species for cosmetics industry and energy sector in many areas.

If one day you are asked the question that ‘What is the most important species in the world?’ we should not forget these species we owe our existence.

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