Smart Vessel Monitoring System.

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Dissertation submitted to the Faculty of Information Technology, University of Moratuwa, Sri Lanka for the partial fulfillment of the requirements of Master of Science in Information Technology.

April 2015

Declaration

I declare that this dissertation is my own work and has not been submitted in any form for another degree or diploma at any university or other institute of tertiary education. Information derived from the published or unpublished work of others has been acknowledged in the text and a list of references is given.

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Date:

Dedication

To my parents…

With love and gratitude

Acknowledgement

I am heartily thankful to my supervisor, Mr. M.F.M. Firdhous for his supervision, advice and guidance from very early stage of this work till the last level as well as providing encouragements and support in various ways which enabled me to develop an understanding of this project.

I am grateful to all of my lecturers and teachers for sharing their invaluable knowledge, experience and providing advice to improve the quality of my life.

And of course, I need to thank my parents. Their unconditional love and support have helped me through some very difficult times. I did my best to give them a reason to be proud.

Lastly, I offer my regards and blessings to all of those who supported me in any respect during the completion of the project.

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April, 2015

Abstract

Fish and fishery product sector plays an important role in Sri Lanka's social and economic life. Deep sea fishing is the main occupation of over two hundred thousands of families in coastal belt. Seafood export sector has a significant scope to uplift their living standards by creating a good market demand for Sri Lankan fishery products.

As the main buyer of Sri Lankan fish products, European Union enforced restrictions over Sri Lankan fishery products by demanding assurance against illegal fishing. Even though the Department of Fisheries and Aquatic Resources of Sri Lanka laid a strong foundation for a managed and controlled fishery, most of the effort fell apart due to absence of electronic vessel monitoring system. Projects initiated to introduce commercial vessel monitoring systems failed due to unbearable cost and no localization to support literacy level of Sri Lankan fishermen.

This project researched on introducing an electronic vessel monitoring system to eliminate illegal fishing and maintain higher sustainability rate of marine lives while providing evidences for legal and controlled fishery in Sri Lanka. To fulfill the main objective as low cost and localized solution, the design was aimed to introduce a vessel monitoring system as an application which converts fisherman's mobile phone into a vessel monitoring system by utilizing common features of smartphones such as GPS receiver, mobile data access, internal storage and Unicode compatibilities. Going beyond the vessel monitoring system, design was embedded E-Logbook as a separate section to records fish catch details, to be used as a good source of information which helps to maintain higher sustainability rate of marine lives by identifying feeding and breeding grounds.

Administration console facilitates harbor officers to record fishing trip details while the monitoring console shows continuous vessel's positions to overlook the trip route. Systems executes a rule based verification at the end of each fishing trip to ensure the legality of its catch and suitability of exporting to European market. System certifies the catch when the vessel have sailed only in legal zone and the catch satisfied commercial fishing regulation. Harbor officers do not release the harvest without catch certificate. That gives a good assurance of Sri Lanka compliance with international trade regulations and marine policies for sustainable fishery.

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Chapter 1

Introduction

1.1 Introduction

This research focuses on an unsolved problem in Sri Lankan deep sea fishery industry while introducing a solution with the use of modern computer technologies. Respective sections will draw the attention from problem to the solution. The introduction section begins with a brief description about background and motivation and highlights the aim and objectives of the work. Brief description about proposed solution comes next. Latter part of this chapter describes how the document has been organized for the convenience of the reader.

1.2 Background and Motivation

Fish and fishery product sector plays an important role in Sri Lanka's social and economic life. Fishing in marine waters is the main occupation of over two hundred thousands of families in coastal area [1, 2]. Fish export sector has a significant scope to uplift their living standards and increases the level of contribution to foreign exchange by creating a good market demand for Sri Lanka's fishery products in world's famous fish markets in Europe and Japan.

According to annual report of Department of Fisheries and Aquatic Resources (DFAR), total fish and fishery product exports in 2013 was 25,000 metric tons, which was roughly 4 percent of its total production worth $206 million and it was accounted as 2.5 percent of total exports of Sri Lanka [2]. Top ranked fish markets in European Union (EU) countries are the main target of Sri Lankan fish exporting industry. More than 65 percent of its total fish exports is going to EU countries where only 30 percent send to Tokyo fish market. [7] 36 large scale fish processing plants out of 38 registered under DFAR have been approved as standard and hygienic processing plants by the EU's trade commission and certified that their products are legal and safe for human consumption. According to DFAR, their daily fish export to EU is roughly 70 metric tons.

As a result of influence made by Food and Agriculture Organization (FAO) and National oceanic and atmosphere administration (NOAA) of United Nation (UN) over

sustainable fishery, powerful countries laid the foundation to implement controls to save inland and marine lives for the next generation [9, 12, 13]. Sustainable fishery is one that is harvested at a sustainable rate where the fish population does not decline over time because of fishing practices. Sustainability in fisheries combines theoretical disciplines with practical strategies. Violation of marine rules and regulation make their harvest illegal [11].

In November 2012 European Commission (EC) was about to ban Sri Lankan fish products in EU claiming that Sri Lankan fishermen were engaged in illegal fishing in international waters. Further EU stated there were repeated instances of poaching by Sri Lankan fishermen and the government had failed to address this issue [7, 8]. EC said that they were not in a position to accept illegal fish from Sri Lankan and be a part of a marine criminal [15, 16]. EC strongly recommended to provide net to plate traceability information which confirm Sri Lankan fish products are legal for human consumption [13]. First attempt by Britain to blacklist Sri Lanka's fish exports to the European markets was averted after the government made a pledge to comply with international industrial regulations and other standards at 16th session of the Indian Ocean Tuna Commission (IOTC) in Korea [19, 20]. Sri Lanka was warned with "Yellow Card" and EU was agreed a relief period until end of 2014 to comply international regulations after the assurance given by the government including installing Vessel Monitoring System (VMS) for each deep sea vessel [7]. Countries who claim well developed fishery industry use VMS to certify that they are not engaged in illegal fishing activities by crossing borders in international waters.

The first phase of the project to introduce VMS was failed due to unbearable cost and incapability of localization. According to the Minister of fisheries and aquaculture resources there were around 3,000 boat and estimated cost was nearly US$ 5,000 per boat and the design of such systems did not match the competency level of Sri Lankan fisherman [18]. Also DFAR realized that introducing VMS would not solve the entire problem and effective and reliable system that interconnect 24 fisheries harbors with DFAR, standardization of documentation, and high availability of necessary information for IOTC, EC and for fish exporters also mandatory to continue fish exports to EU. Even though several practices have been taken place by the Sri Lankan government, there is no a single way implemented to monitor and control vessels fly its flag. That proves the national authorities does not know where the Sri Lanka vessels

fishing and what they catch. Obviously there is no guarantee that Sri Lankan fishing boats land only legal fish. As Sri Lanka incompetent to address the issue, there is a high possibility of labelling Sri Lanka as country of illegal fish by EC and other nations and loosing foreign income worth $206 million.

1.3 The Research Aim and Objectives

1.3.1 Aim

This project aims to introduce a solution which eliminates illegal fishing and leads to a responsible fishery in Sri Lanka.

1.3.2 Objectives

- Introduce a cost effective vessels monitoring system with native language support.
- Introduce on-board catch recording system. (Logbook)
- Introduce a standard way of certifying the harvest against illegal fishing at harbor on arrival. (Check trip routes against marine borders, verify fish catch against commercial fishing restrictions)
- Introduce fishing quota system to maintain higher sustainability rate of marine lives.
- Introduce a system that exporters get the details of availability of legal fish at each harbor.
- Introduce a system that DFAR, IOTC and EU can get the details of each trip, vessel details, harvest, etc.
- Maintain high reliability and comfortability of the system.

1.3.3 Scope

- Scope of this project includes introduction of vessel monitoring system for deep sea fishing vessel in Sri Lanka.

1.3.4 Assumptions

- Fishermen bear the cost of a smart device suitable for vessel monitoring system.
- Fundamental requirements such as whether proof environment, power supply and physical security can be arranged for on-board operation.
- Vessel monitoring system can receive GPS data during deep sea operation.
- Vessel equipped with a crane scale which has serial or Bluetooth communication interface.

- Harbors covered with mobile data services.
- Basic requirements to implement administration and monitoring systems can be arranged.
- Users of the system have the basic knowledge of operating smartphones and personal computers.

1.3.5 Limitations

- Real time vessel monitoring is not possible as satellite data communication does not include in project scope.
- Portable system could be tampered with.
- Single point of failures can be occurred.

1.4 The proposed Solution

Hence the project talks about fishing vessels operate in deep sea, the project is challengeable. That because the systems has to monitor vessels operate over 200nmi (370Km) from coastal line without physical restriction and people at harbor office to make decision over unseen behaviors. Other challenge is how to introduce a low cost system that can be handled by ordinary fisherman and how to make them interesting to follow the system.

Obviously the proposed solution is a combination of hardware and software components operates in unsighted sites. Core area of the project is to introduce a reliable on-board data capturing mechanism and verify them against marine border crossing and introduce a way that fishing to be done below the sustainability rate.

Geo fencing using GPS positions is the only solution found during the research phase that can used to address marine boundary problem. As the outcome of research carried out to find suitable GPS receiver, we found that inbuilt GPS receiver of smart mobile phones can be used since vessel at sea has no obstacle to find GPS sat. That created a new path to see the possibility of introducing vessel monitoring system as a smart phone application.

Hence fisherman does not need additional investment and familiarity, project decided to implement vessel monitoring system as a mobile application using inbuilt GPS receiver, internal storage and mobile data network to communicate with land stations. VMS basically records vessel's geo position with given intervals. Satellite data

connection to be provided to application when and if online communication to be established when the vessel in middle of the sea. Otherwise application records all data in internal storage until it back to mobile data network. Application provides necessary information to decide whether it has engaged fishing in illegal zones. The fisherman is the only user of VMS application. It does not need human interaction ones properly started. E-Logbook is another concept that is to be used in terms of recording fish catch with geo positions. That comes as a part of the VMS where fisherman has to record his fish catch on-board. Crane scale with Bluetooth interface can be linked directly to system to make their life easier. That is all what on-board system does.

Solution has a desktop client and a web client system in land side. Desktop client has been designing for fishery harbor officers to maintain records, monitor vessels and issuing authorization documents considering trip routes. It has all the necessary features to deal with mobile application. For example harbor officer should initiate the trip before the skipper starts his mobile application. Mobile application will start processing only if it find relevant information entered by harbor officers. The web client is another part of the solution designed for fish exporter to keep in touch with vessels. Exporters will get the details of fish landing beforehand and that will help them to plan their processing schedule. Fishermen will be much more benefited with this feature because exporters will be waiting until they landed. This gives an indirect motivation for fishermen to use this system and sell their catch at a good rate on arrival.

The solution runs two server at the backend. Database server hosts a relational database holds all records. The web server hosts the web client application and also act as the intermediate layer in communication between mobile application and database server.

As an additional feature, on-board catch records can be further used to identify feeding and breeding grounds and that will open a new path for predicting fishing grounds.

The solution required a database server to host relational database, a web hosting server with scripting enabled, smart phone which has built-in GPS receiver, internal memory with 100MB free and Bluetooth adapter. Also a suitable scale with Bluetooth interface can be used for fish weighing. Power supply for smart phone and scale should be supplied by using on-board 12V DC battery power or 230V AC generator power.

1.5 Outline of the Dissertation

Chapter 2, titled as "Issues in stopping IUU fishing in Sri Lanka" has critical and organized evaluation of IUU fishing in the world. Chapter highlights the impact of IUU fishing on commercial restrictions for Sri Lanka. Review of set of work done by other countries discussed in detail. Through this section found set of limitations on available solution falsifying implementation in Sri Lanka and identified high cost and no localization support as main issues.

Chapter 3, titled as "Technology Adapted" discuss technologies such as Global Positioning System, Mobile application development, Web application development, Desktop application development, etc. relevance to the solution introducing low cost and localized vessel monitoring system.

Chapter 4, titled as "Smart Vessel Monitoring System" describe how said technologies introduce new approach to solve the problem. Further this section explain how the solution covers different people in different operation environments.

Chapter 5, titled as "Design of Proposed System" describe the design of all components of the system and their integration.

Chapter 6, titled as "System Implementation" describe the implementation phase of the desired solution with the use of modern software application development technique

Chapter 7, titled as "Evaluation of Proposed System" describe the evaluation of proposed system using three test cases. Three trial trips have been conducted to get the actual inputs to the system and evaluate based on set objectives. Evaluation has proven that solution has reached desired objectives.

Chapter 8, titled as "Conclusion and Further work." Conclude the work done in this project. Experimental results in Chapter 7 used to prove the solution have met desired objectives and conclude that solution is successful.

1.6 Summary

Beginning of this chapter described the background and motivation of the problem. Aim and objectives of the project were highlighted next. Description of proposed solution gives a brief idea about the end product of the project. Latter part described how the document has been organized and what each chapter describe.

Chapter 2

Issues in stopping IUU fishing in Sri Lanka

2.1 Introduction

This chapter broadly discusses what IUU fishing is, impact of IUU fishing, approaches by other countries to stop IUU and why Sri Lanka cannot stop it. First section of this chapter describes the background of Sri Lankan fishery industry and fish export sector. Second section describes what IUU fishing is and regulations set by law to eliminate IUU fishing from the world. Other respective sections describe different approaches by Australia, Taiwan, Maldives and Sri Lanka to stop IUU. Next section describes the drawback of current Sri Lanka system and highlights the needs of a vessel monitoring system. Immediate next section describes features of commercially available vessel monitoring systems and final section discusses the unsuitability of such systems for Sri Lankan fisheries industry.

2.2 Background of Sri Lankan marine fishery

The fisheries sector plays an indispensable role in the economy of Sri Lanka contributing around 1.2% to the Gross domestic production (GDP). Fish products are an important source of animal protein, providing around 70% of the animal protein consumed in the country (Food Balance Sheet, Department of Census and Statistics). The sector provides direct and indirect employment to around 650,000 people and is directly linked with the lives of approximately 50% of the population who resides in the coastal belt. Fisheries sector contribution to the total export earnings of the country is around 2.5% [1, 2, 30]. The fisheries sector has a significant scope for increasing the contribution to the national economy, exploiting the huge untapped potential. Fishing industry in the Northern and Eastern provinces, which was hampered to a greater extent during the past two decades owing to the ethnic conflict is expected to revive with the dawn of peace. The Northern and Eastern provinces which accounts for around 60% of the coastline of the island have a huge unexploited potential [30]. Today Sri Lanka's marine fisheries resource base has a total extent of 538,500Km^2 including territorial sea of 21,500 Km^2, continental shelf area of 31,000 Km^2 and Exclusive Economic Zone (EEZ) of 517,000 Km^2. (Sea Appendix A for Sri Lankan maritime zones)

DFAR operates under the preview of Ministry of Fisheries and Aquatic Resource development which mandates Management, Development and Conservation of the Fisheries and Aquatic Resources of Sri Lanka. With the introduction of Act-02 in 1996 [3], department has put a strong step ahead by declaring international conventions and regulations for fish and fishery product exports. With the existence of Indian Ocean Tuna Commission (IOTC) in 1996 as an intergovernmental organization responsible for the management of Tuna like species in the Indian Ocean, 31 countries including Sri Lanka had laid their foundation to introduce tuna based fishery products in worlds' famous fish markets [4, 5].

Due to insufficient knowledge and lack of technology in deep sea fishing, fish exporting was not that much successful until 2010 in Sri Lanka. With the aid of collaboration between Japan, Indonesia and Australia, the DFAR launched a project to introduce long line fishing mechanism instead of traditional nets in deep sea [2]. The Sri Lankan government allocated billions of rupees to purchase multiday fishing boats which has facilities to handle tuna and other large fish species onboard. [1, 2, 6] During last ten years, 3,000 multi day boats have been registered, 24 fishery harbors, 95 ice plants, 48 boat manufacturing yards and 38 fish processing plants have been opened. This figures provide evidence that Sri Lanka is in a rapid boost in fish and fishery product industry by increasing the contribution to GDP.

Sri Lankan seafood companies exported over 25,000 Mt of seafood products worth US$ 206 million, equivalent to almost 4% of Sri Lanka's total marine and coastal fish landings in 2013 [2]. On board gutted, gilled and chilled Yellowfin Tuna *(Thunnus albacares)* and Bigeye Tuna *(Thunnus obesus)* are the principal varieties of finfish exported by Sri Lankan as whole fish and other product including vacuum packed tuna loins, toppings, saku blocks, steaks, belly and cubes. Taste and high quality of Sri Lankan fishery products won world riches fish markets in member countries of EU, member countries of the North American Free Trade Agreement (NAFTA) and the famous Tokyo fish market in Japan. Notably as the second biggest fish exporter, Sri Lanka has exported Tuna and Swordfish *(Xiphias gladius)* products worth US$ 100 million to EU in 2013. It was nearly 50% of total fish exports in Sri Lanka in 2013 [2].

2.3 Illegal, Unreported and Unregulated (IUU) fishing.

Fisheries provide an important source of food, employment and income for people throughout the world. Millions of people depend upon fish for their livelihood. If there is to be enough fish for current and future generations, everyone involved in fishing must help conserve and manage the world's fisheries.

According to Food and Agriculture Organization of United Nations (FAO) there is no clear and generally accepted definitions of fisheries management. [21, 22]However, the working definition used by the FAO is "The integrated process of information gathering, analysis, planning, consultation, decision-making, allocation of resources and formulation and implementation, with enforcement as necessary, of regulations or rules which govern fisheries activities in order to ensure the continued productivity of the resources and the accomplishment of other fisheries objectives".

Fisheries have been strictly managed in some countries for hundreds of years. For example, New Zealand had prohibition against over fishing than they could be eaten for about 700 years [23]. The idea of governmental resource based fisheries management is first developed in North Europe fisheries after over fishing issues came into discussion. In terms of protecting the sea, the fishing banks were divided into areas belonging to the nearest fishing base on land and further subdivided into fields where the boats were allowed to fish. The allocation of the fishing fields was in the hands of local governing committees. [24, 25]According to the FAO, fisheries management in marine waters belongs to a country (within 200 nautical miles (370Km) from coastal line) should be based on objectives set by the local authority. Typical objectives are,

- Maximize sustainable yield.
- Secure and increase employment.
- Secure production and food supplies.
- Increase export income.

In order to regulate fishery in international waters, FAO laid the foundation in 1995 for international marine rules and regulations and publish "Law of the sea" which allocated rights and responsibilities for resource management to individual countries [11]. With the sustainability issues in mind, the term illegal, unreported and unregulated (IUU) fishing has merged to describe wide range of irresponsible activities in fishery in 2001. Illegal fishing take place where vessels operate in violation of lows of a fishery

regulated by national authorities, regional fisheries management organizations and international regulations. Unreported fishing is fishing that has been unreported or misreported to the relevant national authority or regional authority, in contravention of applicable laws and regulations. Unregulated fishing generally refers to fishing by vessels without nationality, or vessels flying the flag of a country not party to the regional authority governing that fishing area or species on the high seas. Responsibilities to maintain the sustainability of marine fisheries have been categorized under three country types by FAO of the UN as Flag countries, coastal countries and port countries [10, 11].

Flag countries are the countries that register fishing vessels and authorize vessels to fly their flags in the sea. They have the primary responsibility to control the fishing activities of their vessels. Before a country allows a vessel to be released and allows to fly country's flag, country should make sure it has the ability to control fishing activities of the vessel and the vessel satisfy the international and regional regulation of marine fishing. For instance method of fishing such as nets, lines, rods, baits, traps and fishing gears used such as hook, line, sinkers are highly important and should comply the regulations. Furthermore, the flag country should maintain records of physical characteristics and authorization to fish of its vessels. For example physical characteristics include Name, Registration number, port registered, length, weight, engine type, engine power, etc. and authorization information include what species can be caught, what gear can be used and where and when the vessel can operate. More especially flag country must have a way of knowing where its vessels being operated and what each of them catching.

Coastal countries should keep track of authorized vessels hold international flags operating in the local sea area and must have a control mechanism implemented to keep track of their positions and what they catch from local zone.

IUU fishers eventually get their catch to port for landing or transhipment. Some countries have begun to limit and regulate access to their ports to control IUU fishing. Countries who stand against IUU deny access to its ports by foreign vessels which operate under international flags. As the key point of controlling IUU fishing, port has to play a significant role in certifying the harvest of each vessels as legal and safe. For instance each fish piece should be certified as legal before entering to the country or

before any transshipment take place. Fishing method used and fishing gears used to be certified as legal and records of vessel movement to be certified to prove that vessels had not been engaged in illegal fishing outside the authorized fishing area. Violation of fishing rules to be informed to the relevant flag country for necessary action is also a responsibility of the relevant port authority.

2.4 Approaches by other countries against IUU

2.4.1 How Australian Fisheries Management Authority work against IUU

The Australian Fisheries Management Authority (AFMA) is the Australian Government agency responsible for the efficient management and sustainable use of Commonwealth fish resources on behalf of the Australian community. The AFMA ensures that fishing is conducted in a sustainable way to provide the benefits such as healthy seafood and employment, while also making sure that there will be fish around for future generations to enjoy. AFMA looks after commercial fisheries from 3 nautical miles out to the extent of the Australian Fishing Zone (AFZ) and surveillance system in practice to avoid vessels entering to AFZ with international flags [25, 26].

According to the annual report of AFMA 2013, there are about 11,500 medium and large vessels registered under AFMA for offshore fishing [27]. During the registration process AFMA allocate a unique registration number for identification and AFMA install a VMS system to monitor its movements and record its harvest on time to eliminate IUU fishing in Australia.

With the collaboration of Australian government, Satellite Information Technology Pty Ltd in Australia has installed majority of VMS called CLS LEO which provides global position of vessels and electronic logbook. CLS's basic solution consist of three parts, LEO mobile transceiver, control box and minicomputer. LEO transceiver receives GPS signals from global positioning satellite in regular intervals and transmit to CLS's earth station through Iridium and Inmarsat satellite networks. AFMA has been facilitated monitor its vessel through vessel monitoring console called "THEMIS". THEMIS is a web based management tool displays VMS reports from information received from satellite providers. It provides real time vessel monitoring, geo-fencing, alert monitoring including zone management. THEMIS provides alerts to AFMA when its vessels sailing out from its authorized zone. Petrol vessels have been engaged by Australian government to bring such vessels back to their zone.

CLS has installed a minicomputer in each offshore fishing vessel connected to LEO transceiver to send catch details of the vessel to AFMA. A person onboard enters details (Fish species, weight) in minicomputer and this information send to THEMIS along with Latitude and Longitude of where it got caught. At the end of the trip AFMA issues a report confirming the harvest against IUU based on position and logbook information [28]. AFMA is capable of providing traceability information up to the sea position of the fish at time of fishing to its consumers. With the help of VMS and electronic logbook system Australia does not permit IUU anymore. There is no chance of having illegal fish in Australia and they certify all their fish exports are free from IUU fish.

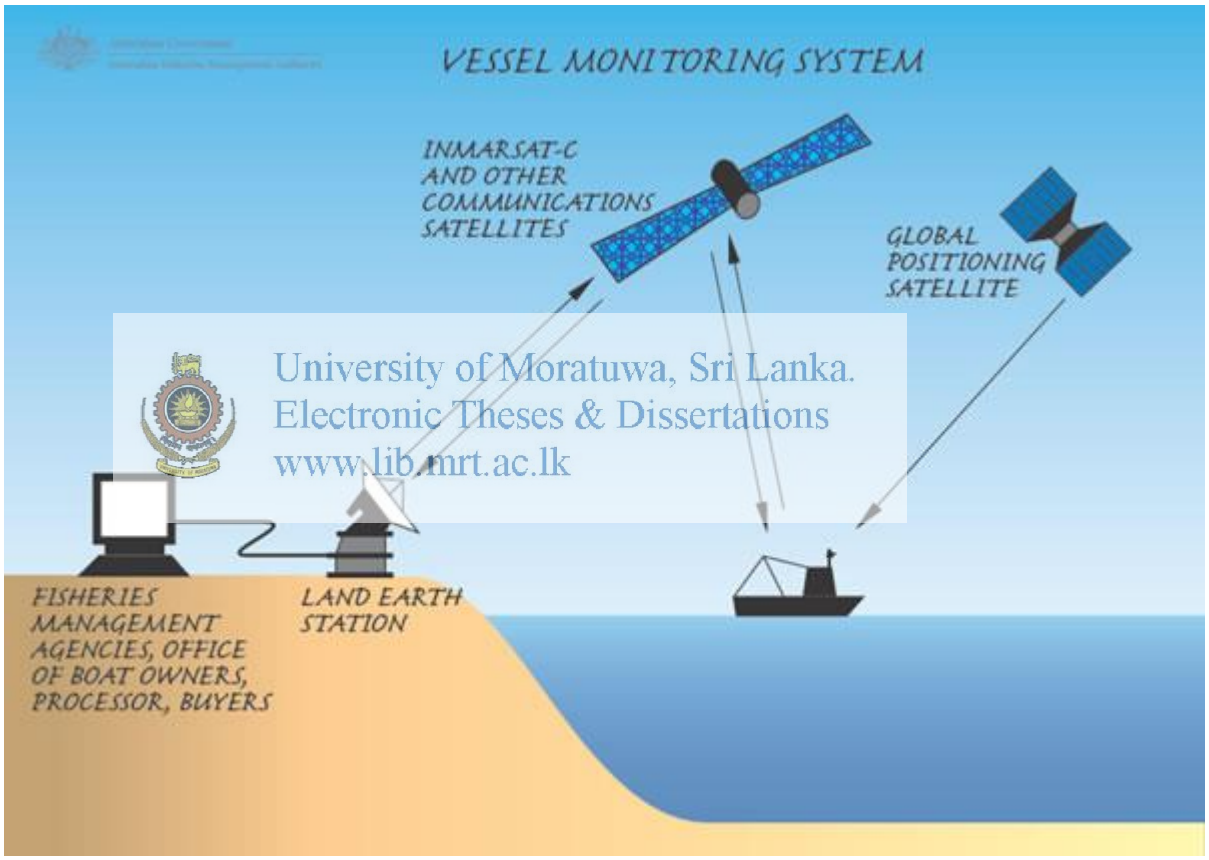

Figure 0.1 - Top level architecture of Australian Vessel Monitoring System

2.4.2 How Taiwan fishery Agency work against IUU.

The fishing activities of Taiwan's deep sea fisheries cover the major oceans of the world, with fishery types including tuna long-line fishery and tuna purse seine tuna fishery. In recent years, their average annual production is around 800,000 tons, with a value exceeding US$1.5billion. This outstanding performance has made Taiwan ranked the 20th fishery producing country in the world and one of the important high seas fishing countries [29].

vTrack is the vessel monitoring system which has been fixed into 1,200 off shore vessels operate under control of Taiwan [31]. Unlike Australia, Taiwan uses only VMS geo position to confirm that their fishermen are not engaged in illegal fishing. 3 land station monitor movement of all off shore vessels and fisheries agency of Taiwan issues a catch certificate by checking the entire route of the trip. Since the Taiwan doesn't not have catch data verification system, they use manual logbook for each vessel. Manual form of logbook does not contain actual weight of fish and latitude and longitude of the position they caught the fish. Manual logbook loses very important source of information for analysis of future sustainability.

2.4.3 How Department of Fisheries in Maldives work against IUU

Fishing industry is the second biggest industry in Maldives. Their marine resource base has 640 Km of coastal line, 35,000 Km^2 of shelf area and 923,000 Km^2 of EEZ around their islands. Tuna export is the main source of foreign exchange for Maldives in fishery sector. Maldives has earned US$ 85 million in 2013 in fish and fishery product exports [32].

In 2011 Maldives government introduced an American VMS called GeoEye OrbMap for their offshore fishing vessels for controlling and monitoring purposes [33]. GeoEye OrbMap supports Maldives' local language Dhivehi and that could be the main reason for selecting GeoEye as their official VMS provider. Maldives fishery uses electronic VMS and use the data for manual catch certificates and logbooks. They provide VMS data for all fish exports to confirm they export only legal fish.

GeoEye is a comprehensive electronic solution designed to cover most of the needs at sea. GeoEye transceiver enables two way communication between vessel and Iridium satellite network. GeoEye gets position in regular intervals from GPS satellites and transfer to their main server. Then main server route position details to appropriate client. As an additional feature to VMS, GeoEye provides position of its buoys. For example, long line fishing vessels can connect buoy to its line and monitor. This outstanding feature makes GeoEye cut above the other vendors and most of the fishery agencies tend to adopt GeoEye not only to monitor vessel but also monitor its line [34].

2.5 Review of current system in Sri Lanka.

As it described in early sections, over 3,000 multiday boats have been registered at DFAR as marine fishing boats and those are authorized to fishing in Sri Lankan sea water which is up to 24 nautical miles from the coastal line. The Indian Ocean Tuna Commission (IOTC) is an intergovernmental organization responsible for the management of tuna and other large fish species in the Indian Ocean. Since Sri Lanka is a member of IOTC most of Sri Lankan multiday boats have been registered for fishing in EEZ which is 517,000 Km^2 in Indian Ocean. IOTC approves Sri Lankan vessels to do fishing in both FAO area 51 and 57 except the sea area belongs to Indian, Maldives and Australia. As a summary;

Registration Authority		Authorized fishing area
DFAR	IOTC	
Not registered	Not registered	Does not permit to release the vessel from port.
Registered	Not registered	Up to 24 nautical miles with In Sri Lankan territorial waters and contiguous waters.
Registered	Registered	Up to 200 nautical miles with in EEZ belongs to Sri Lanka. Does not permit in Indian & Maldives EEZ.

Table 0.1 – Registration authorities and their manageable area

According to the Law of the Sea by FAO, Sri Lanka has categorized under all three country categories.

- Sri Lanka is a flag country which has registered over 3,000 vessels.
- Sri Lanka is a coastal country which has 1,340 Km long coastal line.
- Sri Lanka is a port country which has around 25 fishery harbors island wide.

As a country stands against IUU, Sri Lanka must satisfy following regulations.

- As a flag country, Sri Lanka should maintain a record of its fishing vessels. The should include owner information and physical characteristics (Type, Length, Weight, Fishing method, Number of fishing gears)
- Sri Lanka should maintain records of fishing history of its vessels.
- Sri Lanka should have a vessel monitoring and controlling system to manage vessels fly Sri Lanka flag.

- Sri Lanka should maintain fishing authorization document for its vessels. That should include,
    - What species can be caught
    - What gear can be used
    - Where and when the vessel can operate
- Sri Lanka should maintain a Logbook for its vessels to record details of the harvest. That should include,
    - Trip Start / End dates
    - Marine positions of where they caught each individual fish
    - Type, weight of each individual fish
- Sri Lanka should issue a Catch Certificate for each fish export by confirming that the particular vessel has not been engaged in illegal fishing and its harvest is legal.

DFAR has implemented a vessel registration system to register details of vessels fly Sri Lankan flag. Registration process basically depends on Type of the vessel, Type of the engine and registered port and unique registration number to be issued for vessels satisfy basic requirements for related category. For example IMUL-A 0333 NBO is one of the registration number issued by DFAR. Letter "I" says the vessel has inboard engine, "MUL" stands for "Multiday" which means this vessel has facilities for fishing at sea for more than one day, "A-0333" is a serial number and "NBO" represent the registered port. This vessel has registered in port Negombo. DFAR uses electronic registration system which stores owner information and other physical characteristics of the vessel.

The deep sea fishing license is a certificate issued for each deep sea vessel that confirms the boat is authorized for fishing in EEZ. License states what species can be caught, what fishing gears are authorized and where and when the vessel can do fishing. Deep sea fishing license also has the unique certificate number which denote year of valid and port issued. (14HS0001NBO). Issuing operation licenses is a total manual process in Sri Lanka. (See Appendix B for sample operation license)

Maintaining a Logbook for fishing vessels is a concept of FAO to provide Net to Plate traceability for consumers and build up a valuable source of information where fish are available during different seasons. Logbook basically records details of catch. GPS

position of where they caught, fish species and their weight, etc. Logbook concept directly help to stop IUU fishing. Since it records GPS position for each fish, there is no way of producing illegal fish. Logbook records provide very important source of information for national authorities. For instance close analysis may illustrate where fishing vessel can find good catch in different periods of year and also where they should not do fishing to protect younger fish.

In Sri Lanka Logbook is a manual printed book supplied to offshore fishing vessels. A person on-board fills the book with aid of radar device fixed into the vessel. (See Appendix C for sample logbook)

Exporters have been advised to collect the copy of fishing license and copy log sheet of related boat when purchasing raw fish and produce to DFAR with their export details. DFAR approves the export only after studying documents provided to them. (See Appendix D for sample Catch certificate)

2.6 Comparison of approaches by different countries against IUU.

FAO rules & regulations to stop IUU fishing.	Approaches by Australia	Approaches by Taiwan	Approaches by Maldives	Approaches by Sri Lanka
Maintain a record of fishing vessel registration including owner's details and physical characteristics of the vessel.	Australian fishery management agency does vessel registration prior releasing for commercial fishing. Uses an electronic vessel registration system.	Taiwan fishery agency does vessel registration and update regional fishery management authorities prior commercial fishing in EEZ. Uses an electronic vessel registration system.	Department of fisheries in Male does commercial fishing boat registration and update IOTC. Registration system is manual paper based.	Department of fisheries and aquatic resource management of Sri Lanka does commercial fishing vessel registration prior releasing for fishing and update IOTC. System has an electronic database and rest of the things are manual paper based.
Maintain a record of fishing authorization for all offshore fishing vessels.	AFMA issues a permit to fish and monitor and control via VMS	TFA issues a permit to fish and monitor and control via VMS	DF issues a permit to fish and monitor and control via VMS	DFAR issues a permit to fish. **No monitoring and controlling mechanism implemented.**
Maintain a logbook for each offshore fishing vessel to record its catch.	AFMA uses full electronic logbook linked with VMS. Very efficient.	Manual logbook. Not efficient. Use VMS to control.	Manual logbook. Not efficient. Use VMS to control.	**Manual logbook. Not efficient. No controlling mechanism implemented.**

Implement a vessel monitoring and controlling system to monitor vessels fly its national flag.	24 hours VMS in operation and petrol vessels engaged in surveillance of EEZ.	24 hours VMS in operation.	24 hours VMS in operation.	**No VMS implemented.**
Maintain a record of fishing history for all offshore vessels.	Position and catch records for each trip are available. Use VMS and electronic logbook.	Only position record for each trip is available. Use VMS.	Only position record for each trip is available. Use VMS.	**No proper system to collect historical record. No VMS, No proper logbook in practice.**
Implement a catch certificate schema to be certified by local authority against illegal fish.	AFMA does not permit to land vessels with illegal fish. Does not permit to do fishing outside Australian EEZ. Certify the catch on arrival.	Closely monitor its vessel and make sure they do fishing in EEZ. Certify the catch for exports.	Monitor its vessel through VMS and confirm against IUU. Fishery officer at the Male airport checks and verifies against illegal fish.	**No proper mechanism implemented to identify illegal fish and IUU activities. No proper catch certificate schema.**

Table 0.2 - Comparison of approaches by different countries against IUU

2.7 Drawbacks of current Sri Lankan system.

Decades have passed since the world has addressed sustainability issues in marine lives. Comparing to other countries, effort made by Sri Lanka to maintain marine sustainability is very regretful. Not only fish producers but also fish consumers pay their attention over sustainable fishery.

As a country benefited by fishery industry, Sri Lanka must stand against IUU fishing. Sri Lanka has introduced good management policies and it has good vision how to eliminate IUU fishing but due to lack of monitoring and controlling most of the effort made is unproductive. Even though it is not a simple task, Sri Lanka has tied up by law to control its fishing vessels at sea. As it discussed in early sections, other countries manage to take control of its vessels by using 24 hours VMS which gives real time position of its vessels.

A logbook for fishing vessels is becoming mandatory as the world has seen lots of benefits out of it. Sri Lanka has lost a valuable source of information due to improper use of logbooks. The logbook in Sri Lanka is just piece of paper and nobody can rely on its information. Fishermen used to maintain logbook not because they understand the importance but because they have been asked to do so. Fishermen start sailing without knowing where the fish are. Only few countries including Sri Lanka practice this method where other countries including Maldives direct their fishing vessels to fishing grounds. Logbook is a good source for identifying fish breeding grounds and fries in different zones in different period of year. Countries like Australia has marked authorized fishing ground for different time periods to protect fries and breeding grounds. Sri Lanka does not have such valuable source of information so people catch younger fish and fish about to breed.

Catch Certificate is a legal document produced by local fisheries authority to consignee's authority. For example DFAR provides catch certificates to EU's import authority, EU's food and agriculture organization. This document confirms fish in the consignment is legal. Countries use VMS can provide marine positions of vessels produced fish for the consignment. Countries use logbooks have further evidence to confirm legality of fish. But even though DFAR produce catch certificates, it does have evidence to prove fish is legal and all are from Sri Lankan EEZ. Since Sri Lanka failed to present evidence for legal fishing, it is about to lose market for its fishery products.

2.8 Features of Commercial Vessel Monitoring & Electronic Logbook System

Features	CLS ELO THEMIS	GeoEye OrbMap	globaVista	vTrack / vCatch	Mini-c
VMS Features					
Real time marine position recording	Yes	Yes	Yes	Yes	Yes
Global coverage	Yes in Zone A1, A2, A3, A4	Yes in Zone A1, A2, A3, A4	Yes in Zone A1, A2, A3, A4	Yes in Zone A1, A2, A3, A4	Yes in Zone A1, A2, A3, A4
Zone management	Yes	Yes	Yes	No	No
Tamper protection	Yes	No	No	No	No
Vessel mode detection	Yes (Stop, running)	Yes (Stop, running)	Yes (Stop, running)	No	No
Electronic logbook support	Yes, Via Bluetooth	No	Yes, Wired to laptop	Yes, Wired to laptop	No
Operate in 12V DC	Yes	Yes	Yes	Yes	Yes
Battery backup	Up to 10 days when 1 position per hour	Up to 4 days when 1 position per hour	Up to 10 days when 1 position per hour	No	No
Electronic logbook					
Additional device required	Yes, Mini laptop		Yes, a laptop	Yes, a laptop supports web browser	
Real time marine positions	Yes		Yes	Yes	
Electronic scale support	No		No	No	
Onboard Movability	Yes if Mini laptop can move		No, it's wired	No, it's wired	
User friendly interfaces for fishermen	Support only mouse and keyboard. No touch screens		Support only mouse and keyboard. No touch screens	Support only mouse and keyboard. No touch screens	
Sinhala / Tamil language support	No		No	No	
Inbuilt memory	Yes		Yes	Yes	

Operate in 12V DC	Only if Mini laptop can support		Only if laptop can support	Only if laptop can support	
Battery backup	Depends on laptop battery		Depends on laptop battery	Depends on laptop battery	
Cost					
Initial cost of transponder and monitoring software	US$ 2,800	US$ 3,499	US$ 3,000 – 3,500	US$ 2,000 – 2,500	US$ 2,000 – 2,500
Annual monitoring software cost	US$ 800 + User account fee	N/A	US$ 1,000 for 5 users	N/A	US$ 500
Annual air time cost	US$ 600 (6 positions per day)	US$ 1,200 (12 positions per day)	US$ 10 per position, per vessel, per month. US$ 720 (6 position per day)	US$ 900-1200 (6 positions per day)	US$ 900-1200 (6 positions per day)
Initial cost of electronic logbook	US$ 900		US$ 590 + cost of laptop	US$ 1500 + cost of laptop	
Annual air time & logbook fee	US$ 1,000 – 1,500		Depend on data capacity and # of vessels	Depend on data capacity and # of vessels	

Table 0.3 - Features of Commercial Vessel Monitoring & Electronic Logbook System

2.9 Why commercial VMS and Electronic logbook systems are not suitable for Sri Lankan fisheries industry.

1. High initial costs

   Sri Lanka has more than 3,000 multiday offshore vessels. Initial cost of a transponder which supports electronic logbook would be roughly US$ 3,000. DFAR has planned to install VMS for 1,000 vessel in first phase. That would cost US$ 3 million only for transponders.

   A logbook terminal would initially cost US$ 1,000 and it is US$ 1 million for 1,000 vessels.

2. High air time cost.

   A basic 40' fishing boat has 20 hp engine which can go faster as 8 nautical miles per hour. It is recommended to have 1 marine position in two hours. That would roughly cost US$ 1,200 per vessel per year.

3. Unnecessary air time cost for Logbook data transfer.

   The purpose of electronic logbook is to record catch details with marine position. It is not necessary to transfer such information to land over satellite connection. Catch details is required only after vessel landed.

4. Computer based systems are not suitable for on-board use.

   Commercial versions of logbook terminals are installed on multipurpose laptops and mini laptops. Such system may fail due to,

   - Lack of basic computer knowledge for fishermen
   - Unsuitability of laptops for on-board use
   - No continues power supply
   - Inconveniences of using keyboard, mouse on board
   - Lack of mobility
   - No transshipment guarantee

5. No electronic scale support

   None of the commercial electronic logbook systems support on board crane scale to get weight readings. Fishermen have to input weight manually and input errors may occur.

6. No Localization support

   Sri Lanka fishermen do not familiar with English. So systems must support local languages. (Sinhala & Tamil)

7. High annual license cost

   There are about 25 fishery harbors and several DFAR officers need access to VMS and electronic logbook system. Annual software and license cost would be more than US$ 2,500.

2.10 Summary

At a time the entire world is concentrate on sustainable and controlled fishery, effort made by Sri Lanka is very regretful. Not only producers but also consumers pay their highest attention over illegal fishing and they always keen on not to promote marine crimes. Most of the countries use VMS electronic logbook systems to control its vessels at sea. There are couple of reasons why commercial VMS systems are not suitable for Sri Lankan offshore fishing industry. High initial cost, high operation cost and no localization support are key issues of proposed systems. Since there is no evidence to prove that Sri Lankan fishing vessels do not engaged in IUU activities, there will be no market demand for Sri Lanka fish. Sri Lank is about to lose over US$ 200 million worth annual foreign income from fish exports. Red light has come, it is high time to introduce suitable monitoring mechanism for Sri Lankan deep sea fishing vessels.

Chapter 3

Technology Adapted

3.1 Introduction

Previous section bear witness to the importance of addressing the said issue since it is $200 million worth annual foreign income and the direct and indirect impact on social and living standard of Sri Lankan fishermen. Hence it has proved the unfeasibility of applying readymade VMS systems, this chapter discusses how modern computer software and hardware technologies can introduce new approach to solve the said issue. Respective sections describe adapted technology and their relevancy to the proposed system.

3.2 Why technology is required and what technology should do.

Unlike the vehicles on roads, vessels are not guided by giving a particular path or instructed by different signs. People may think vessels at sea can sail as the captain or skipper wants. That is not. Sea waters have been divided into different zones and have been marked by virtual lines. Countries surrounded by sea waters claim their own territorial waters and Exclusive economic zone where they empower their control. Rest of the sea except special declarations considered as international sea where nobody empower their controls. Sri Lankan marine border in Indian Ocean is bit complicated since it finds Maldives and Indian borders from Southwest to North. Same as the vehicles have been guided by road signs, vessels should have a mechanism on-board to guide the captain or skipper to stop entering to marine zone which belongs to other nations. This is a key point where the project should adapt suitable technology to,

- **Identify the vessel's positions at sea.**
- **Identify marine boundaries and Zones.**
- **Identify the zone vessel belongs to.**

Loose of inadequate data has been identified as one of the major impediments to the rational control of marine sources [35, 36]. Recent research conducted by NARA [37] found that Sri Lankan fish catch is above the sustainability rate and there is a high possibility of decline Tuna like commercial fish species in near future. Further stated,

Indian Ocean was identified as a breeding ground for Bluefin Tuna which has the highest commercial value in Tuna family. Bluefin Tuna had been declined over decades due to overfishing and now it is a dream fishermen find them in Indian Ocean. DFAR has totally restricted catching some fish species (Ex:-Treasure Shark) and weight limit has been enforce for some species (Ex:-Swordfish) as part of the solution for sustainability issue. This is another occasion where technology should adopt to,

- **Support fishing to be done below the sustainability rate.**

As the EU is demanding NET TO PLATE traceability and the certificate against illegal fish (Discusses in Chapter-2), the solution should have technology to be adopted to

- **Identify exact sea location where the fish caught.**
- **Identify legal and illegal fish.**
- **Introduce a mechanism to evaluate skipper.**

That is obvious the solution runs from land to the fishing vessels operate in deep sea. Solution should have interconnected segments to cater different needs of different people and should be able to use under different operating environments. As discussed in previous chapter, couple of effort to introduce commercial VMS were failed due to lack or no localization support. System goes to the fisherman's hand should meet his literacy level and at least should be able to interact with Sinhalese and Tamil languages. Identifying different features or operations using different graphical representations would be optional. (Using pictures or different colors) It is more likely fishermen reject things they feel uncomfortable with, no familiarity and hard to understand. So the design has a crucial job to introduce a system which does not require additional familiarity of the fisherman. The project has to keep the initial cost as lower as possible to make it bearable for fishermen. Devices to be used onboard should easy to be used and suitable. As a summary, system on-board should adopt the technology to,

- **Introduce user friendly system with native language support.**
- **Introduce suitable system for deep sea operation.**

Technology to be used for the rest of the system to achieve,

- **Provide high performance and security.**
- **Provide easy access and higher reliability.**

- **Provide ability to further enhance.**

Summary – What technology does in this project?

What technology should do
Identify the vessel's positions at sea.
Identify marine boundaries and Zones.
Identify the zone vessel belongs to.
Identify exact sea location where the fish caught.
Support fishing to be done below the sustainability rate.
Introduce a mechanism to evaluate skipper.
Introduce user friendly system with native language support.
Introduce suitable system for deep sea operation.
Provide high performance and security.
Provide easy access and higher reliability.
Provide ability to further enhance.

Table 01- What technology should do?

3.3 Overview of Technology Adapted.

3.3.1 Global Positioning System (GPS Technology)

The Global Positioning System (GPS) is a space based satellite navigation system the provides location and time information under all whether conditions on earth surface where there is an obstructed line of sight to four or more GPS satellites [38]. 27 (24 in operation and 3 extra in case of failure) GPS satellites fly in Medium Earth Orbit at an altitude of approximately 20,200Km. Each satellite circles twice a day. GPS receiver is a special device has been designed to connect with at least four GPS satellites in the sky and retrieve the GPS coordinates. GPS coordinates contains the latitude and longitude of the position where the receiver is hold. GPS comes as a free of charge service so anytime if the receiver can contact four out of 24 GPS satellites it gets the GPS coordinates.

Once the sailors lose sight of land everything looks the same in all direction and it is easy to get lost. Before the magnetic compass came into the practice, sailors had to wait until sun rose or set to identify WEST and EAST. When sailors talk about ship's location that means the Latitude and Longitude on the ocean. Early days sailors had a

very big job finding its position using horizontal and vertical lines referring to navitables and magnetic compass. With the introduction of GPS technology all such hard job turned much simpler as GPS receivers get the exact location in few seconds.

GPS can be considered as the key technology used in this project. Hence the project based on a vessel at deep sea, any other technology cannot be used rather than GPS to locate the vessel. Throughout the project vessel's position is a GPS coordinates with latitude and longitude. And location to be marked comparing to the horizontal and vertical virtual lines.

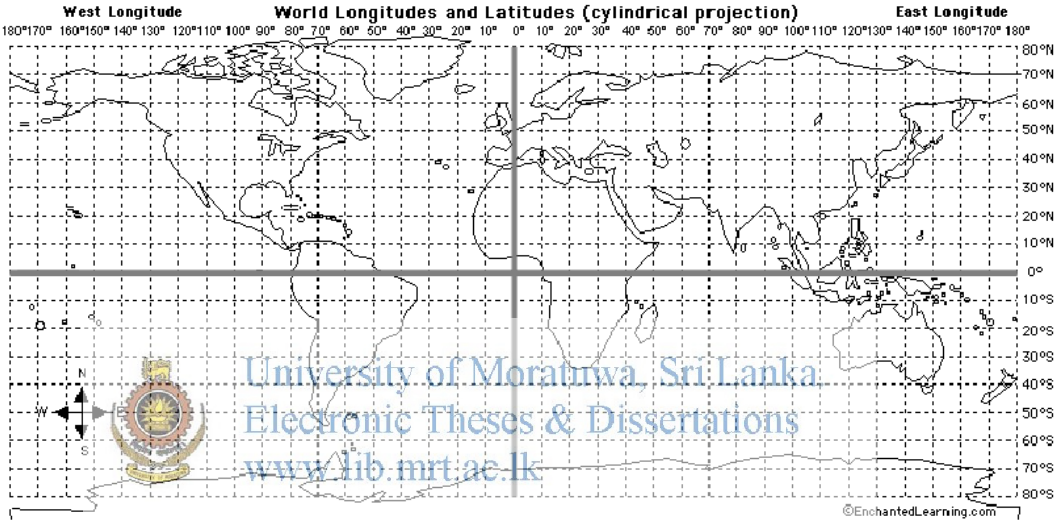

Figure 0.1 - World map with virtual lines

Vessel's position itself does not give any meaning. That gives the meaning when comparing to the marine zones and borders. Meaningful identification could be,

- Vessel is inside Sri Lankan EEZ
- Vessel is currently located 100nmi away from south coastal line
- Vessel is located in international waters, 100nmi from Maldives border and 50nmi above the Sri Lankan EEZ.
- Vessel is being operated in Maldives EEZ.

It is crystal clear such meaningful explanation always comes with referring to marine borders and zones in the sea. Again all these things are virtual, no physical representations are available.

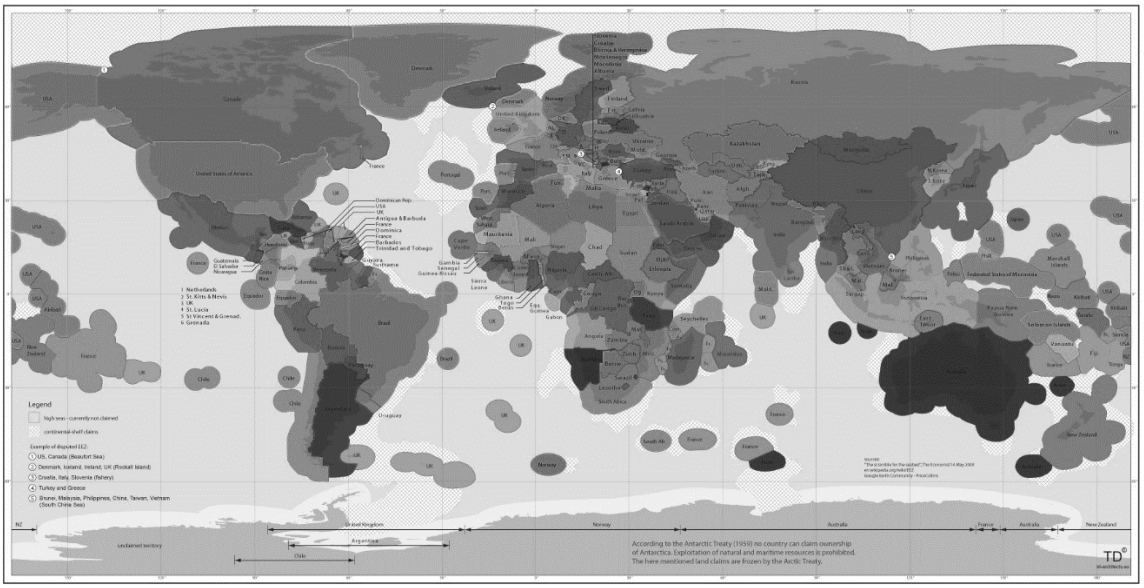

Figure 0.2 - Exclusive Economic Zones in the World

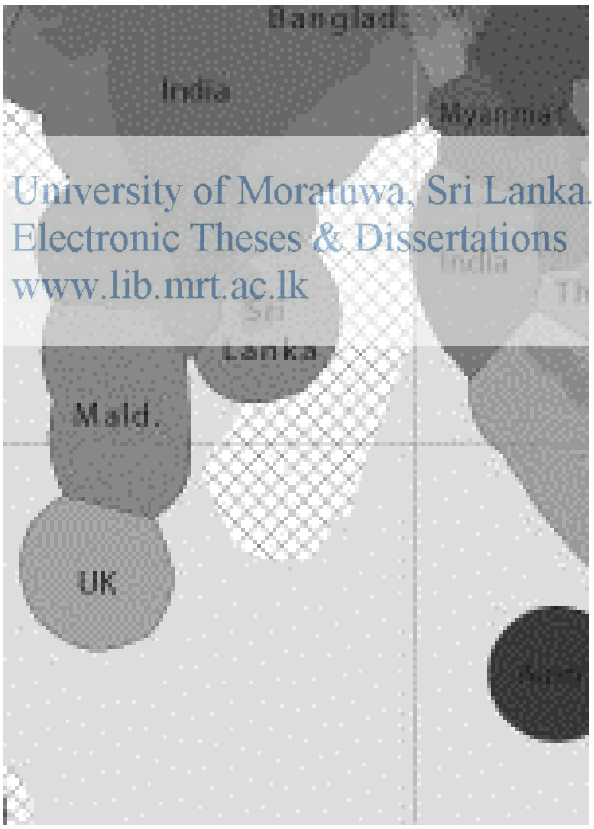

Figure 0.3 - EEZ boundaries around Sri Lanka

Interconnected GPS coordinates to represent boundaries and form marine zones as polygons.

This project focused on representing marine boundaries in terms of GPS coordinates. It has found the marine boundaries can be performed by interconnecting GPS coordinates

carefully marked on virtual lines. Such interconnection can performed a polygon which is the marine zone surrounded by boundaries. This approach helps to identify any given position of the vessel is inside any zone or sailing free in international waters.

Use of 'haversine' formula to calculate the great-circle distance between two points

The great-circle distance is the shortest distance between two points on the surface of a sphere, measured along the surface of the sphere. The distance between two points in Euclidean space is the length of a straight line between them, but on the sphere there are no straight lines and they are virtual.

The haversine formula is an equation important in distance calculating giving great-circle distances between two points on a sphere from their longitudes and latitudes. It is a special case of a more general formula in spherical trigonometry, the law of haversines, relating the sides and angles of spherical triangles.

Haversine formula: $a = \sin^2(\Delta\varphi/2) + \cos\varphi 1 \cdot \cos\varphi 2 \cdot \sin^2(\Delta\lambda/2)$

$c = 2 \cdot \text{atan2}(\sqrt{a}, \sqrt{(1-a)})$

$d = R \cdot c$

Where φ is latitude, λ is longitude, R is earth's radius (mean radius = 6,371km).

The distance 'd' comes in Km and has to be multiplied by 0.53996 convert to nautical miles (nmi).

This distance function can be used to calculate the distance between vessel's position and coastline, distance to west and east boundaries and calculate the nautical miles away from Sri Lankan EEZ.

3.3.2 Mobile software development technology

There is a special reason for this project to check the feasibility of using a smartphone for on-board use. That is the in-built GPS receiver. Basic smartphone is one of the cheapest solution as a GPS receiver hence it is multitasking so no dedicated cost for a GPS receiver. Vessel at sea has no obstacle to see the sky. So on-board GPS receiver should not require much power to contact GPS satellites. Smartphone built-in GPS receiver should me more enough for this concern. If the project uses smartphone as the

GPS receiver, can it uses the same device for other concerns? If so fishermen may use their phones where they do not need additional investment and familiarity. New approach begins. On-board needs to be catered by introducing a smartphone application.

The smartphone application basically receive position data from GPS receiver and that can be stored in internal memory for further use. Mobile data network or any other compatible transmission media can be used to transfer data from device. To record GPS coordinates of each fish catch, smartphone application may have a separate section. Rather than using a desktop or laptop computer, use of smartphone for this purposes is more adequate. Because

- Easy to use and easy to handle.
- Has built-in GPS receiver and data transmission network support.
- Does not need special familiarity.
- No additional investment.
- Can have waterproof devices.
- Sealed and fan less so has good resistance to sea mist.

Also there are some other miner reasons. If smartphone to be chosen, which platform to be selected and what development technology to be used?

Native App or Web App or a combination of the two

In most cases web applications for smartphones are rather popular than native smartphone applications. Unlike the native applications, web application can be done to be run on different platforms since they are browser dependent. Customization and graphical representations also very rich comparing to the native apps. Native application development would be more appropriate in this case due to couple of reasons.

- Cannot expect internet connectivity on-board so web app will not be suitable
- App should be able to handles hardware and software facilities within the device such as GPS receiver, internal storage, etc so web app will not be suitable

However the smartphone application should have a way to communicate with outside world. That can be trough the mobile data network or through satellite link provides. In

such situation web app will be performing better with HTTP request (also scripting) than the native applications. So the smartphone application development will adapt characteristics of both native and web application developments.

A Cross-platform mobile application

Mobile technologies are in a rapid growth and tend to changes very frequently. Until recently, iOS dominated the mobile market, but now Google's Android has overtaken. In Sri Lanka more than 80% smartphone user use Google's Android and cannot expect any of Sri Lankan fishermen using expensive iOS. However project adapted cross platform support technology for the mobile development to avoid complete rework when and if cross platform support is necessary. Application should be a Unicode compatible to introduce in English, Sinhalese and Tamil languages.

3.3.3 Rule based decision making model

More often this project has to make decisions based on complex movement of the vessel. Without a structured way decision making is complicated and time consuming. Decisions in this project to be formed as rule sets and remove the complexity. For example to decide catch is legal or illegal, each GPS point to be sent through a rule set arranged in a tree structure which checks boundaries, species restriction, size restriction, etc and return a single value.

3.3.4 Web Application development technologies

Web Application development technology to be adapted for this project due to two main reasons.

- Use Google Maps API
- Communicate with Smartphone App through HTTP request

This project should have a dynamic map solution to display vessel's position, its trip route, marine boundaries and marine zones. Google Maps is the trusted and free of charge solution for dynamic map needs. Google Maps API V3 provides much more capabilities for this project since they have introduce forming polygons interconnecting series of GPS coordinates. The project decided polygons to be used to represent marine zones. And also API V3 provides necessary features to calculate great-circle distance

between two points on earth surface which decided to use to calculate distance between vessel's position and boundaries.

3.3.5 Desktop Application development technologies

Desktop Application development to be adapted to develop an application for harbor or DFAR officers to interact with the system. This system to be used to,

- Enter primary records. (Vessel details, skipper details, etc)
- Generate reports.

Since this is for limited set of users, it is not necessary to introduce as a web application and make available through internet. While desktop application provide better performance and high security, it provides rich tools for report generating.

3.3.6 Database technologies

The solution has a centralized data store that can be accessible via Smartphone App, Web App and Desktop App to read or write data. Smartphone App does not have direct access, it always comes through the Web communicator for security reasons and maintain better performance. Web App and Desktop App have the direct access.

Smartphone App send the vessel's position and fish catch data to be hold for further use. Unlike other data, this project hold GPS coordinates of vessel's position, boundaries and marine zones. So the selected data base should have the capability of storing spatial data types and maintain the relationship between them. The relational database MySQL with Spatial data types would be the ideal solution since it is free of charge and has better performance.

3.3.7 Summary of technology adapted

What technology should do	Technology Adapted	How the adapted technology works
Identify the vessel's position at sea.	GPS technology, Mobile App development technologies.	Get the GPS coordinates of its current position
Identify marine boundaries and Zones.		Series of GPS coordinates to be interconnected and form polygons to represent marine boundaries and zone.
Identify the zone vessel belongs to.		Identify vessel's GPS coordinates belongs to which polygon.
Identify exact sea location where the fish caught.	GPS technology, Mobile App development technology,	Get the GPS coordinates of each fish catch
Support fishing to be done below the sustainability rate.	Rule bases decision making, Database technologies.	Apply restriction to do fishing in breeding grounds.
Introduce a mechanism to certify fish catch by evaluating trip route against boundaries and considering sustainability measures.	GPS technology, Google Maps API, Rule base decision making.	GPS coordinates of trip route and fish catch to be verified against boundaries. Decision to be made based on type of fish and weights
Introduce a mechanism to evaluate skipper.		Decision to be made based on route verification against boundaries, type of fish caught (restricted or

		allowed types) and their weight (commercially allowed weights or not)
Introduce user friendly system with native language support.	Mobile App development technologies	Use of Native mobile app development with Unicode support to introduce English, Sinhalese and Tamil Languages. Color separation and graphical representations to make the identification easy.
Introduce suitable system for deep sea operation.		No wired connections. Use maximum mobility and use touch screen.
Provide high performance and security. Provide easy access and higher reliability. Provide ability to further enhance.	Relational database technologies, Web technologies (Secured data transfer) Mobile App development technologies (Cross platform support, Secure data transfer)	Database design make useable for future decision support and interconnected relationships provide high performance and security. C# Xamarin provides cross platform support. Data set can be further used for an intelligent system.

Table 0.2 - Summary of technology adapted

3.4 Summary

This chapter described why this project need technology and what they supposed to do for this project. Mobile application development combines GPS technology to introduce on-board data capturing mechanism for the project. Web technologies fill the gap between data capturing and graphical representation. On the other hand web technologies contribute desktop application development to organizing data into meaningful form for decision making. Combination of all these technologies make the approach possible. Next chapter describe the novel approach against illegal fishing in Sri Lanka.

Chapter 4

Smart Vessel Monitoring System

4.1 Introduction

Chapter-2 described the issues in stopping IUU fishing in Sri Lanka with the support of literature. Also it has mentioned reasons why commercial VMS systems are not feasible in Sri Lankan fishery. Chapter-3 broadly discussed the challenges in introducing a new approach, where the technology to be adapted, what technology to be adapted and briefly discussed how technology to be used to overcome said problem. This chapter discusses how adapted technologies to be used to produce the solution.

4.2 Overview of the Solution

Abstract view of the solution should have a mechanism to stop Sri Lankan fishermen engaged in illegal fishing and should have a trustable mechanism to prove Sri Lanka exports only legal fish to EU. This solution covers operations in both on-board and land side. On-board system interact with fishermen to collect necessary data, Land side system for harbor or DFAR officers' use for monitoring, controlling and decision making. As an additional feature and motivation factor, another land side system is introduce to strengthen the relationship between fisherman and exporter. Next respective section will describe features of On-board system, Land side system for DFAR officers and land side system exporters.

4.3 Smart VMS Application

Users

Fishermen

Inputs

GPS coordinates of vessel's position, GPS coordinates of fish catch, Fish type, Fish weight.

Outputs

Alert fishermen upon reaching the borders, Total fish catch figures and provide trip route and fish catch details to land stations.

4.3.1 Overview of Smart VMS

Smart VMS is a Native application which converts fisherman's mobile phone into a VMS system. The Native application to be developed using Unicode support where English, Sinhalese and Tamil languages can be implemented. Use of graphical representations and different colors to make fishermen more comfortable with the App. Since the hardware is fishermen's phone and VMS is an application, there is no additional cost and no additional familiarity required.

VMS App records vessel's position in given time intervals with the help of in-built GPS receiver and internal storage. When and if the online data transmission is required, smartphone should be facilitated with a satellite data transmission link. *This part is out of the project scope. See Appendix for available solutions.* VMS App has been designed to transfer such position data to a central database located in the land via mobile data network. Data will be recorded in internal storage until the vessel back to mobile data coverage. Native mobile application uses a web transmission module at the backend to transfer recorded data into the database through the web server. The web server located in the land act as the intermediate layer of data transmission between Smartphone APP and database.

The VMS App has an alerting system to alert skipper or captain when reaching the boundaries. Later sections of the chapter discuss how the marine borders and zones are made and how to calculate the distance.

4.3.2 Overview of Smart E-Logbook

The logbook comes as a part of the Smartphone Application. While VMS records vessel's position details, logbook section records the fish catch details. Fish catch details are essential for providing catch certificate to EU and as a source to understand the sustainability of different fish species. Logbook has an interface where fisherman can select fish species and enter fish weight. Application receives the GPS coordinates and store them in internal storage. For example,

Yellowfin Tuna, 56.50Kg, 2.76545, 78.09884

Fish Specie name or index, Weight, Lat, Long

Logbook data also transfers in the same way it transfers vessel's position data. The implementation should make sure all these interfaces including fish names should be available in all three languages for their convenience.

4.4 Land side Web Application

Users

Fish Exporters, Desktop Client

Inputs

Trip number, harbor name

Outputs

Visual representation of marine boundaries and zones, Visual representation of trip route, Visual representation of fish catch positions, GPS coordinates of each position, distance from harbor, Distance to West and East boundaries.

4.4.1 Overview of Web Application

The web application is a combination of Google Maps API V3, JavaScript, PHP and AJAX technologies. Web application communicates only with the database server. The web application retrieves GPS coordinates required to draw Sri Lankan EEZ, West and East boundaries and put them in a queue in order they need to interconnect. For example,

Area ID	Lat	Long
EEZ_1	4.719087	77.293584
EEZ_1	4.967796	77.486138
EEZ_1	5.457252	77.835511
EEZ_1	5.648707	77.958026
EEZ_1	5.96128	78.163702
EEZ_1	6.237566	78.286953

Table 0.1- Sample EEZ GPS Coordinates

All such points to be interconnected and form a closed polygon which represents the marine zone. *You will find more details in Implementation Chapter.*

Users can see the vessel's trip route by entering the trip identification code. Web application gets all GPS coordinates relevant to the trip from database and trip route also represented as a line connecting its positions.

Each GPS position of vessel's trip route and fish catch should go through the verification rule set to verify against illegal fishing. The rule set as follows

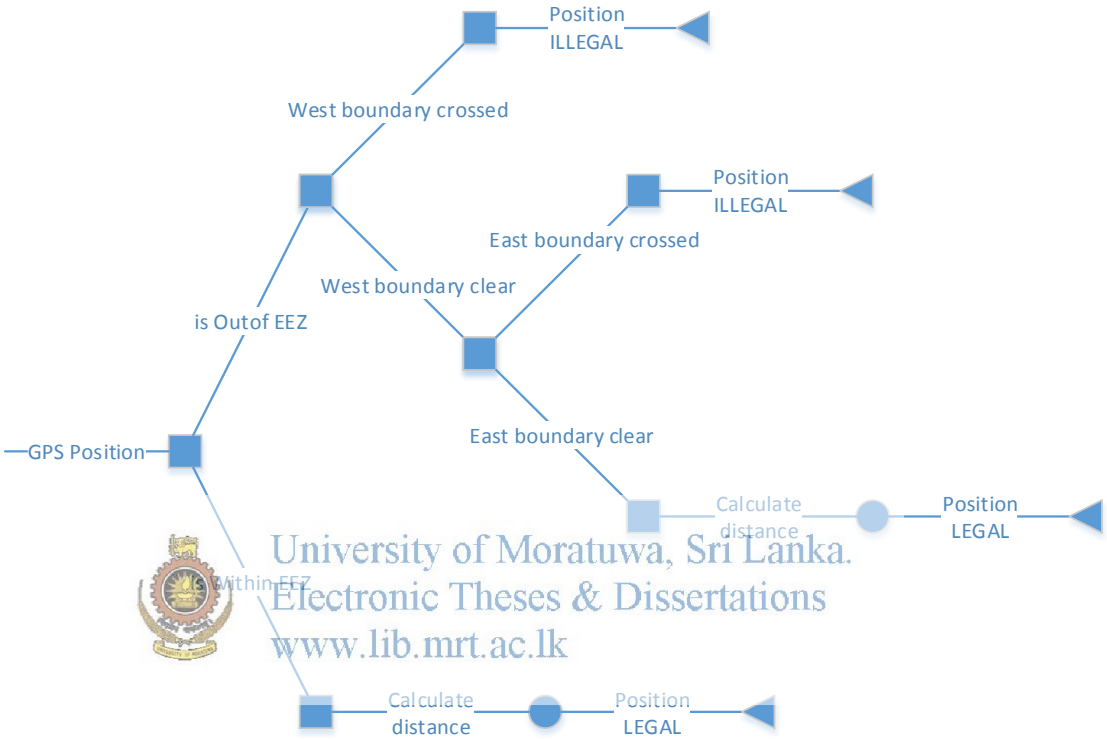

Figure 0.1 - Decision Tree - Make position legal or illegal based on boundaries

Verification data of each point to be stored for further use. Fishing trip can be legal and their catch can be legal only if they SAIL in FISHING within EEZ or INTERNATIONAL WATERS which does not belongs to any nations. If the fishing has happed in International waters, system should calculate direct distance from harbor where they started the trip. As described in Chaper-3 'haversine' formula to be used to calculate the great-circle distance.

Also this solution made effort to keep the higher sustainability rate of marine lives. Solution has followed two approaches.

- Apply fishing quota and define commercial fish sizes

Apply fishing quota and define commercial fish sizes

Identifying decline fish species is not covered within this project scope. This project introduces an approach how to restrict people do overfishing by applying quota and commercial fish sizes. This how the rule set should apply in this concern

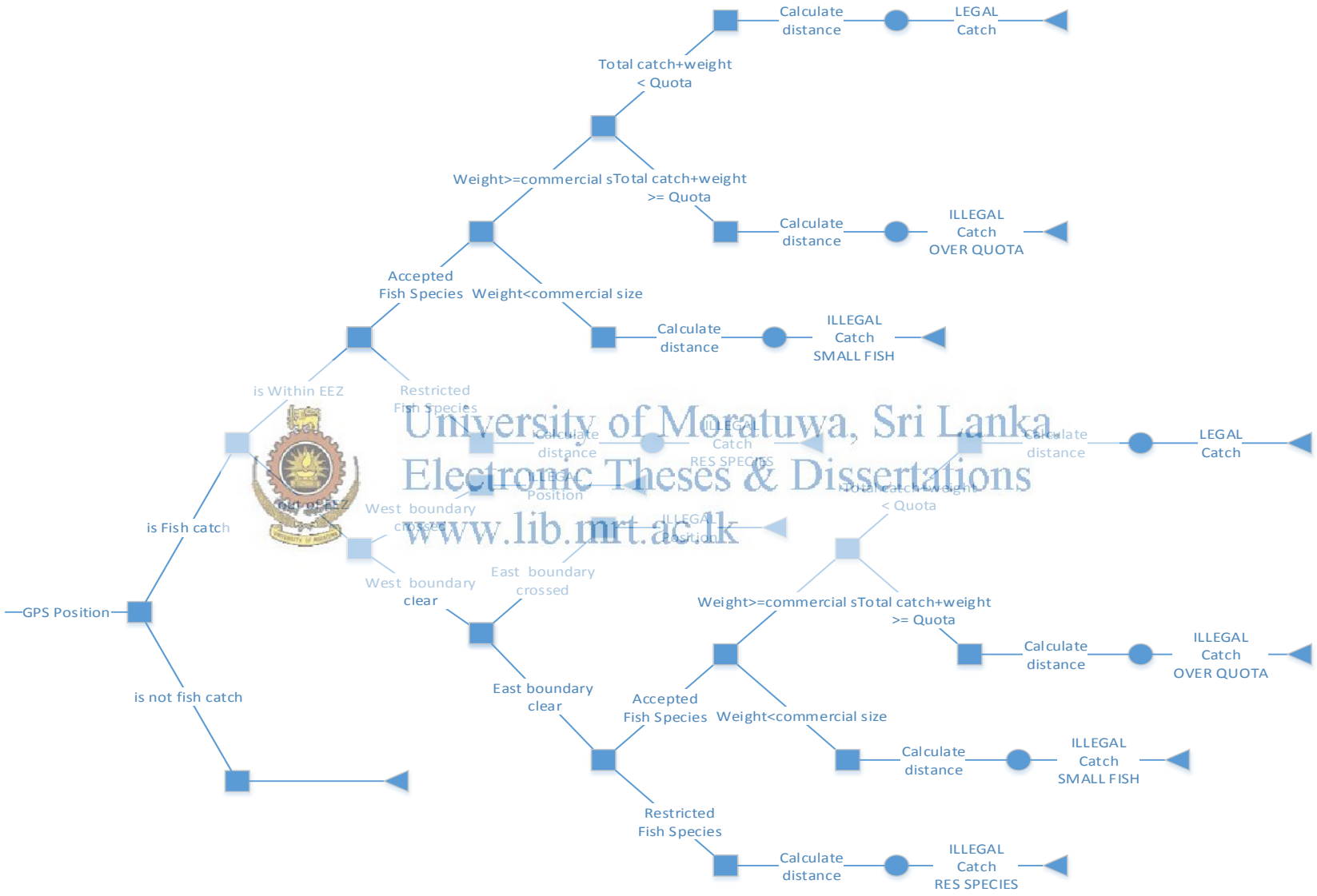

Figure 0.2 - Decision Tree - Decide fish catch legal or illegal

4.5 Land side Desktop Application

Users

Harbor officer, DFAR officers

Inputs

Vessel details, Skipper details, Device information (device that uses Smartphone APP), Trip details, Fish species information

Outputs

Visual representation of marine boundaries and zones, Visual representation of trip route, Visual representation of fish catch positions, GPS coordinates of each position, distance from harbor, Distance to West and East boundaries.

Reports- Trip route verification report, Trip summary, Catch certificate, Trip route detailed report, etc.

4.5.1 Overview of Desktop Application

Desktop application is a combination of desktop application development technologies and reporting capabilities. Desktop application to be implemented for harbor officers and DFAR offers' use. Main administration part to be executed here. The trip verification done at the Web application will be converted to a printable version at this point.

4.6 Summary

This chapter introduced a new approach to eliminate illegal fishing from Sri Lanka by using smartphone application. Use of smartphone application is a part of the solution and a Web Application, a Desktop Application also interoperate to build up the complete solution. Smartphone application interact with fishermen at deep sea to capture necessary data using its in-built features and devices. Web Application involved in map construction and verification process while Desktop application convert them into printable form. This approach has covered requirements of EU and has overcome drawback of commercial VMS that failed in Sri Lanka.

Chapter 5

Design of Proposed System

5.1 Introduction

The previous chapter described the Smartphone Application based approach to eliminate illegal fishing in Sri Lanka. The presented approach is a combination of software and hardware components operate in different environments. This section described how each component has been designed and integrated. The top level designed of the system gives an abstract view to the design phase while the other respective sections describe the each module in detail.

5.2 The top level architecture

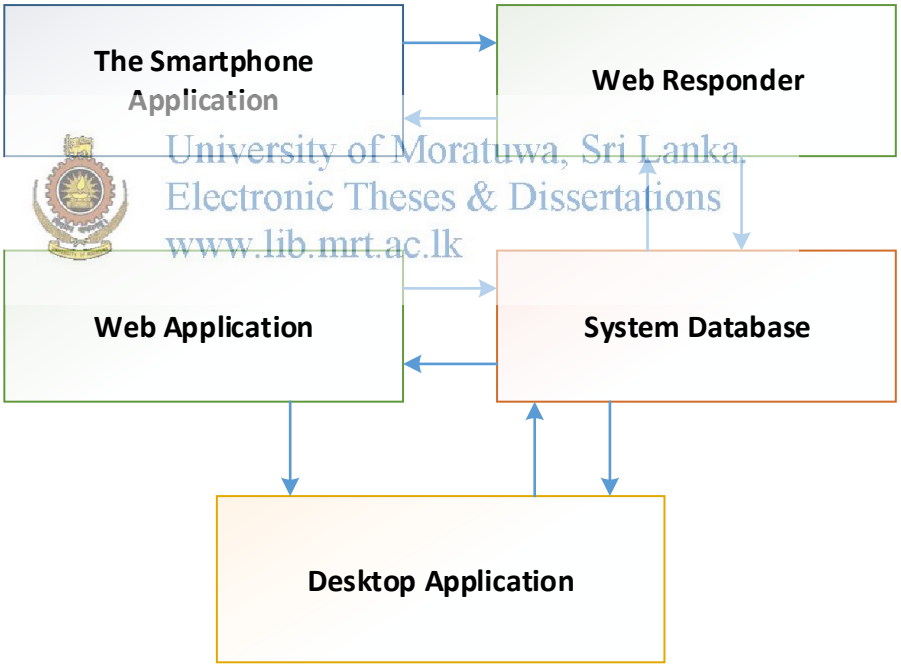

Figure 0.1 – Top level architecture of the proposed system

The top level architecture of the proposed system comprises of five main components, namely The Smartphone Application, Web responder, Web Application, Desktop Application and System Database. Figure 5.1 shows the interaction among them. Mainly these components are different from each other by their occasion. When consider the technology, these five components use four different technologies as Smartphone application development, Web application development, Desktop application development and database technologies.

The Smartphone application has been designed to use on-board by fishermen. The smartphone Application is not just a software application. That is a combination of software and hard ware components of the smart device. This is the only module which works with hardware components in this project. Identify vessel's position using in-built GPS receiver and record details, record fish catch details using on-board scale figures and user inputs and transfer those details to Web Responder application component are the main tasks of the smartphone component.

Both 'Web responder' and 'Web application' are web applications to be developed using web development technologies. The Smartphone application necessarily be a Native mobile application since it has to operate non-internet zone and has much work to do with hardware components. To reduce the workload that Native Mobile Application does and increase the data security during the transmission, a Web Mobile Application module integrated to perform data transmission between Smartphone and system database. Since the Web mobile application does not have facilities to directly talk to the system database, it talks to intermediate web application 'Web Responder'. Then Web Responder communicates the database. Connection between smartphone and web responder is a Web connection and Web responder to database is a database connection. This makes smartphone communication simpler hence no database connection handling is required.

The Web application component has considerable weight in this project. It does couple of jobs. It uses Google Maps API to give a graphical representation to the data provided by smartphone application. Without the web application, data provided by smartphone application is just number and no meaning at all. The web application component uses Google Maps API to graphically represent where the vessel is and where they catch fish. It plots all point on a world map and draw the path that vessel sailed. In the same way it draws important marine boundaries and mark marine zone around Sri Lanka.

Desktop application is the administration console provided for harbour officer and DFAR officers to interact with the system. The web application is integrated here for desktop application users access its features. Also the desktop application converts data into printable form.

5.3 Smart Application Design

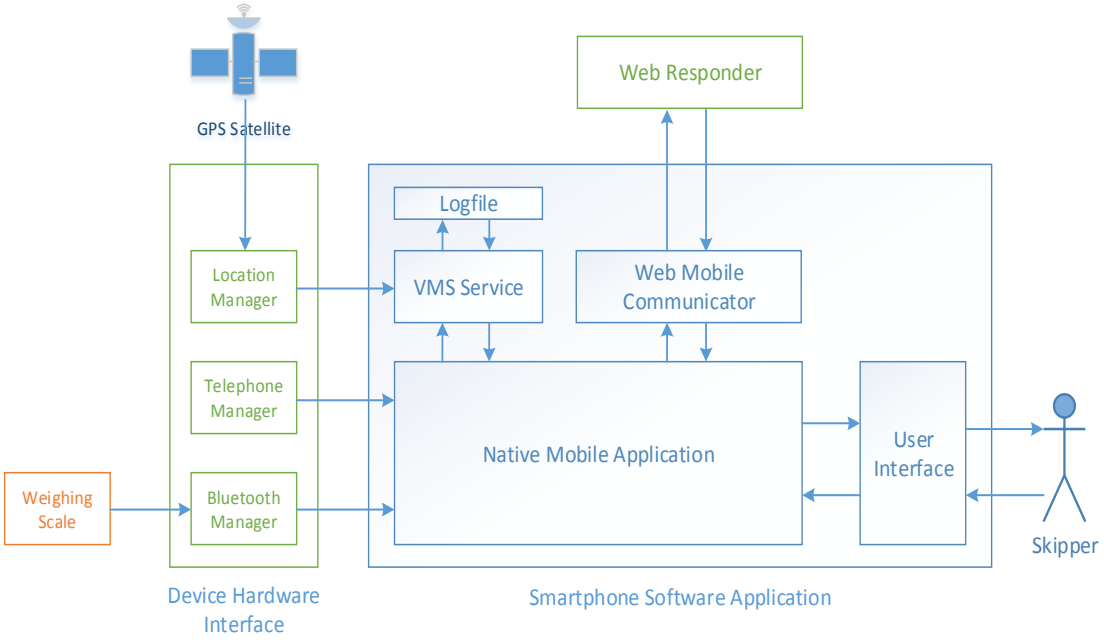

Figure 0.2 – The architecture of Smartphone Application

Figure 5.2 shows the architecture of the Smartphone application. The application has four modules named as User Interface, Native Mobile Application, VMS Service and Web Communicator. User Interface module provides graphical user interfaces to interact with users. Implementation of User Interface module should be in all three languages. The native mobile application does the main operation. It directly communicates with service such as VMSService and Web Mobile Communicator and also communicates with its hardware interface through its operation platform. VMSService is also a part of the native mobile application but runs as a service with separate life cycle. VMSService communicates with Location Manager in regular time intervals and store vessel's position in Log file stored in internal storage. Since it is running as a service with separate lifecycle, there is no harm even the user kill the UI application. Web Mobile Communicator is the part which communicates with outside the application. That is a Mobile Web application with a separate lifecycle so changes to UI application lifecycle does not effect this process.

Main application and VMSService working very closely with its built-in hardware interface with the help of operating system support. The location manager access the GPS satellite to obtain vessel's GPS coordinates in regular intervals. To make fish

weighing recording easier, Bluetooth enabled scale can be connected through inbuilt Bluetooth manager enable data flow from scale to the mobile application. Telephone manager gives some information about device such as device ID (IMEI), Network type, Network signal strength, battery level, etc.

5.3.1 Native Mobile Application and User Interface module design

Hence the user interface module interconnected only with the native mobile application, it is easy to design them together. The user interface design in application should match the literacy level of Sri Lankan fishermen. Hence it has to develop all its UI in English, Sinhalese and Tamil. Language selection should be easily done by user at any occasion. So the welcome screen may have a language selector. Smartphone application has three main processes which have user involvement. The UI should have a panel to select these three options.

- Display Dashboard.
- Launch VMS.
- Operate E-Logbook.

5.3.1.1 Display dashboard – Process design

Device registration process to be followed before a smart device use as a Smartphone VMS App. Trip registration process to be executed before starting a fishing trip. Trip registration process record data against the smart device identification ID. Usually the device ID is its IMEI. *All administration processes are comes under desktop application and describe later this chapter. VMSLogFile is a log of user action and system failures.*

Dashboard is a place where users can get the information about the device and registered trip.

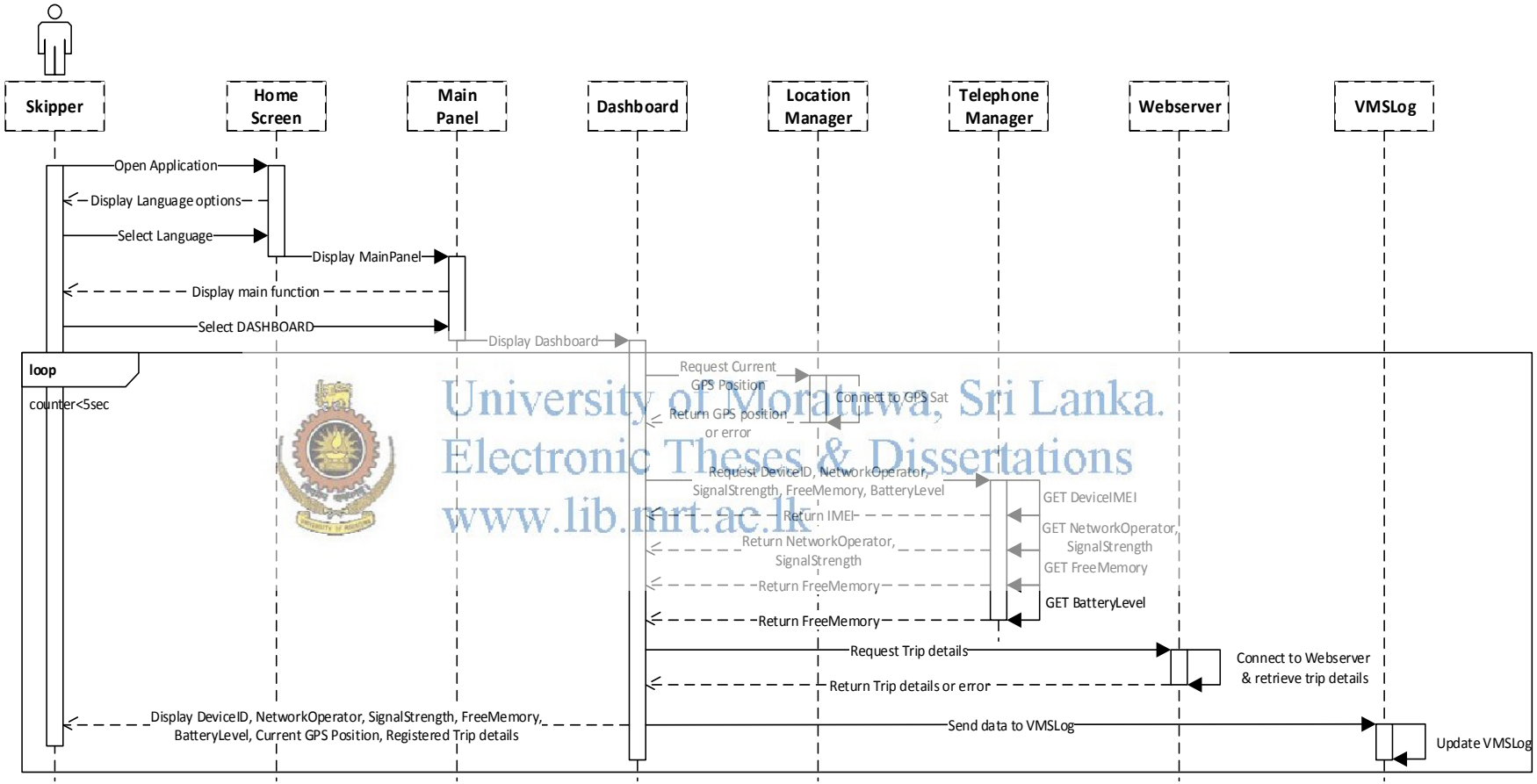

Figure 0.3 - Sequence Diagram - MobileApp - Display Dashboard

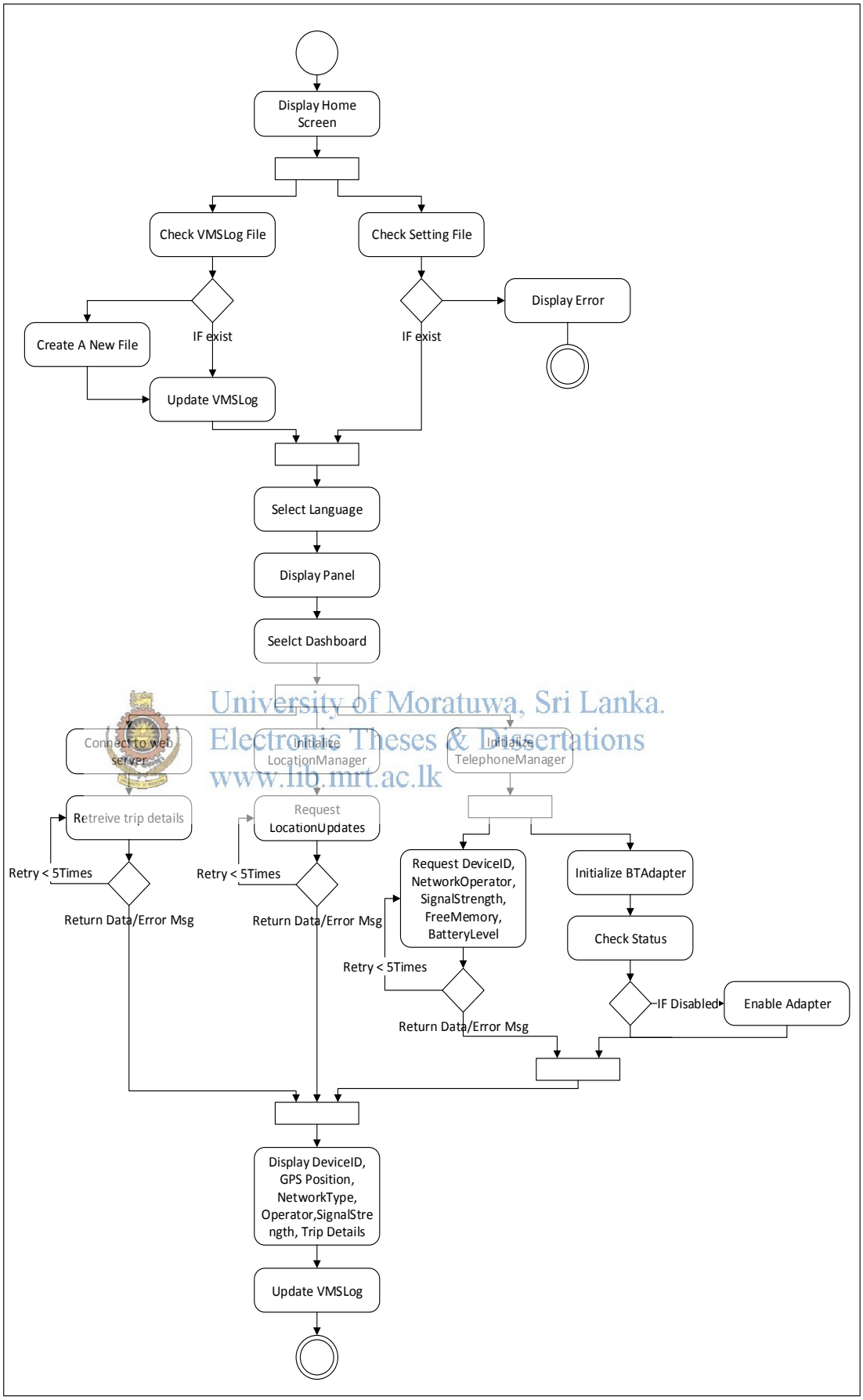

Figure 0.4 - Activity Diagram - MobileApp - Display Dashboard

5.3.1.2 Launch VMS – Process design

Launch VMS is the process that starts 'VMSService' service. This process has to be run before the vessel leaves the harbor. This process has couple of verification steps before staring the service. Once the service started the vessel can start the fishing trip. Initial verification processes are,

- Check the availability of relevant hardware components

It is important to check the condition of hardware components before starting the service since the vessel about to leave for fishing. Hardware failure may cause data loss of entire trip. For instance GPS receiver, Bluetooth adapter and Mobile data network access to check before starting the service. The application needs at least 100Mb free space on internal device. That also has to be checked before starting the trip.

- Obtain registered trip details for the smart device

Trip registration is to be done at harbor using the desktop application by authorized officers. That grants permission for fishermen to leave for fishing. Registration process adds a new entry to the records set with Vessel ID, Skipper ID, etc against Device ID. That point onwards Device ID represent the relevant trip details. *Trip registration process describe in detail later this chapter.* At the second step of the verification process, smartphone application request trip information from database by sending its ID. Process will not continue if relevant records are unavailable.

- Pair Bluetooth scale and do initial calibration

Scale to be linked with the system via Bluetooth adapter to get fish weights for E-Logbook records. The phase pair the provided Bluetooth scale and perform initial calibration to identify any calibration issues.

- Validate trip duration.

Trip start and End dates are set during the registration process. VMS launch process checks the current date and time against the scheduled date.

If all these verifications are true, it starts the 'VMSService' service with a separate lifecycle.

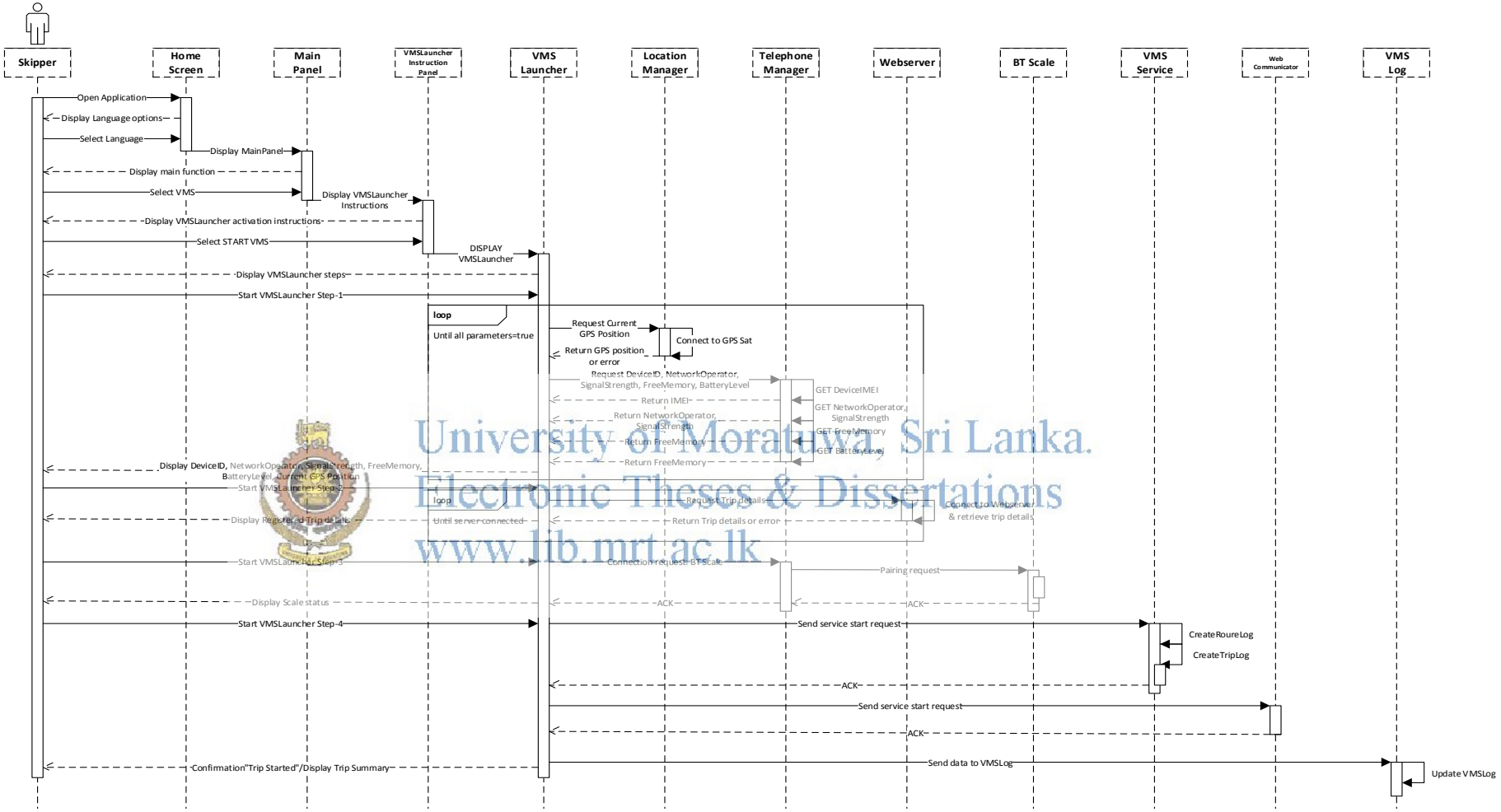

Figure 0.5 - Sequence Diagram - MobileApp - Start VMS

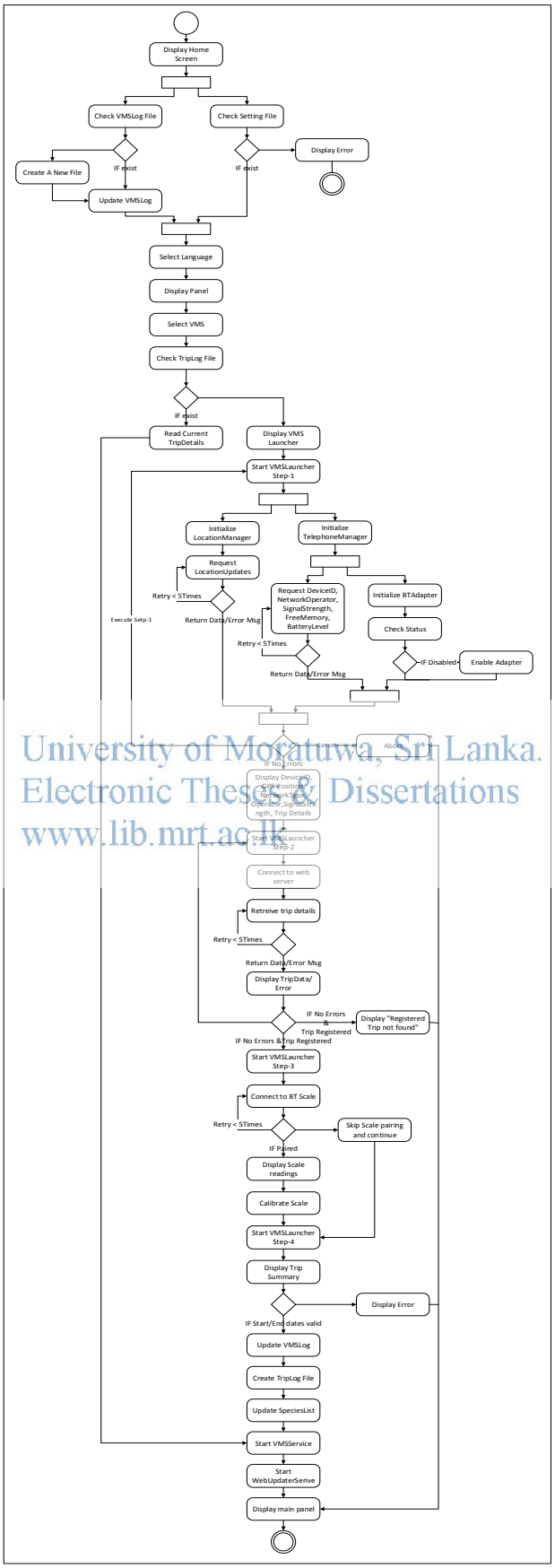

Figure 0.6 - Activity Diagram - MobileApp - Start VMS

5.3.1.3 E-Logbook – Process design

Fish Logbook is a concept in fisheries industry which has been implemented to collect fish catch statistics for various decision making and research purposes. Catch details without its marine positions are bit helpless for such decision making. Logbook basically records fish species type, fish weight and GPS coordinates of where they catch fish.

E-Logbook system comes as a part of the main native mobile application. It has couple of inputs as,

- User select fish species type.
- GPS coordinates from GPS receiver.
- Weight figures from on-board scale.
- Fish species details from data source.

Basically it has four processes.

- Arrange fish species list

The fish species list is not static. That should be updated occasionally. System database has a different table to store fish species names in all three languages. During the VMS registration process, a copy of species list in the database table will be stored in smart device's internal storage. Every time this section loads, fish species list need to arrange on UI according to the selected language.

- Obtain weight figures from scale.

Fishermen weigh their fish harvest when recording them. The application should have the capability of receiving weight figures if the use Bluetooth enabled scale. Then the fishermen do not need to feed the weight figures manually.

- Obtain GPS coordination

Obtaining GPS coordination is a common practice in this system. E-logbook part also need to obtain GPS coordinates at the time of catch recording. Then all these information to be recorded in a file and Web Communicator service will pick record at a time and send to system database in land side.

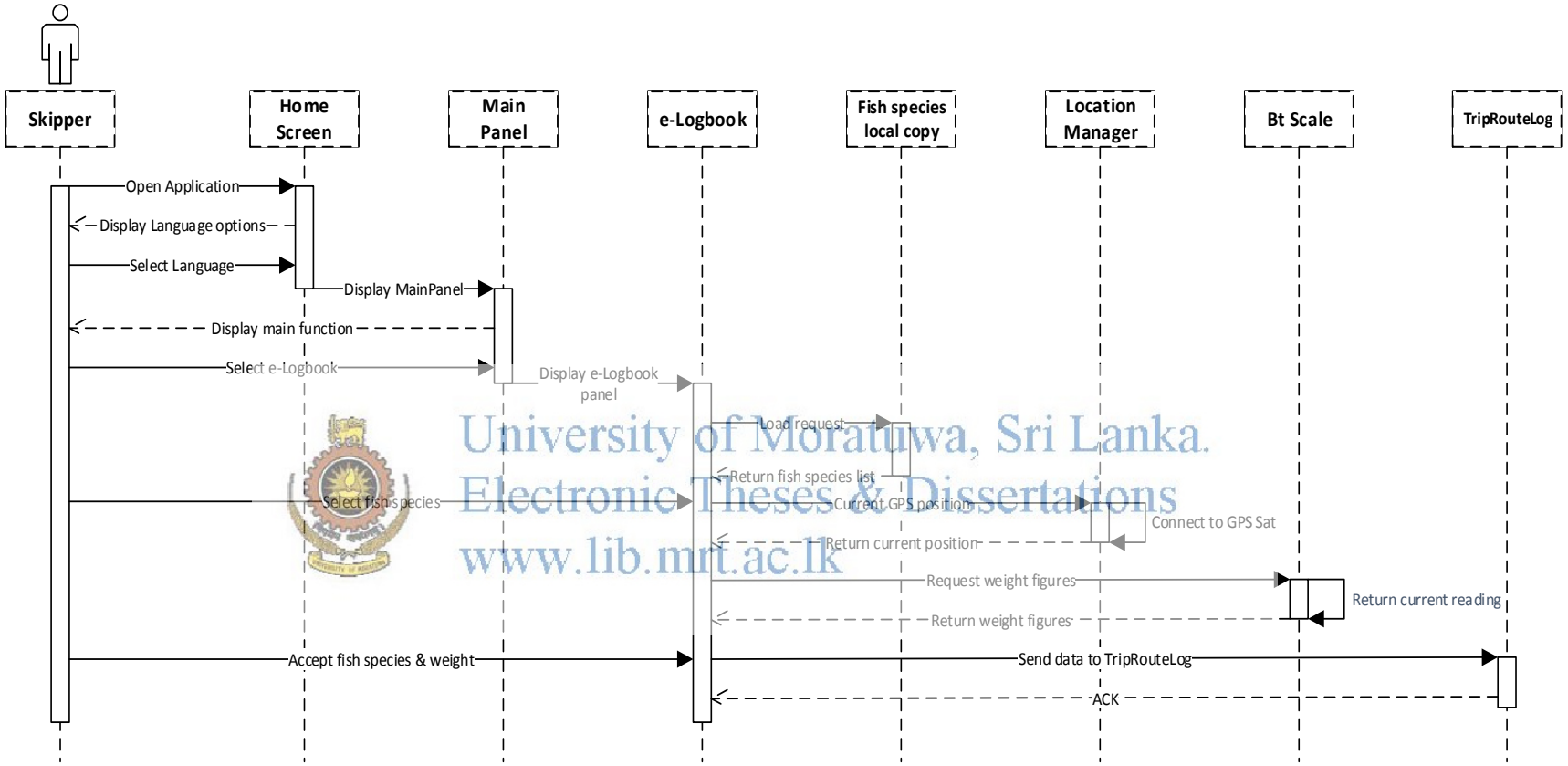

Figure 0.7 - Sequence Diagram - MobileApp – e-Logbook

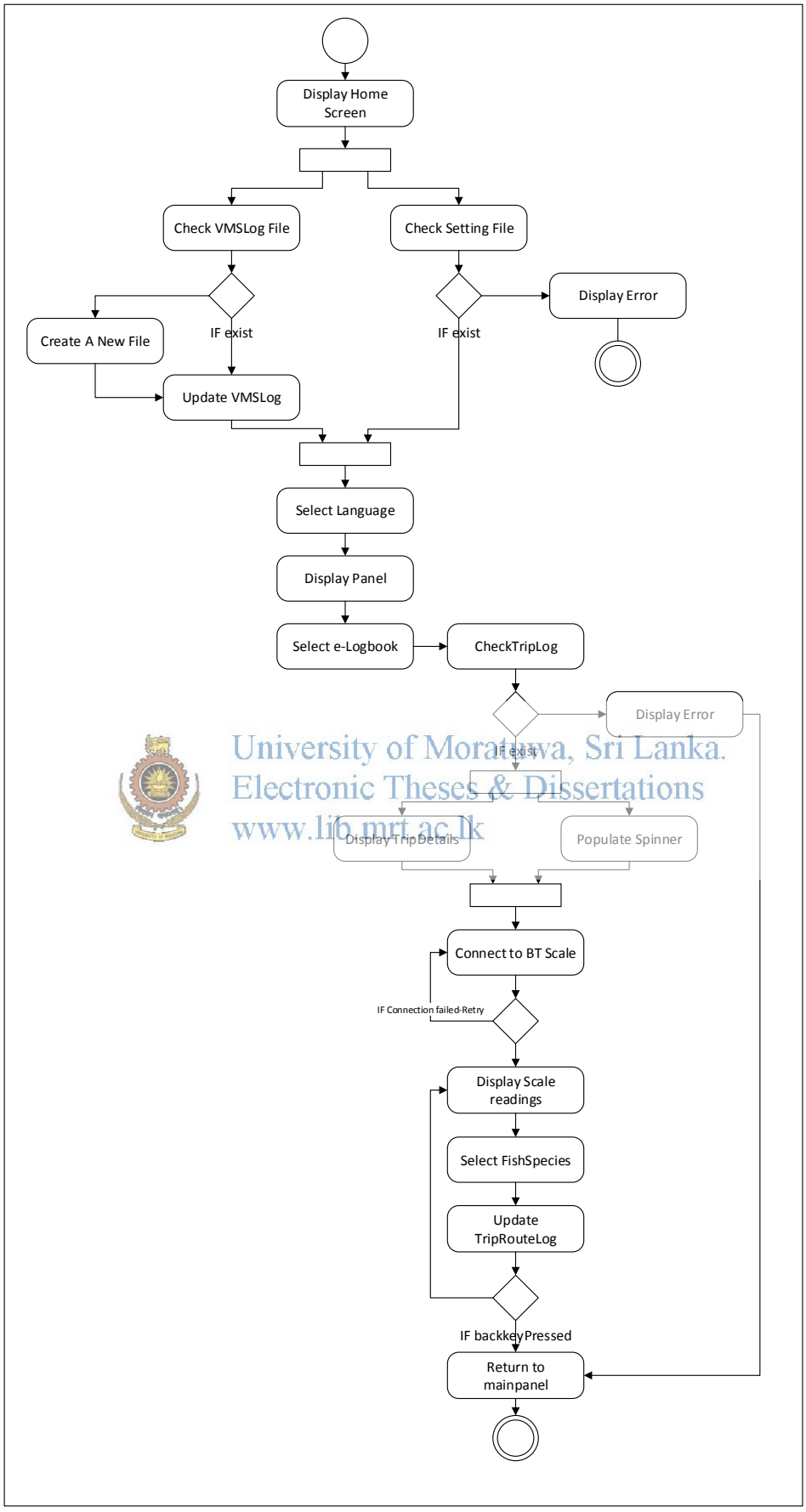

Figure 0.8 - Activity Diagram - MobileApp - eLogbook

User and other external entity interaction with VMS and E-Logbook system

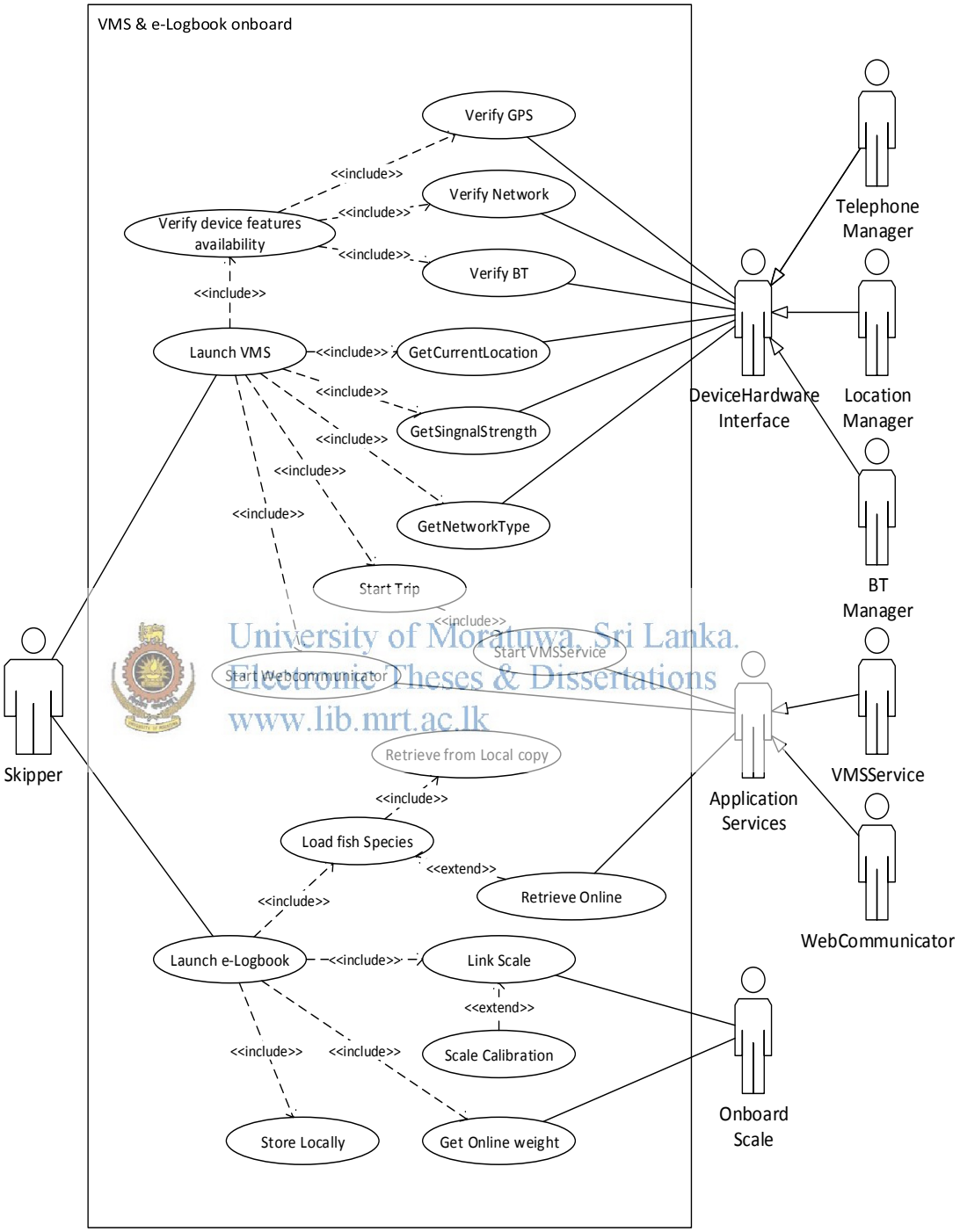

Figure 0.9 - Use Case Diagram - MobileApp - Launch VMS & e-Logbook

5.3.2 VMSService module design

VMSService is a service comes as a native mobile application with a separate lifecycle. This service has been designed to work closely with its hardware interface. Main application starts this service during the trip registration process before leaving the harbor. At first point it instructs the Web Mobile Communicator *(Describe in next section)* to update the system database by passing the GPS coordinates of the position it starts the service. This verify first GPS coordinates will be considered as the start point of the trip. Also considered as harbor. During service starting process, main programs will set time duration between iterations. For instance if it is 1 hour, VMSService will go on pause mode for 1 hour after each execution. Iterative execution will obtain GPS coordinates (trip route coordinates), Battery level (as a fact that helps to investigate reasons for undesired occurrences), Signal Strength (fact that identifies whether device under mobile or satellite coverage) and store them in a structured file with current data and time. Apart from iterative executions, main application may resume this service on demand. For example, when e-logbook system needs to record the fish catch it passes fish species index and weight to VMSService. VMSService resumes its operation and record the fish catch with data from hardware interfaces (Specially GPS coordinates). Then it goes pause mode again until next iteration or any walkup call.

5.3.3 Web Mobile Communicator module design

'Web Mobile Communicator' is a combination of Native and Web Mobile application technologies. This is running as a service in the background with no UI. It has a separate lifecycle so no matter what happen to the main application. This is the only module in smart device which communicate to outside. This service basically talks to the 'Web Responder' web application in land side. Same as the VMSService, this service also has an iterative execution. Before the original data communication take place, it sends a web request including trip ID and wait for acknowledgement. If the acknowledgement doesn't come before the timeout, service decide the web server is unreachable. If acknowledgement comes, it comes with last record index updates in database relevant to the trip. Then service start sending records which have not been updated.

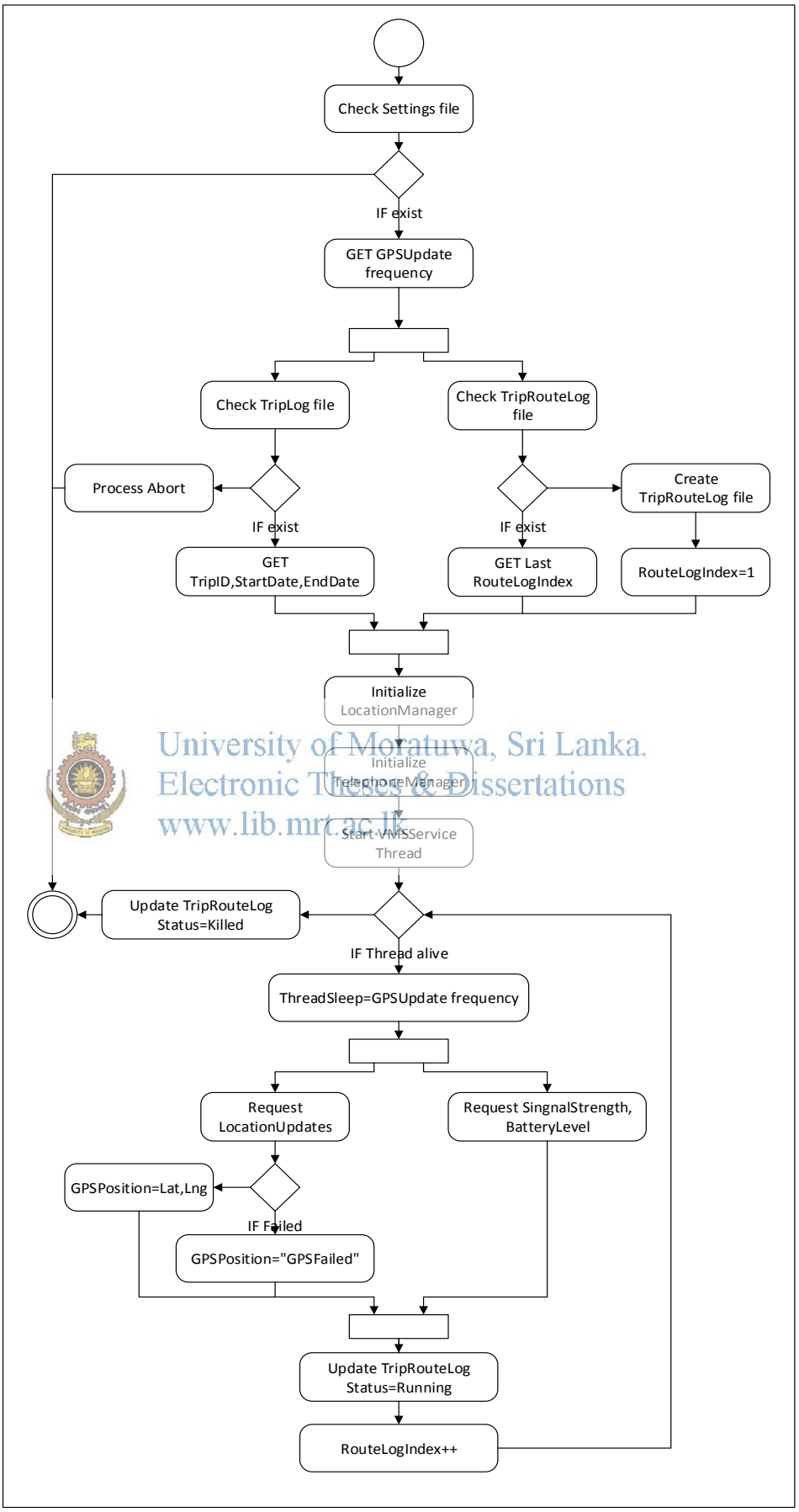

Figure 0.10 - Activity Diagram - MobileApp – VMSService.

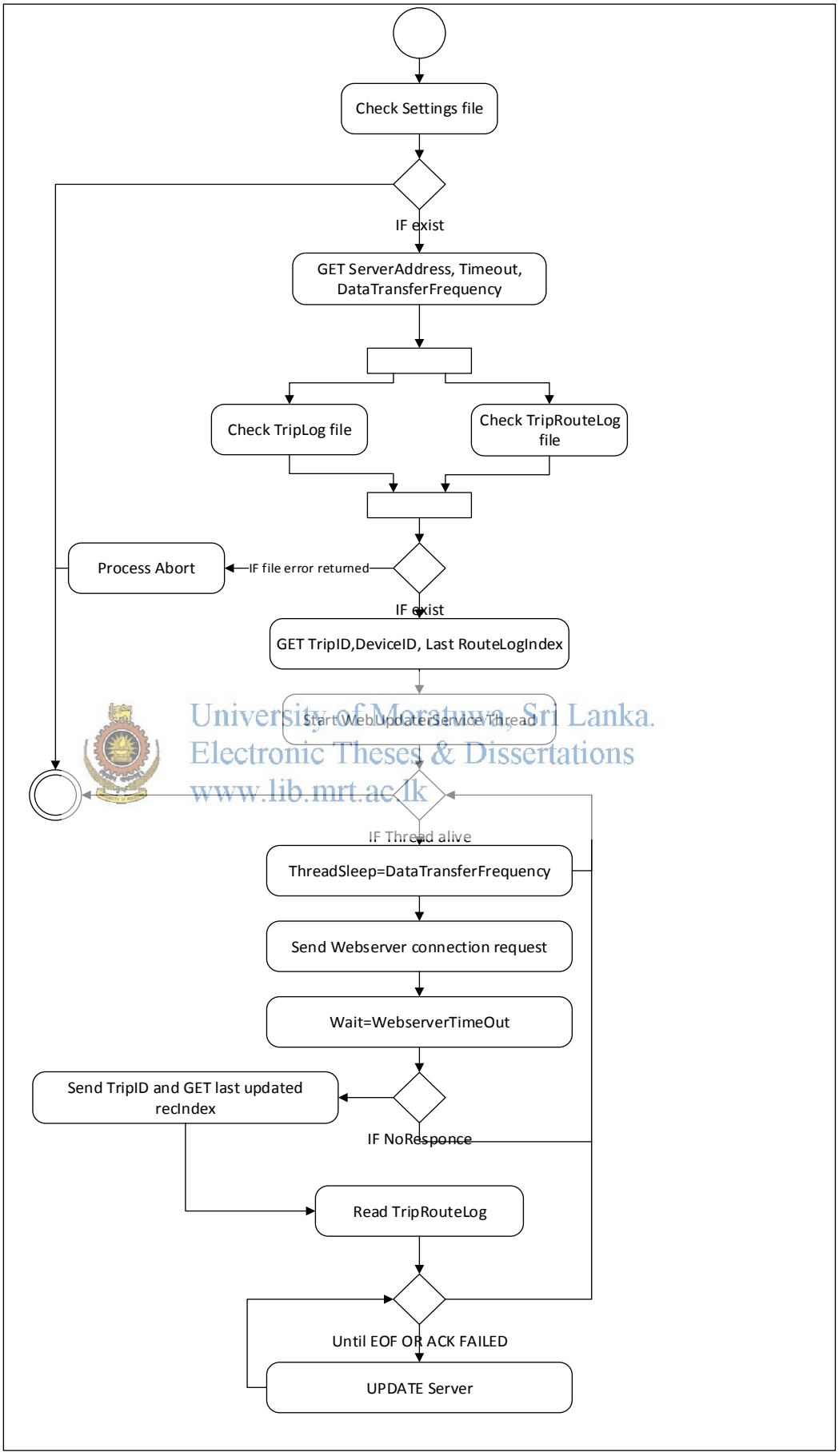

Figure 0.11 - Activity Diagram - MobileApp – WebUpdaterService

5.4 Desktop Application Design

Desktop application has two main modules to serve its users. Administration module handles all the administration processes while reporting module turns data into printable form. The administration module has,

- Trip registration process
- User management processes
- Vessel registration process
- Control box registration process
- Skipper registration process
- Device registration process
- Manage fish species process

and reporting module has report generating processes.

User management processes basically cover adding system users, assigning security levels, auditing user events, etc. Hence such processes are common in many systems, here it does not described in detail.

5.4.1 Administration module design

5.4.1.1 Trip Registration – Process Design

According to the users view point, Trip registration is the process that grants permission for fishing. That is to be executed before commence of each commercial fishing trip by harbor officers.

A trip has a,

- Trip ID – Unique identifier for each trip (Ex: 1001)
- Start Date – Vessel to be left for fishing on or after this date (Ex: 02/01/2015)
- End Date – Vessel to be landed on or before this date (Ex: 16/01/2015)

A trip ID denotes a fishing trip assigned to a fishing vessel. So the trip has a,

- Vessel ID – Unique identifier for each vessel (Ex: IMULA0001NBO)

Each vessel has a control box. (Control box is a hardware unit used on-board in this project for several security reasons. Find detail description in Implementation chapter) Control box has a unique identifier

- ControlBox ID - Unique identifier for control box (Ex: 00-1C-C0-DF-34-91)

Fishing trip has skipper and he uses his smart device for his VMS. So trip has a,

- Skipper ID - Unique identifier for Skipper (Ex: 663600602V)
- Device ID - Unique identifier for device (Ex: 35588505944100)

See the Entity Relationship diagram for more details

Trip registration process creates a trip by linking relevant entities.

5.4.1.2 Vessel Registration – Process Design

Vessel registration process store vessel's details in the database. A vessel is uniquely identified by the vessel number issued by DFAR. Unique number generation is not required here. Each fishing vessel has a license issued by DFAR permitting to do fishing at internal waters. This project identify it as VLBNo or Fishing License Number. Obviously vessel registration process need to work closely with DFAR to obtain necessary details. Since the DFAR does them in manual form, this project has to enter license information manually. Registration number, license number, license validity period are the mandatory fields in this process while vessel name, owner's details, etc are optional.

5.4.1.3 Control box Registration – Process Design

There is no way to identify vessel electronically. This project has a challenge. After the registration, device ID represent the vessel number. But there is no way that device can know whether it has located inside the correct vessel. For example, Trip ID 1001 denotes IMULA0001NBO's fishing trip and device on-board is 35588505944100. When land side receive data from device 35588505944100, it assumes that data belongs to IMULA0001NBO's current fishing trip. But there is no guarantee that is IMULA0001NBO. Since the device is mobile, that can be taken to another vessels. Control box has been designed to avoid this problem. Control box has a Bluetooth transmitter connects to on-board device. Registration process tells the control box ID (MAC address if Bluetooth transmitter) to smart device and smartphone application

creates a link with the control box when it comes on-board. When the link broken we assume that smart device has taken out from vessel. Control box registration store Bluetooth transmitter's MAC address and its PIN.

5.4.1.4 Skipper Registration – Process Design

Skippers to be registered with the system with unique identifies for their performance evaluation. The project uses skipper's NIC as the ID

5.4.1.5 Device Registration – Process Design

'Device' is the smart device which holds the smartphone VMS application. Device always link with skipper as this project use his mobile phone for VMS application. Devices to be identified by a unique ID which is the IMEI of the device. Device ID, type and model are mandatory information for device registration. Device has fallen immediately under skipper, so device belongs to a skipper.

5.4.1.6 Manage Fish Species – Process Design

All fish species legal for commercial fishing are indexed in this project. Fish species registered with desktop client will be transferred to smartphone's internal storage during the registration and will be appeared in E-Logbook page.

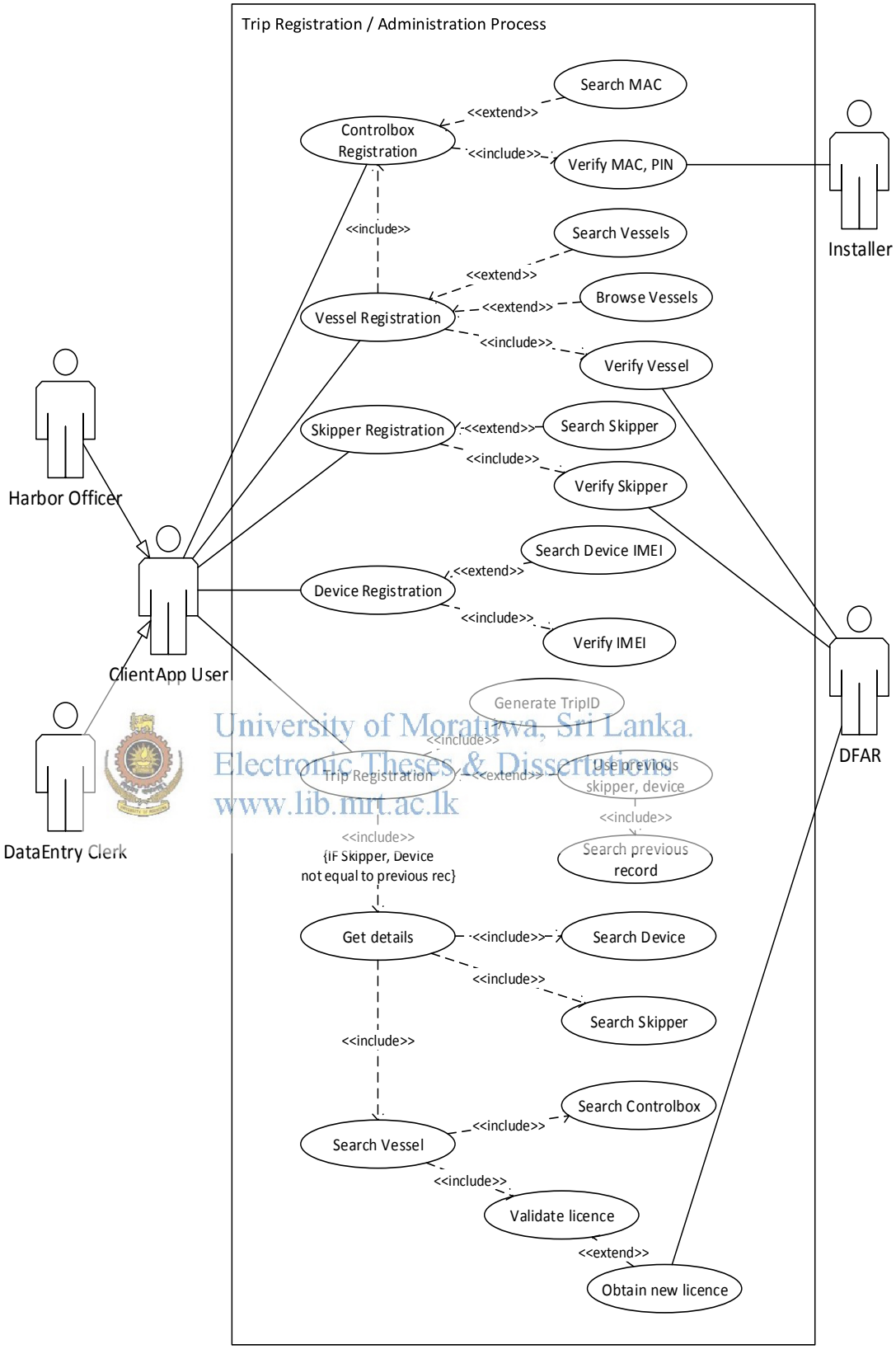

Figure 0.12 - Use Case Diagram - DesktopApp - Trip Registration & Adminstration Proce

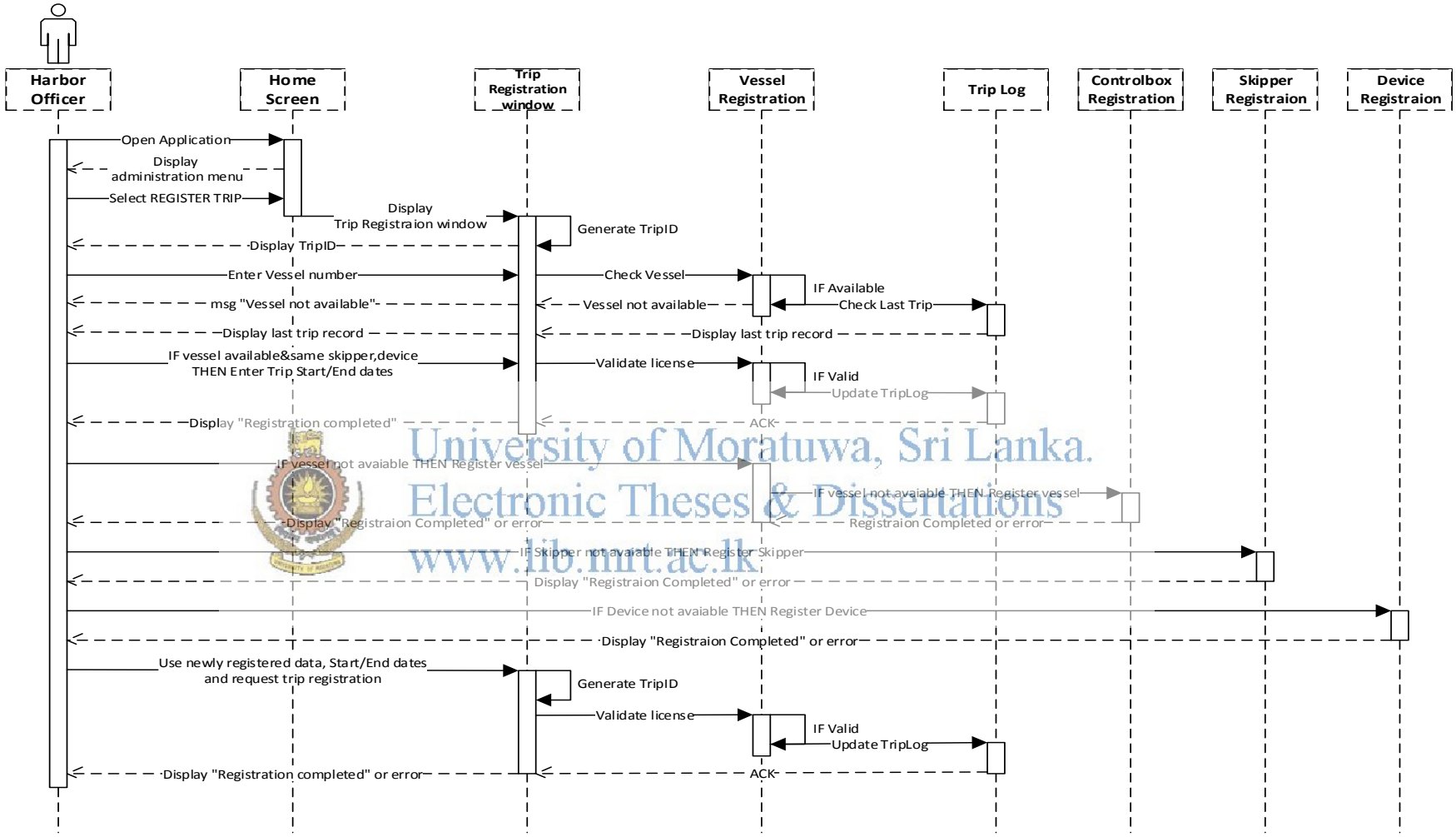

Figure 0.13 - Sequence Diagram - DesktopApp - Trip Registration/Administration

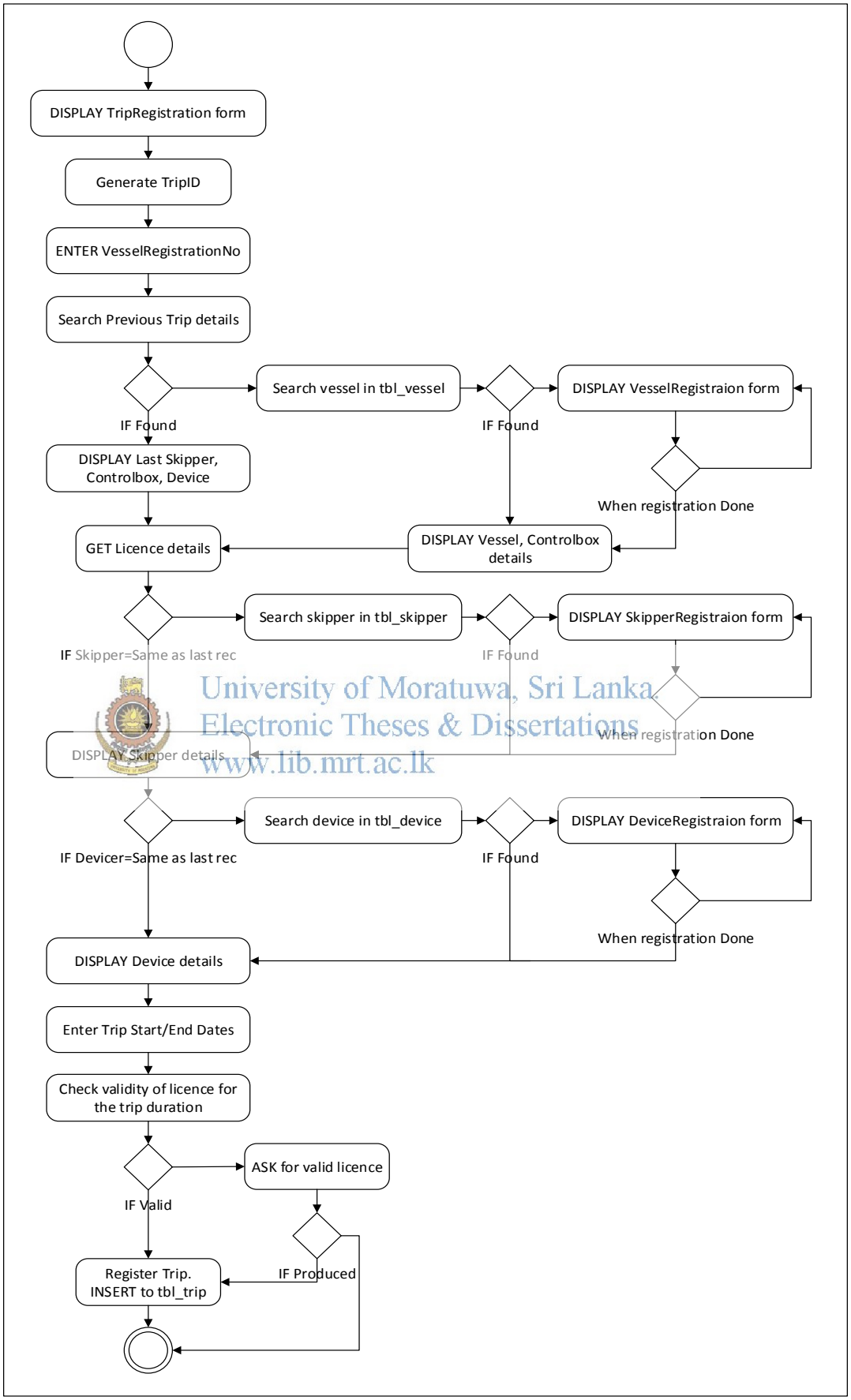

Figure 0.14 - Activity Diagram - DesktopApp - Trip Registration

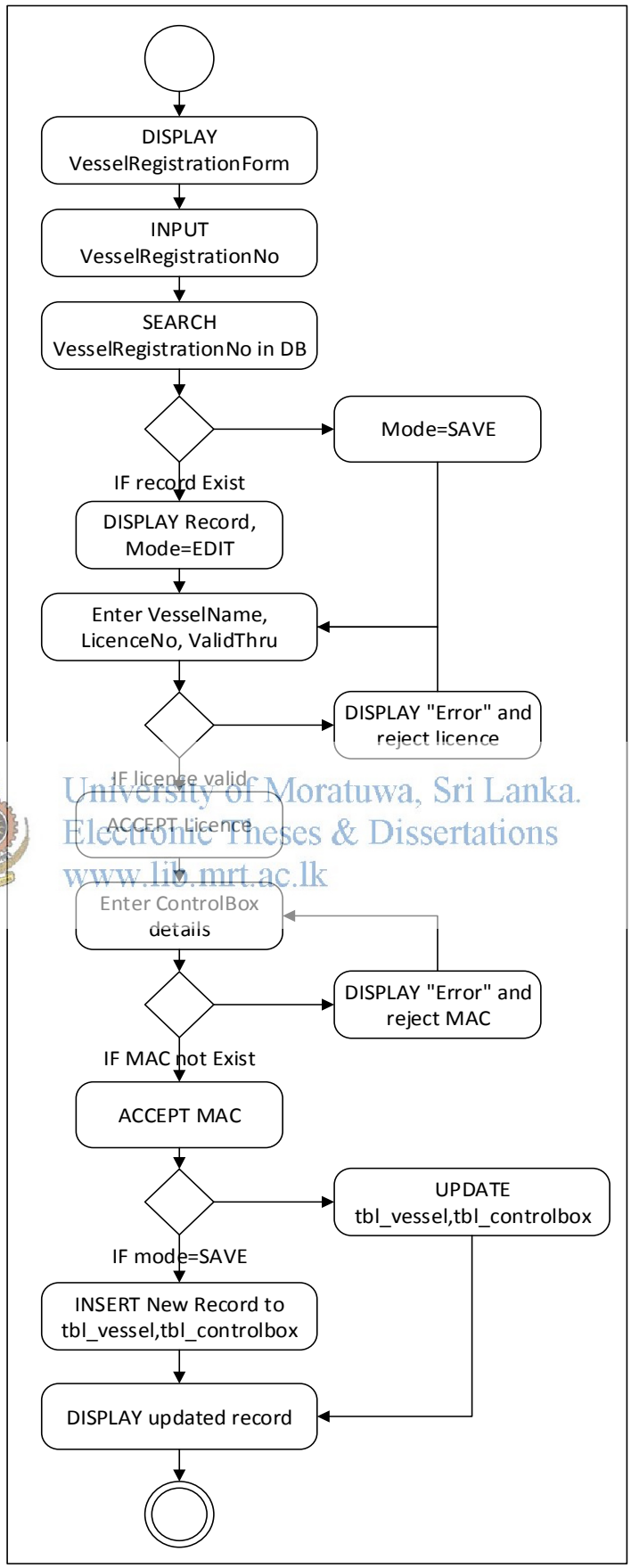

Figure 0.15 - Activity Diagram - DesktopApp - Vessel Registration

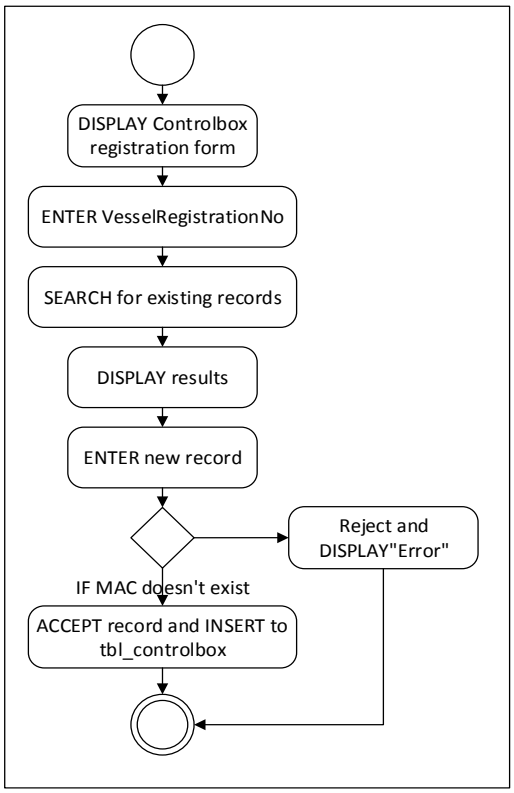

Figure 0.16 - Activity Diagram - DesktopApp - ControlBox Registration

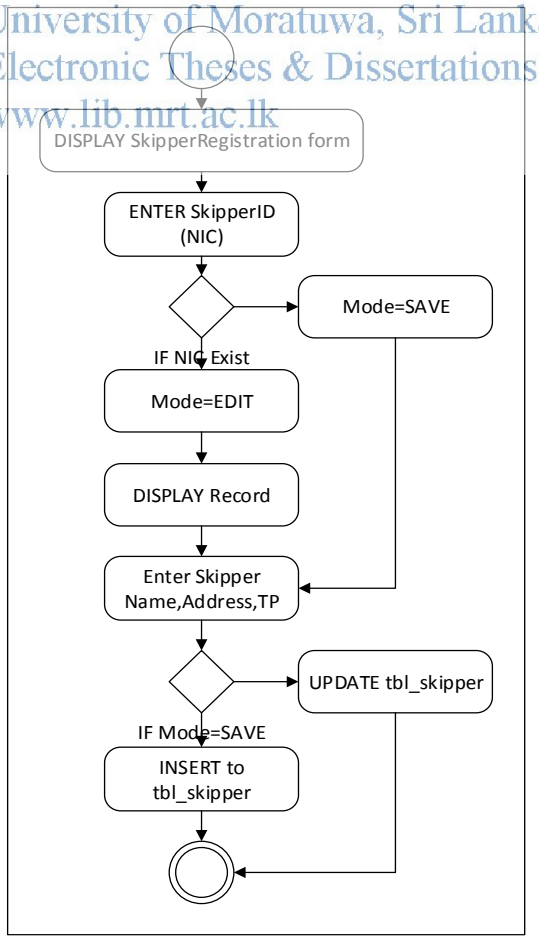

Figure 0.17 - Activity Diagram - DesktopApp - Skipper Registration

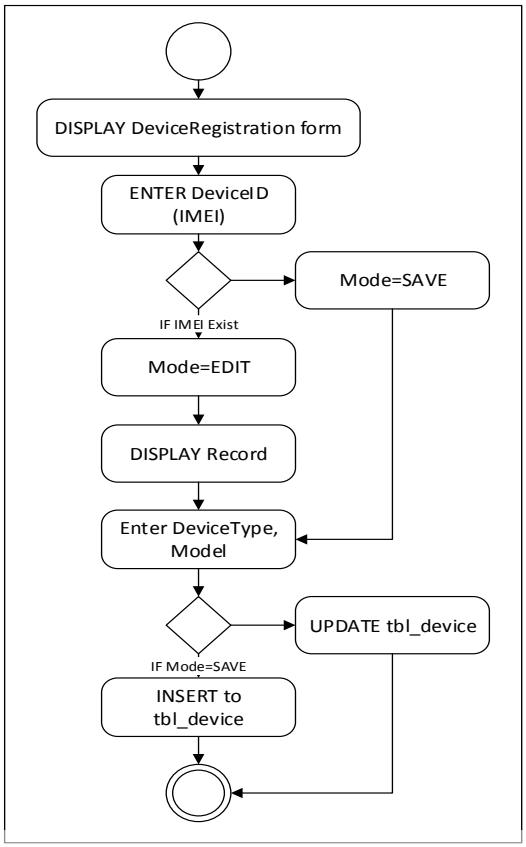

Figure 0.18 - Activity Diagram - DesktopApp - Device Registration

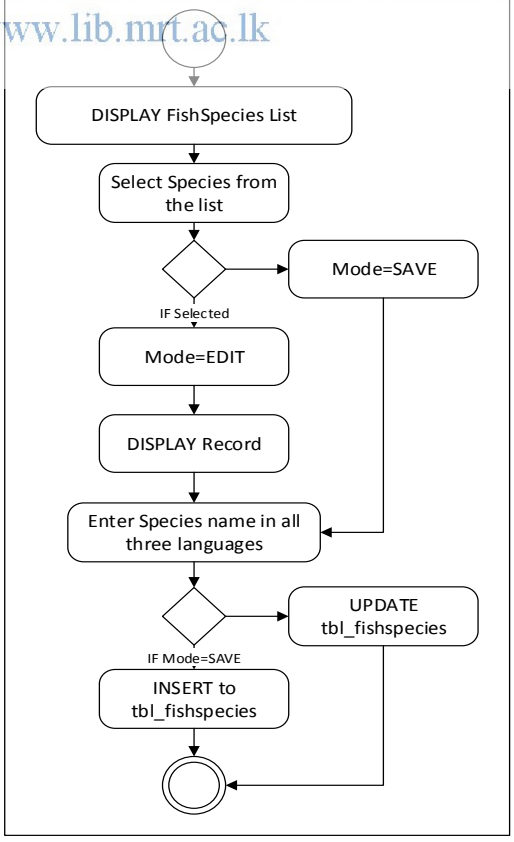

Figure 0.19 - Activity Diagram - DesktopApp - Manage Fish species

5.5 Web responder Design

The Web Responder is a web application with has no user interaction falls as an intermediate component between Smartphone application and database. This component initiate communication between smartphone apps and database. In other worlds, it combines two different technologies together and make the communication possible.

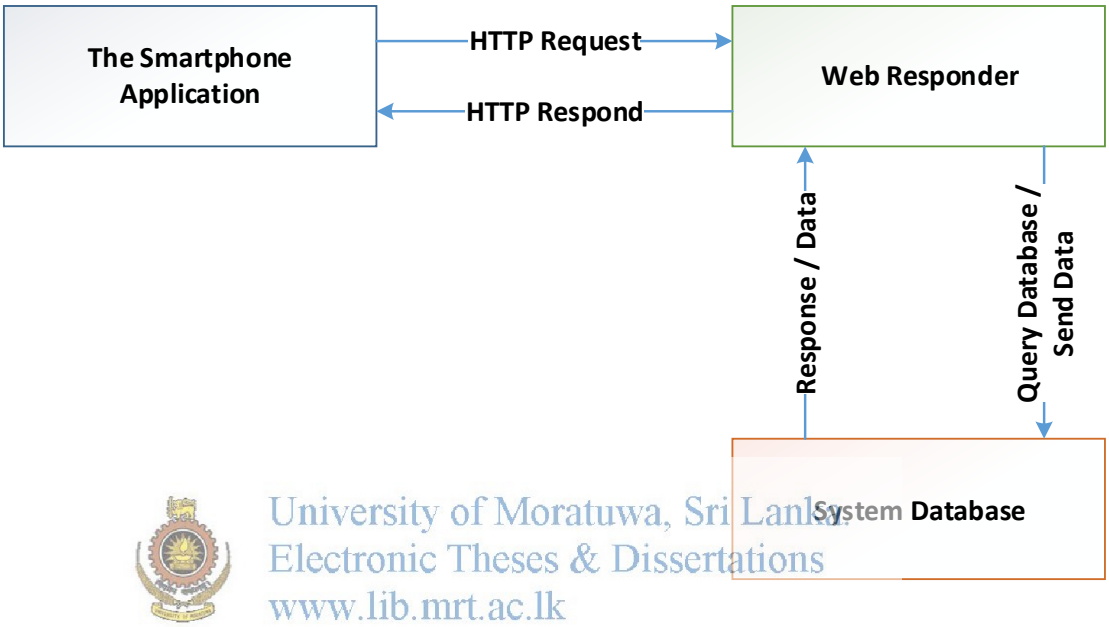

Figure 0.20 - Data flow through Web Responder

The Web Communicator module in the smartphone application component deals with HTTP requests and corresponding HTTP responses. HTTP connections cannot be directly handled by database systems. As an intermediate component, Web Responder listens to HTTP request from smartphone application, generate corresponding database query and direct to DBMS. It does the vice versa. Data from database send back to smartphone application as web responds.

5.6 Web Application Design

Web Application component is a GUI component interact with users.

- Map drawing module
- Trip data representation module
- Trip data analyzing module

5.6.1 Map drawing module

Graphical representation of trip details need a world map with related marine zones and boundaries identified. This solutions designed to use Google dynamic Maps and construct relevant boundaries and zones. Boundaries are virtual lines. Boundaries can be dynamically drawn if virtual lines can be converted to GPS coordinates. This phase of design used static map sources (See appendix) and did map tracing on Google Maps to get corresponding GPS coordinates. Positions to be stored in database with reference ID. For example, Sri Lankan EEZ boundary can be drawn using 1000 GPS points and Sri Lankan West border can be drawn using 10,000 GPS points. All such data to be organized in same format with different reference IDs. At least implementation need 3 boundaries, namely Sri Lankan EEZ, West boundary and East Boundary. Marine zones to be constructed by interconnecting boundary lines.

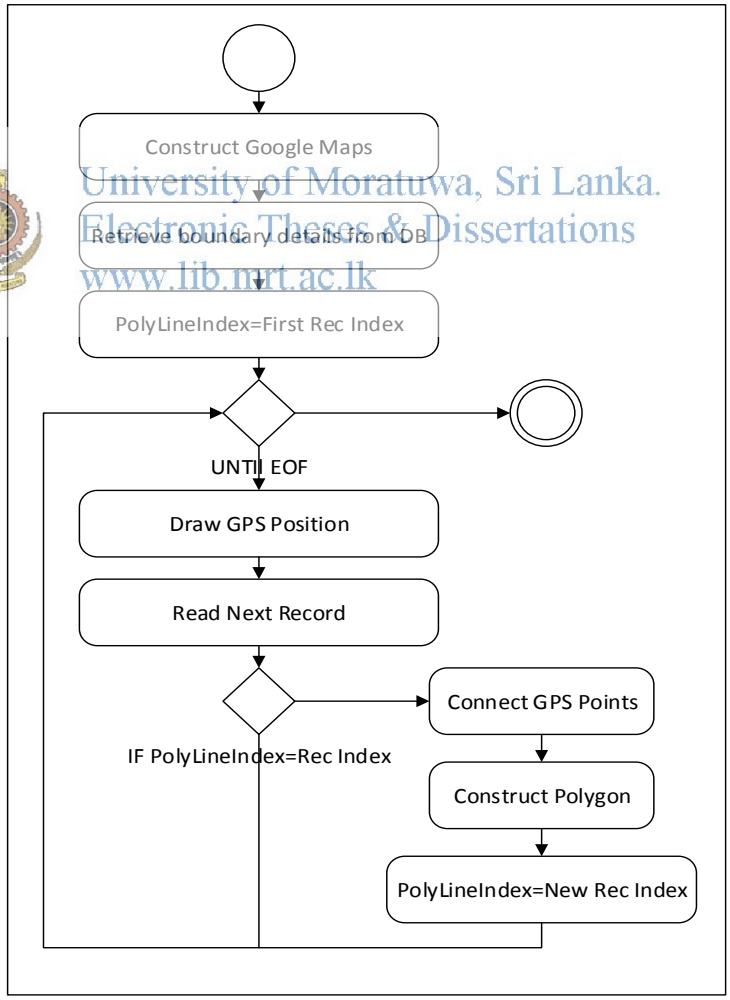

Figure 0.21 - Activity Diagram - WebApp - Draw boundaries

5.6.2 Trip data representation module

Technical functions of Trip data representation module is bit similar to map drawing module. Both uses the same technique. This module has special feature that recognize type of the GPS position data in database. For instance a GPS point can be either vessel's position or fish catch position. That has to be identified and represent in different way that users can identify them easily.

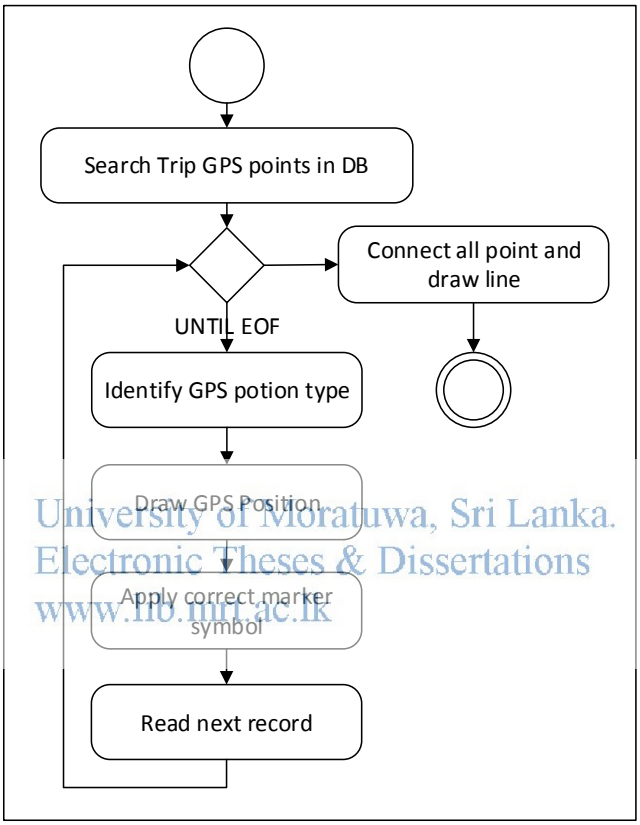

Figure 0.22 - Activity Diagram - WebApp - Draw trip route

5.6.3 Trip data analyzing module

Trip data analyzing module does mathematical calculations to find out whether GPS points are within Sri Lankan EEZ, whether it has crossed west and east boundaries and calculate the between GPS point and harbor.

Sri Lankan EEZ formed as a polygon and both West and East boundaries also formed as polygons. Data analyzing phase check each GPS point in trip route against above three polygons and store the results in database. Trip starting to considered as the harbor and distance between each GPS point and harbor to be calculated using 'haversine' formula. (Described in Chapter-3)

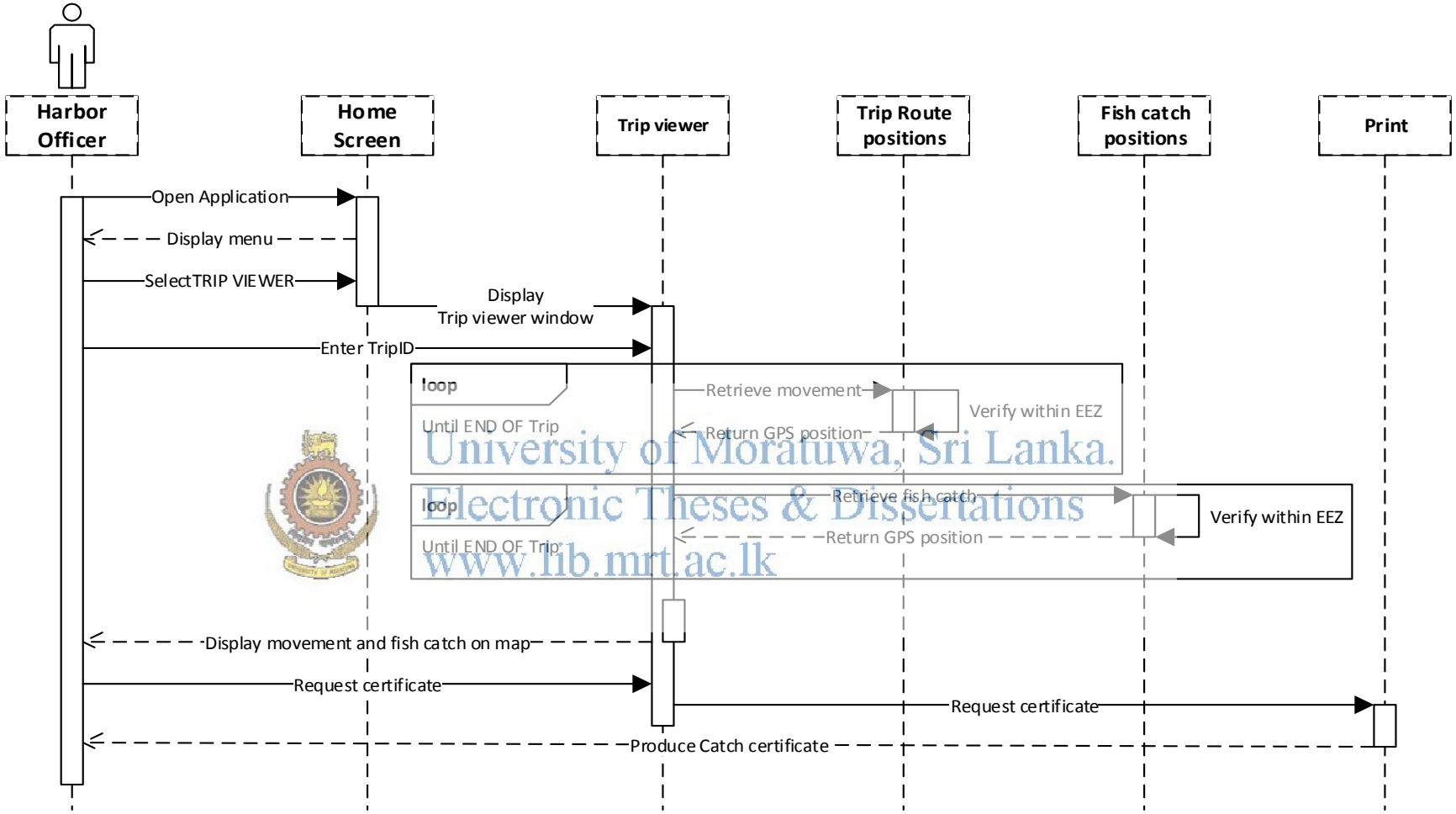

Figure 0.23 - Sequence Diagram - DesktopApp - Trip Viewer/Catch certificate issuing

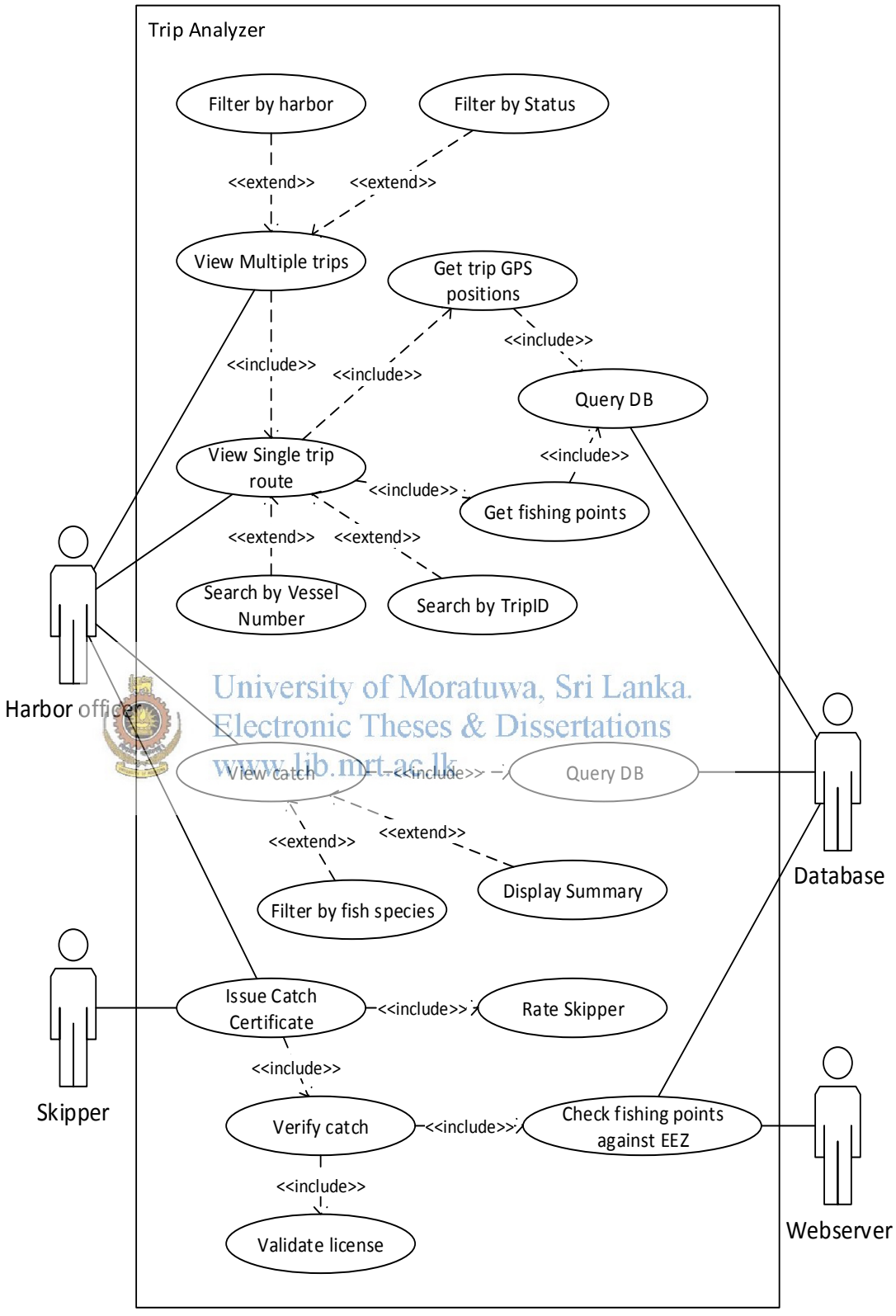

Figure 0.24 - Use Case Diagram - DesktopApp - View & analysing trips, Issue catch certificates

5.7 Database Design

There are two main purposes of designing a database architecture for this solution.

- Organize data in an effective way that storing and retrieving make easy and fast.
- Use dataset as a source for decision making and build up opportunities for further research.

Database system in this project should compatible with text, numbers and geometry data. Geometry data in this solution is not complicated as lots of work doing through computerized function. Hence it does not contain multilayer or multipoint geometry data, storing latitude and longitude in a single field would be more enough. As the project cost is a big concern, free open source solution would make a big sense.

Design of database has to consider several entities such as Vessel, Skipper, Device, Fish Species and Trip. The normalized entities should be,

- Vessel
- VesselOwner
- VesselControlbox
- Skipper
- Device
- FishSpecies
- Trip route
- TripRouteLog

Since all the entities are interconnected, relational database management system to be engaged with this project. Appropriate key to be used to avoid unnecessary data duplication and maintain high integrity.

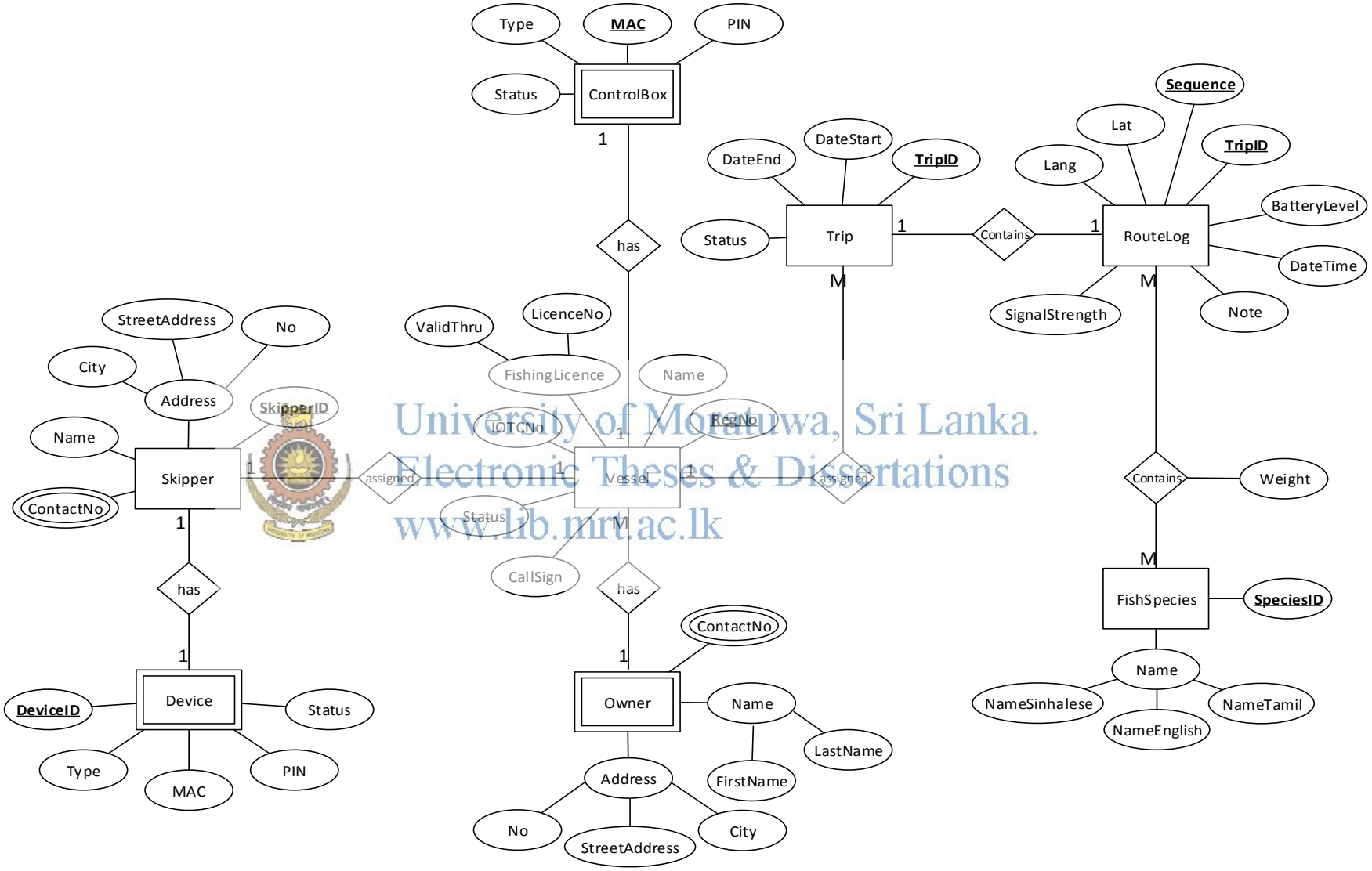

Figure 0.25 - ER Diagram

5.8 Summary

Design of this system has five main components for different purposes. Smartphone application component capture data on-board. The system database holds all necessary data for this project. Web responder establish communication between smartphone and database. Web application uses Google Maps API to construct dynamic map to represent all vessel positions and define marine boundaries and zones. Desktop application handles the administration section and generate reports based on user requirement.

Chapter 6

System Implementation

6.1 Introduction

The previous chapter described the system design of the proposed solution in detail. Design has four main components, each component has different module to be implemented by using suitable technologies. This chapter describes how available software and hardware technologies used for the implementation. Chapter starts giving an abstract idea how the final solution looks like and other respective section describe how each module described in design chapter are implemented. Please note all code fragments are not included in this document to avoid document get unnecessarily lengthy. Find full code in CD-ROM.

6.2 Abstract view of implemented solution

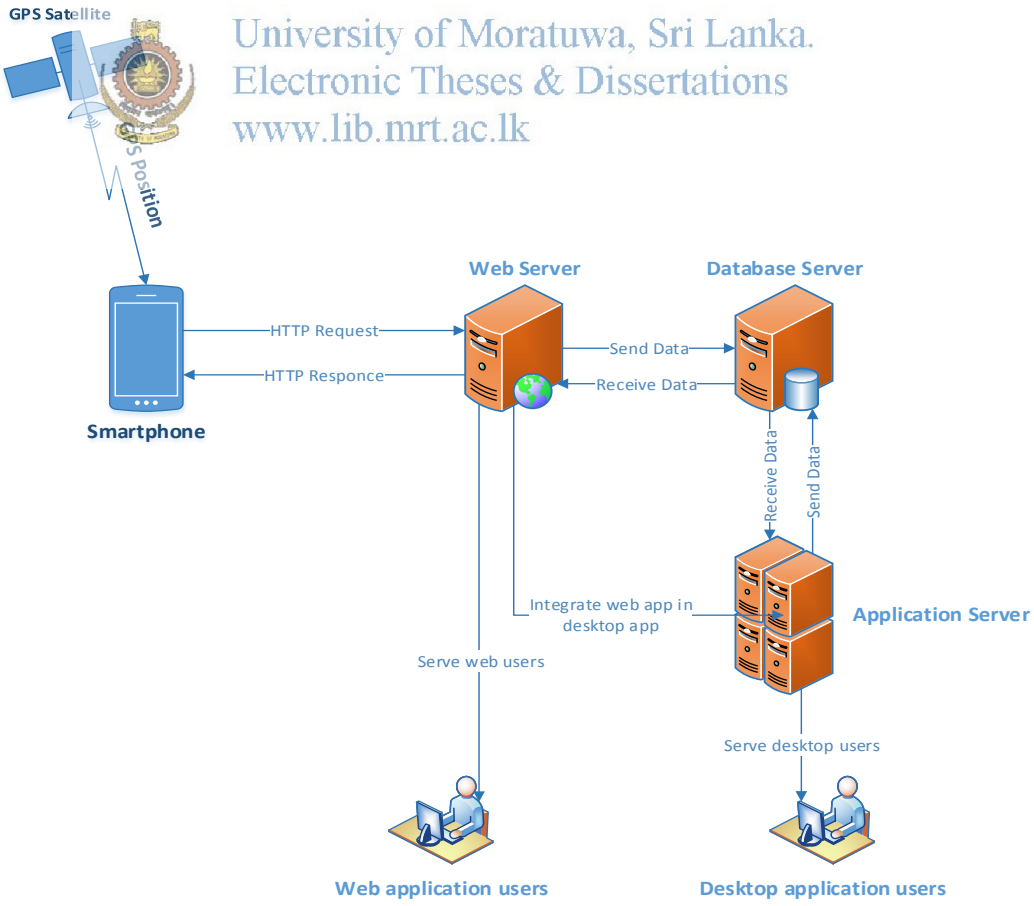

Figure 0.1 – Top level architecture of the proposed system

6.3 Smart VMS Implementation

Smartphone component implementation has both hardware and software implementations in this project. Android mobile operating system based hardware devices are very popular. Also cheap comparing to Apple's hardware. The target group of this implementation is general fishermen. Implementation should be affordable and should not require special familiarity. Solution could be introduced only for android platform. But what if somebody uses Windows Mobile or Apple iPhone? Getting an android device is an additional cost for him. Also he obviously needs to get used to android features.

Mobile application cross platform support is the next step in native mobile application development. Cross platform support applications share the same business logic between all supported platforms and regenerate user interface and application layer which holds platform specific functions and binding between business layer and user interface.

The implementation of this solution also target cross platform support to server Android, iOS and Windows device users with zero business logic redesign and minimum UI rec. This chapter describes the implementation using Android platform.

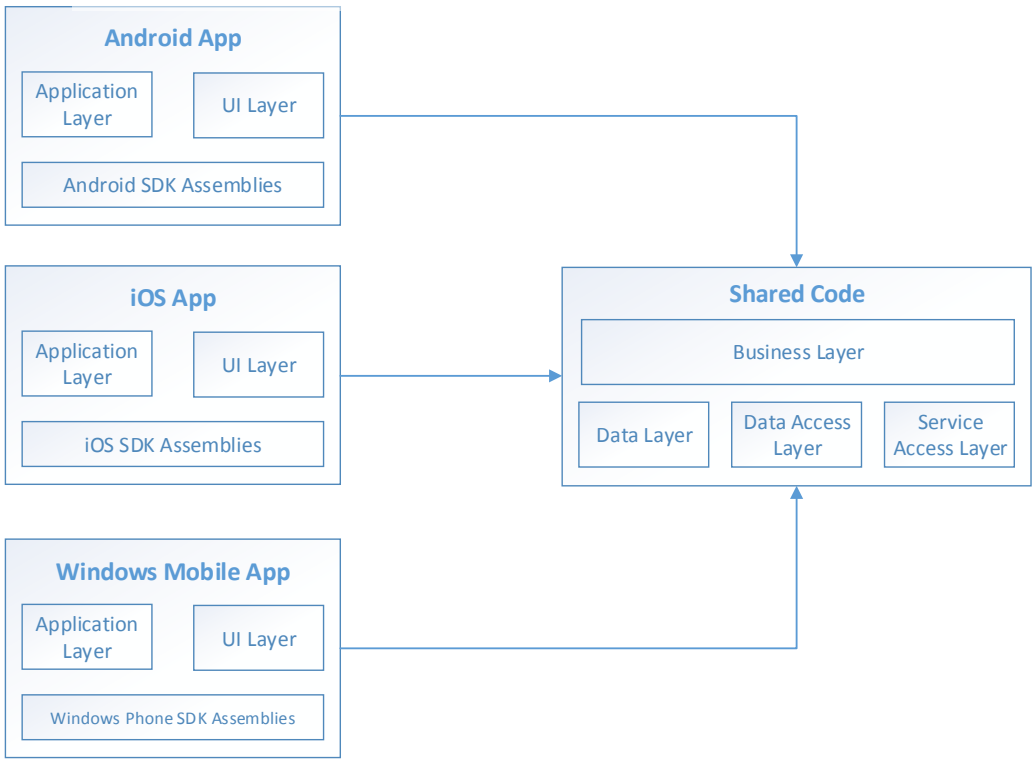

Figure 0.2 - Architecture of cross platform mobile application

There are various technologies to share code across different platforms. Many approaches use same interface loosing native features of the platform. Users may not feel the native look at all. Using C# and the Mono Tools allow to share a large subset of an application's code across multiple platforms while still building a completely native user interface on top of it for each platform. Applications created with this approach will look and feel native because they are using the exact same APIs and toolkits exposed by the platform.

Implementation phase selected C# Xamarin for the mobile component development of this project due to several reasons.

- Cross platform support.
- Use Native API.
- Starter version is free of charge and it has features that implement VMS App.
- Xamarin provide test could which has thousands of virtual devices.

6.3.1 Native Mobile Application and UI module implementation

UI implementation should have a good structure since all the contents come in three languages. User interfaces are develop as separate layer and have two types

- Static user interface layer
- Dynamic user interface layer

Static UI layers have static contents. All such layers have been implemented using xml. Dynamic UI layers have more dynamic contents and created at the backend. Only the layer structure is done using xml. Since the static layer contents do not change rapidly, a single screen may developed using different layers, one layer for a language. But for the dynamic contents, xml does the provision and contents to be generated at the backend according to the language selected.

Different resources: Drawables, Layouts, Values, Classes

Drawables are set of predefined static object in this project. For example, application Icon is a drawable, customized buttons are drawables. Drawables can be called anywhere within the scope. xml layouts are the UI design. For example, vmsInstruction has all static text contents instructing users how to operate the system. The same UI has

three xml layers for three languages. Application will pick up the relevant layer during runtime.

Structure of Activities / Classes

Early section described how UI are organized. It has different activity classes and listener classes to executive related methods in the program.

- MainActivity – Load relevant UI layers and do basic stuffs
- VMSService Activity – VMS Module
- LB Activity – Logbook Module
- Webupdater Activity – Web Communicator Module
- GPS Listener – Capture GPS signals
- GSMSignalStrengthListener – Receive GSM Signals

Load Smartphone Application

Load Smartphone Application

```
LOAD Native API
LOAD MainActivity
INITIALIZE VMSService
INITIALIZE Webupdater
INITIALIZE LocationManager
SET File Path
ADD Log entry
START the GUI
        DISPLAY Home Screen
        REPEAT
                DISPLAY Screen in English
                WAIT for user input
                DISPLAY Screen in Sinhalese
                WAIT for user input
                DISPLAY Screen in Tamil
                WAIT for user input
        UNTIL User select language
        IF User select “English” THEN
                DISPLAY Main panel in English
        ELSE IF User select “Sinhalese” THEN
                DISPLAY Main panel in Sinhalese
        ELSE IF User select “Tamil” THEN
                DISPLAY Main panel in Tamil
        END IF
```


Figure 0.3 - Pseudo code - Load Smartphone Application

The smartphone application starts with “MainActivity” and initialize VMSService and Webupdater classes.

System records all activities during its running time. For example following is a sample record of application launch.

2/10/2015 12:00:33 AM,7.15905599043612,80.1161833629115,APP,APP LAUNCHED#

INITIALIZE VMSService: VMSService provide GPS positions in regular intervals.

INITIALIZE Webupdater: Webupdater transmit data in RouteLog to database.

INITIALIZE LocationManager: Initialize GPS receiver to receive GPS position when required.

Figure 0.4 - Smartphone App - Home Screen

Figure 0.5 - Smartphone App - Main Panel

6.3.1.1 The Dashboard Implementation

Dashboard is a user interface that user get information about device and registered trip. It has,

- **Device ID** - Device ID is the IMEI No of the device. That need to initialize the telephoneManager interface.
- **GPS Receiver –** Since the locationManager has initialized onCreate, now it can directly call
- **Bluetooth Adapter –** The implementation uses Bluetooth adapter for two reasons. Connect to on-board control box and connect with on-board scale. Here it check the condition of Bluetooth adapter. That enables the adapter if in disabled mode.
- **Mobile network and Data Connection –** This is important when transferring data to outside. Since the telephoneManager has initialized, now it can obtain details directly.
- **Signal Strength –** Signal strength also comes from telephoneManage. Signal strength may use to understand the reason for device not transmitting data to land stations. If the level is equal to 99, that means no service

- **Internal Storage** – Free memory calculation is bit complicated. Android platform returns the number of blocks available. That comes in long type and that has to be converted to human readable form.
- **Battery Power -** Battery meter also used to find reasons for undesired terminations. For example, somebody may kill the application or remove the battery of device at the middle of the sea to make the VMS unavailable. VMSService use battery meter inputs when is records data in intervals.
- **Online Trip Information –** This section is discussed under WebUpdater class. Here it shows how call getTripInfo() method. Webupdater class has a method called Responder which returns string array of data received from web server. Responder class need the complete command to call and then it convert that to HTTS request. Command for online trip information request is “getTripInfo”. Command should be sent alone with the device ID.

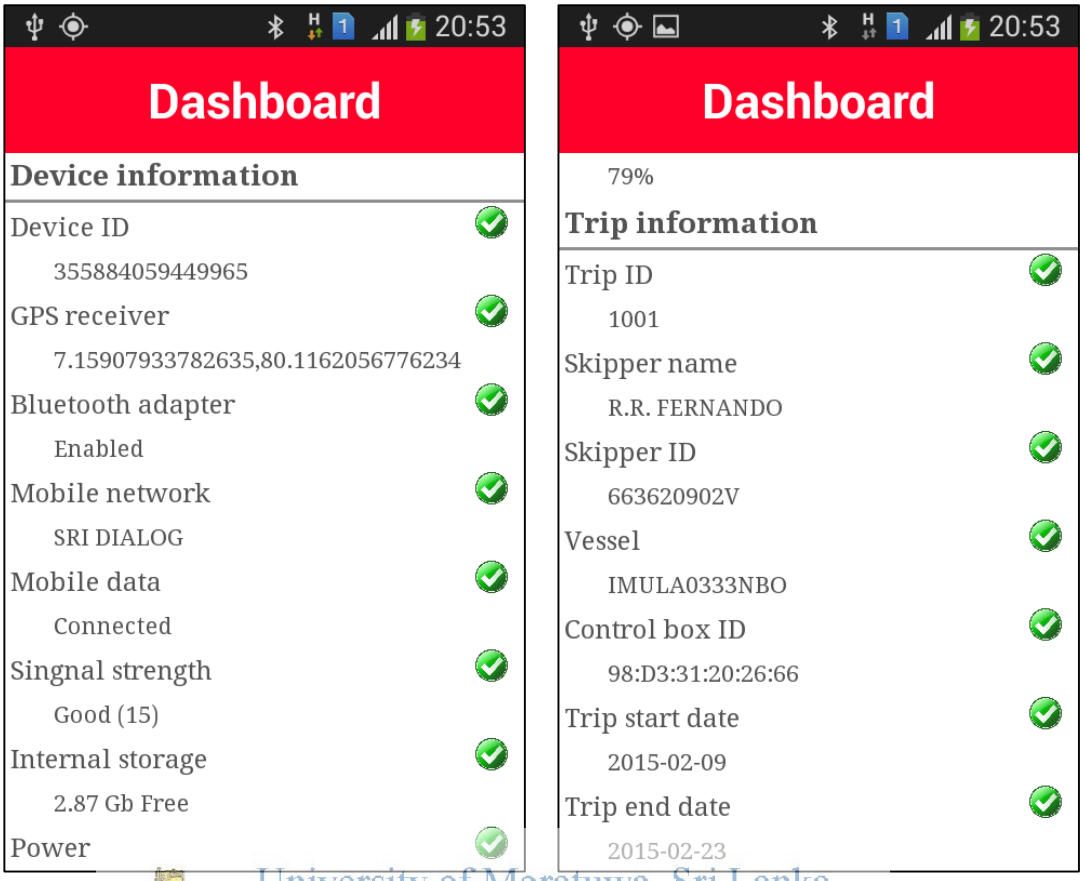

Figure 0.6 - Smartphone App - Dashboard Screen

6.3.1.2 'Launch VMS' Implementation

Launch VMS is the process that starts 'VMSService' service. This process has to be run before the vessel leaves the harbor. This process has four steps. Each step goes on a loop until five time to get through. If failed will not continue to next step.

- Check the availability of relevant hardware components

  This is almost same to the dashboard device information. Same methods have been recalled.

- Obtain registered trip details for the smart device

  This section also same to the on-line trip information retrievable. Trip details in database can have three status. "NEW", "REGISTERED" and "FINISHED".

  New – Trip has initiated but not registered with device.

  Registered – Trip has registered with device and on sailing mode.

  Finished – The trip has finished. No more in active state.

- Pair Bluetooth scale and do initial calibration

  This step has couple of sub processes.

  1- Search for Bluetooth scale
  2- Send pair request
  3- Do calibration with 10Kg standard weigh

- Validate trip duration.

Trip start and End dates are set during the registration process. VMS launch process checks the current date and time against the scheduled date.

If all these verifications are true, it starts the 'VMSService' service with a separate lifecycle.

This process create offline trip information file called "TripLog" to obtain trip details when device is out of coverage. Sample record is given below.

2/10/2015 1:20:16 AM,7.15909293060963,80.1162658938556,1001,355884059449965,R.R. FERNANDO,663620902V,98:D3:31:20:26:66,IMULA0333NBO,1234,02-09-2015,02-23-2015,#

Also it updates the fish species offline file. Sample record is given below

1,කෙලවල්ලා,Yellowfin Tuna,கிளவரெய்,#

2,ඇස්ගෙඩි,Big Eye Tuna,கிழவரே,#

3,තලපත්,Sailfish,அருக்குல,#

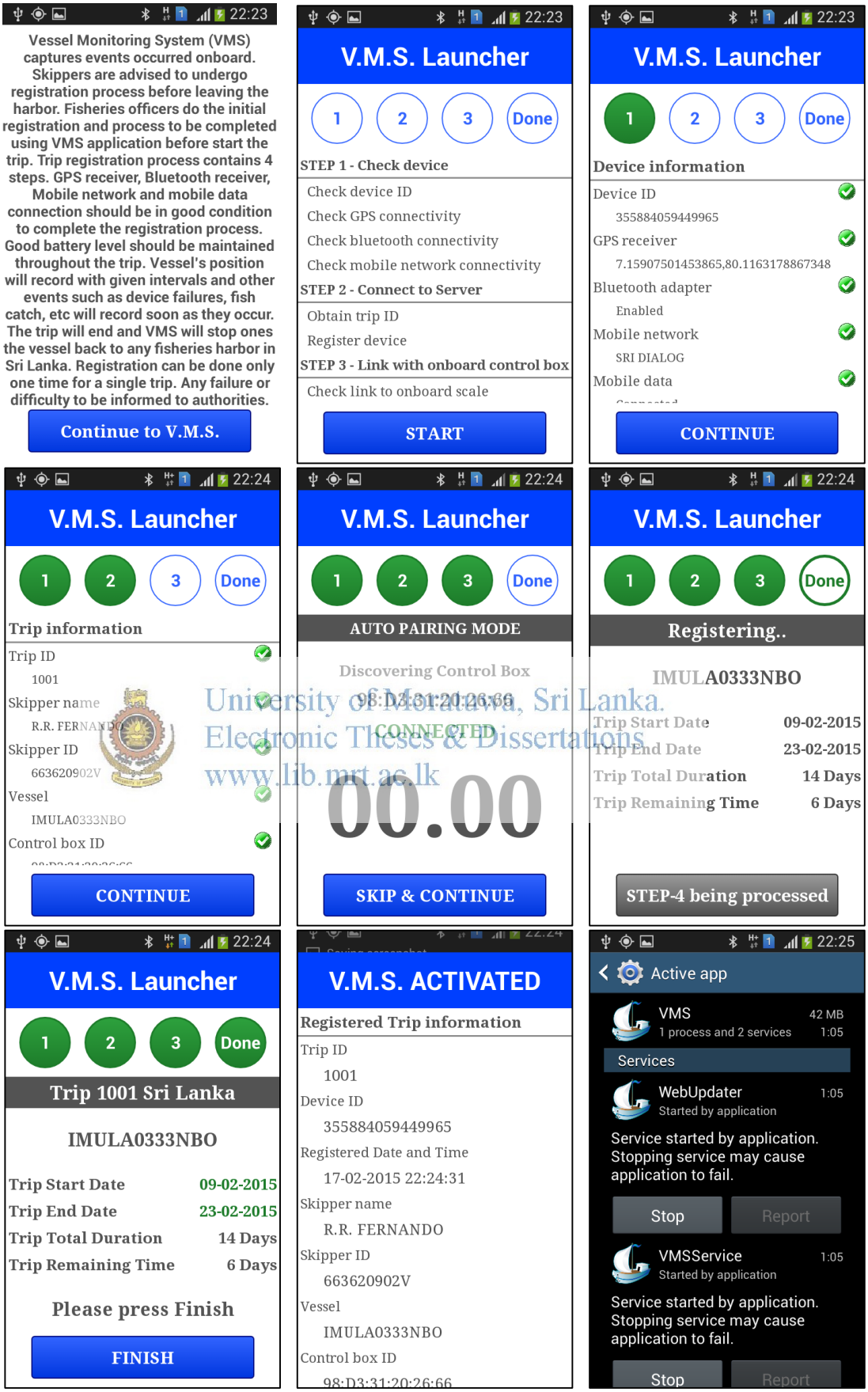

Figure 0.7 - Smartphone App - Launch VMS UI

6.3.1.3 E-Logbook Implementation

E-Logbook associate with class LB. E-Logbook gets inputs from use and Bluetooth scales. User select relevant fish species and system display weight from scale. Data will pass to VMSService when user submit data. VMSService record entry as fish catch in TripRoutelog.

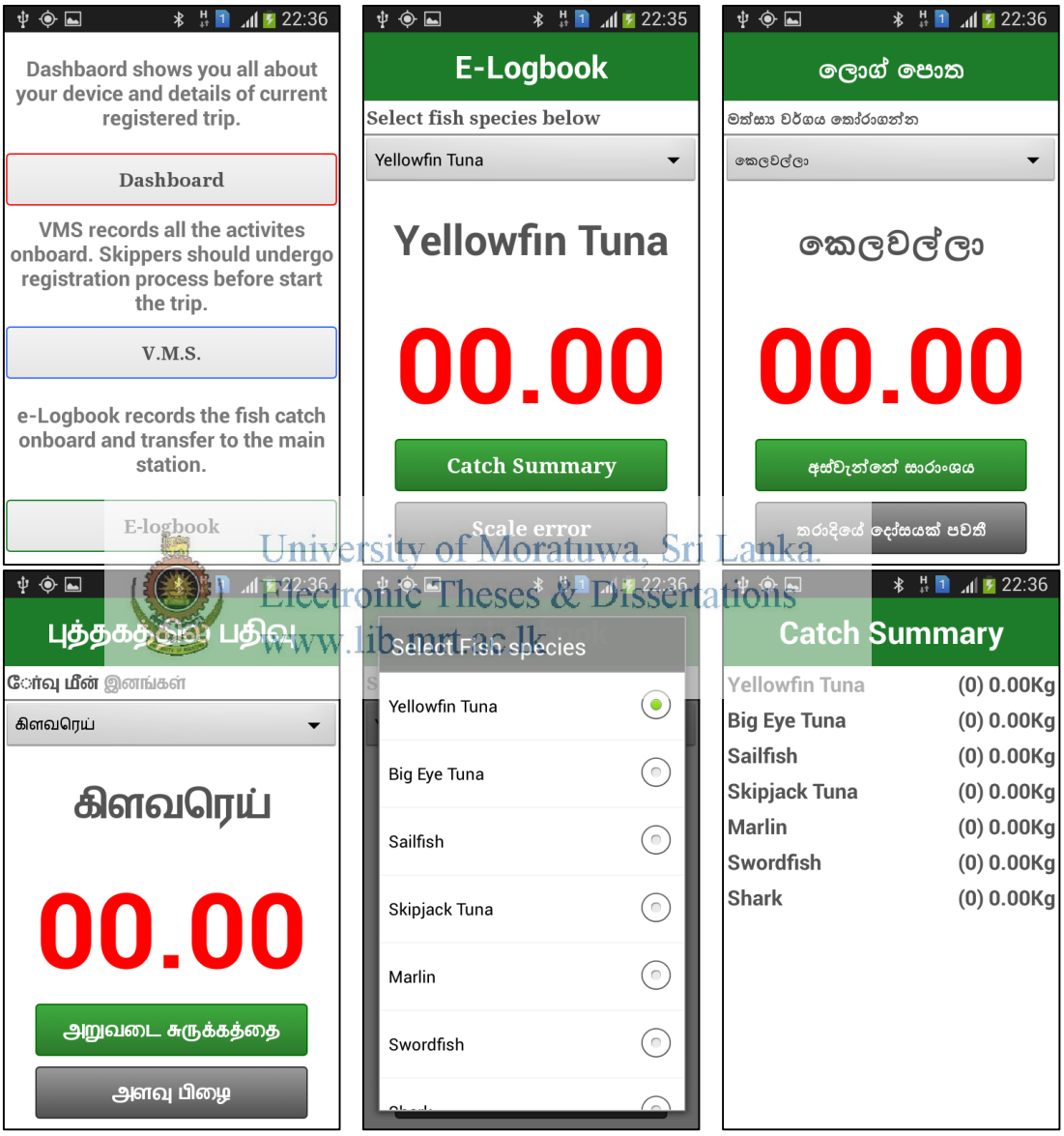

Figure 0.8 - Smartphone App - E-Logbook Screen

6.3.2 VMSService Module Implementation

VMSService is a service comes as a native mobile application with a separate lifecycle. This service has an iterative process which records vessel's position, battery level and signal strength with regular time intervals. All these points plot on the map for graphical representation at web application.

This is a sample record

1001,3,2/17/2015 10:24:34 PM,7.15903864589382,80.1162475362089,88%,15,Running,#

6.3.3 Web Mobile Communicator Module Implementation

'Web Mobile Communicator' is a combination of Native and Web Mobile application technologies. This is running as a service in the background with no UI. It has a separate lifecycle so no matter what happen to the main application. This is the only module in smart device which communicate to outside. This service basically talks to the 'Web Responder' web application trough HTTP requests.

6.4 Desktop Application Implementation

The Desktop application development of this project used Microsoft Visual Basic .net version. At some point, the desktop application integrate web application to give Google Maps related features to its users. Built-in crystal report tool has been used for report generations.

The implementation has been organized using object oriented concepts. Different classes have been used for different entities. This solution uses MySQL database for data storing and following is how the connection has been established.

Administration module covers all the administration tasks carryout by the fishery officers. Vessel registration process records vessel details such as Vessel registration number provided by DFAR, Vessel Name, Fishing License number, License expire date, IOCT number, etc. Vessel registration number is used as unique identifier.

For example, Vessel registration number: IMULA0333NBO, Name: Nilushika, License No: LB0333NBO, Exp Date: 31/12/2015, IOTC: IOTC0333NBOSL

Control box does two things. Convert scale's serial communication interface into Bluetooth and authenticate VMS application. VMS application requires a digital authentication to ensure the portable device on correct board. MAC address verification is the method used for this concern. MAC address of control box also recorded during the registration process and MAC address is the digital vessel identifier in this system.

Skipper and device registration processes are to record skippers' and his device's details and IMEI number of the device is the digital identifier of skipper.

Trip registration process generates unique TripID for each trip. When the UI is first loaded, it checks the last indexed used in database and use the next number as new TripID.

Once the user enter vessel number for the current trip, system checks for its last trip's details. Because most of the time same skipper is sailing the vessel. So no need to do the skipper and device selection process. If the skipper is different or if no previous data available, skipper and device for the trip to be selected.

6.5 Web responder Implementation

Web responder is a backend web application hosted in Apache web server. It does convert HTTP requests into database queries and vice versa to enable communication between VMS application and databases server. HTTP request has a parameter called "command" tells what command to be executed. For example, this is how android requests registered trip information. The android application send its device id with command "getTripInfo".

<serveraddress>/vms/androidResponder.php?command=getTripInfo&deviceID=355652459982

Web Responder send the respond in plain text as: *1001,355884059449965,R.R. FERNANDO,663620902V,98:D3:31:20:26:66,IMULA0333NBO,1234,2015-02-09,2015-02-23,*

6.6 Web Application Implementation

Web Application component is a GUI component interact with users. The implementation has been done by using Google Maps API, JavaScripts, PHP and AJAX.

- Map drawing module
- Trip data representation module
- Trip data analyzing module
- Fishing ground identifying module

6.6.1 Map Constructing Module Implementation

Google Maps API has been used for dynamic map construction in this project. Pre stored coordination (GPS positions) of relevant marine zones (Sri Lankan EEZ, Indian and Maldives boundaries in this project) to be plotted on map using JavaScript. Interconnected coordination represent different zones in different colors.

Figure 6.9 shows how the boundaries appear. EEZ around Sri Lanka appears in Green while west and east boundaries appear in Red.

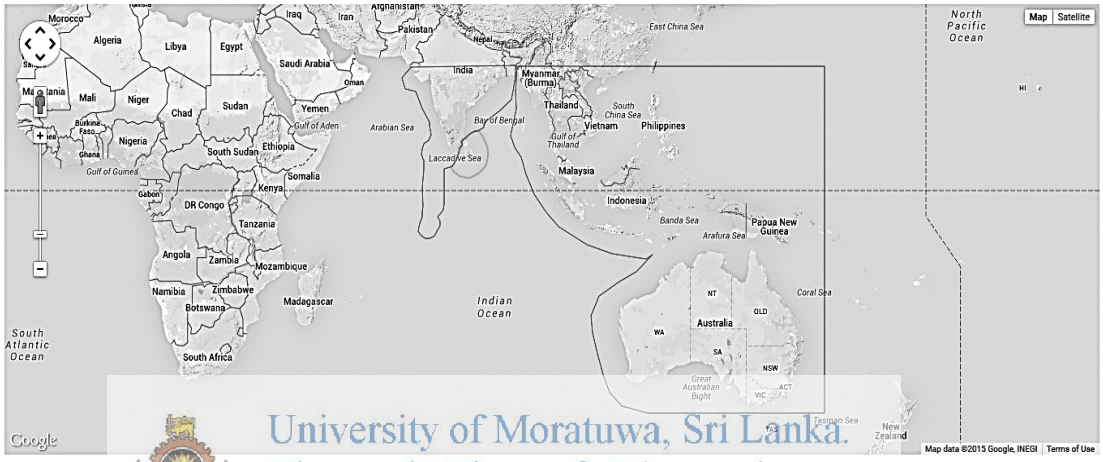

Figure 0.9 - Boundaries on map

Figure 0.10 - Sri Lanka EEZ on map

6.6.2 Trip data Representation Module Implementation

Drawing vessel's route on map is bit similar to constructing marine zones. GPS coordinates stored in database to be plotted on map using JavaScript. Unlike marine drawing marine zones, this has couple of additional features such as, identifying point type and display additional data to user. For instance different occasion to be displayed in different symbols to make them visible clearly (Figure 6.11). Interconnection of GPS coordinates will draw trip's route.

This is how the trip route marked with different signs and how information being displayed.

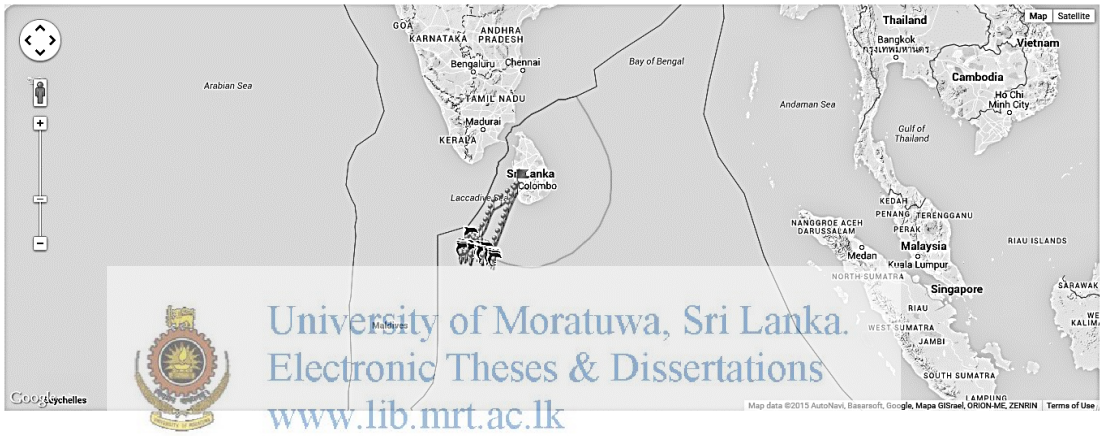

Figure 0.11 – Trip route with marine boundaries

Figure 0.12 – Trip route with different symbols

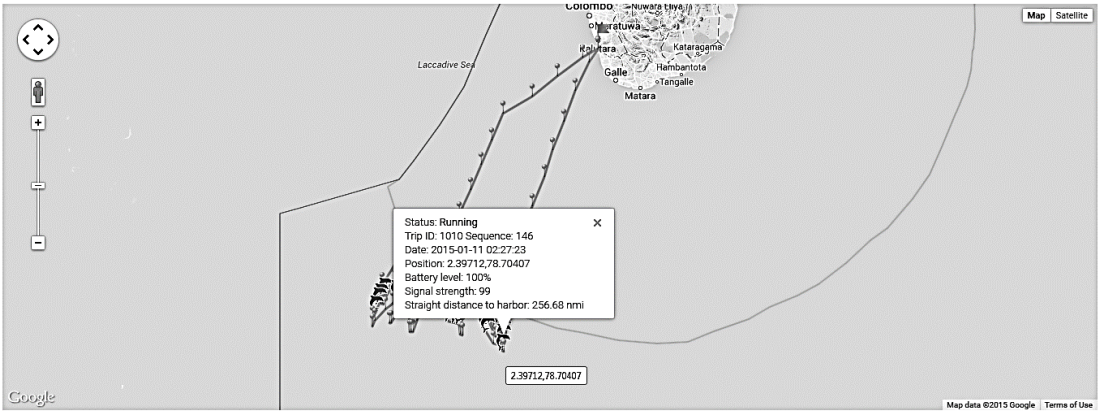

Figure 0.13 – Trip route with additional information

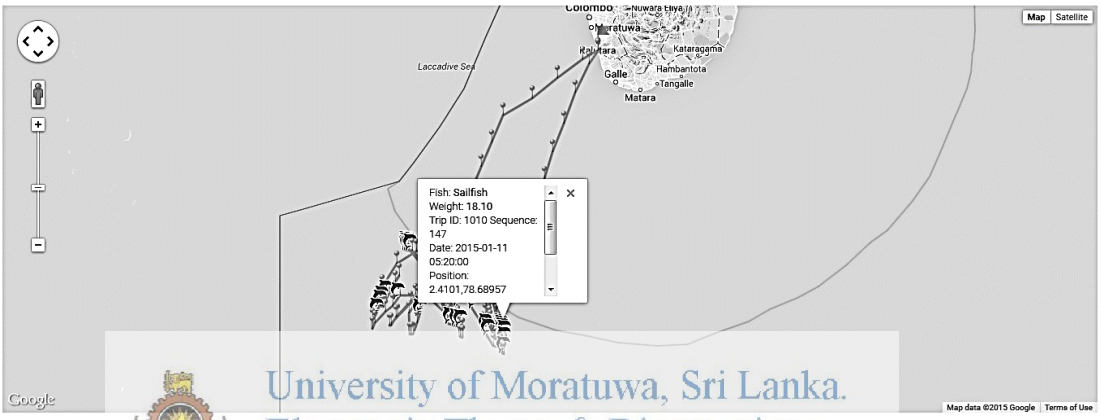

Figure 0.14 – Trip route with fish details

6.6.3 Trip data Analyzer Module Implementation

Trip data analyzing module does mathematical calculations to find out whether GPS points are within Sri Lankan EEZ, whether it has crossed west and east boundaries and calculate the distance between GPS point and harbor.'haversine' formula has been implemented to calculate great-circle distance. This implementation has used Java technology and its Math class.

```
var R = 6371000; // meters
var φ1 = lat1.toRadians();
var φ2 = lat2.toRadians();
var Δφ = (lat2-lat1).toRadians();
var Δλ = (lon2-lon1).toRadians();

var a = Math.sin(Δφ/2) * Math.sin(Δφ/2) +Math.cos(φ1) * Math.cos(φ2) *
      Math.sin(Δλ/2) * Math.sin(Δλ/2);
var c = 2 * Math.atan2(Math.sqrt(a), Math.sqrt(1-a));

var d = R * c;
```

Figure 0.15 - Code Segment - Implementation of haversine formula

Figure 6.16 shows GPS point evaluate against marine borders and calculate distance. Trip start point identified as the harbor. If the GPS point is not within Sri Lankan EEZ, then system checks the point in west and east zones. In it is in west or east zone, which means vessel has crossed the border. If the position does not belongs to either west or east zone, which means position at international waters. For any occurrence, it calculate the straight distance between harbor and point, straight distance between west border and point and straight distance between east border and point.

GPS point evaluation

```
LOAD GPS Points to Array
GET Position
REPEAT
        IF Position within EEZ THEN
                CALCULATE Distance to West boundary
                CALCULATE Distance to East boundary
                STATUS "Within EEZ"
                UPDATE Record-> Status, West boundary distance,
                East boundary distance.
        ELSE IF Position within West Zone THEN
                CALCULATE Distance away from West boundary
                CALCULATE Distance to East boundary
                CALCULATE Distance from harbor
                STATUS "West boundary crossed"
                UPDATE Record-> Status, West boundary distance,
                East boundary distance, Distance from harbor
        ELSE IF Position within East Zone THEN
                CALCULATE Distance away from East boundary
                CALCULATE Distance to West boundary
                CALCULATE Distance from harbor
                STATUS "East boundary crossed"
                UPDATE Record-> Status, West boundary distance,
                East boundary distance, Distance from harbor
        ELSE
                CALCULATE Distance to West boundary
                CALCULATE Distance to East boundary
                CALCULATE Distance from harbor
                STATUS "In International waters"
                UPDATE Record-> Status, West boundary distance,
                East boundary distance, Distance from harbor
        END IF
UNTIL Pointer<Array length
END Process
```


Figure 0.16 - Code Segment - GPS point evaluation

6.7 Database Implementation

The relational database has been implemented by using MySQL technologies. Basically it has 12 tables with key relationships.

tbl_vesselRegistraion – Hold vessel registration details.

tbl_vesselOwner – Hold vessel owner's information.

tbl_controlBox – Hold control box details.

tbl_skipper – Hold skipper details.

tbl_device – Hold device information.

tbl_fishSpecies – Hold fish species details.

tbl_areaIdentifier – Hold boundary details.

tbl_areaPositions – Hold boundary GPS position.

tbl_trip – Hold fishing trip information.

tbl_tripRouteLog – Hold on-board data received from smartphone application

tbl_tripRouteVerifier – Hold GPS point analyzed data

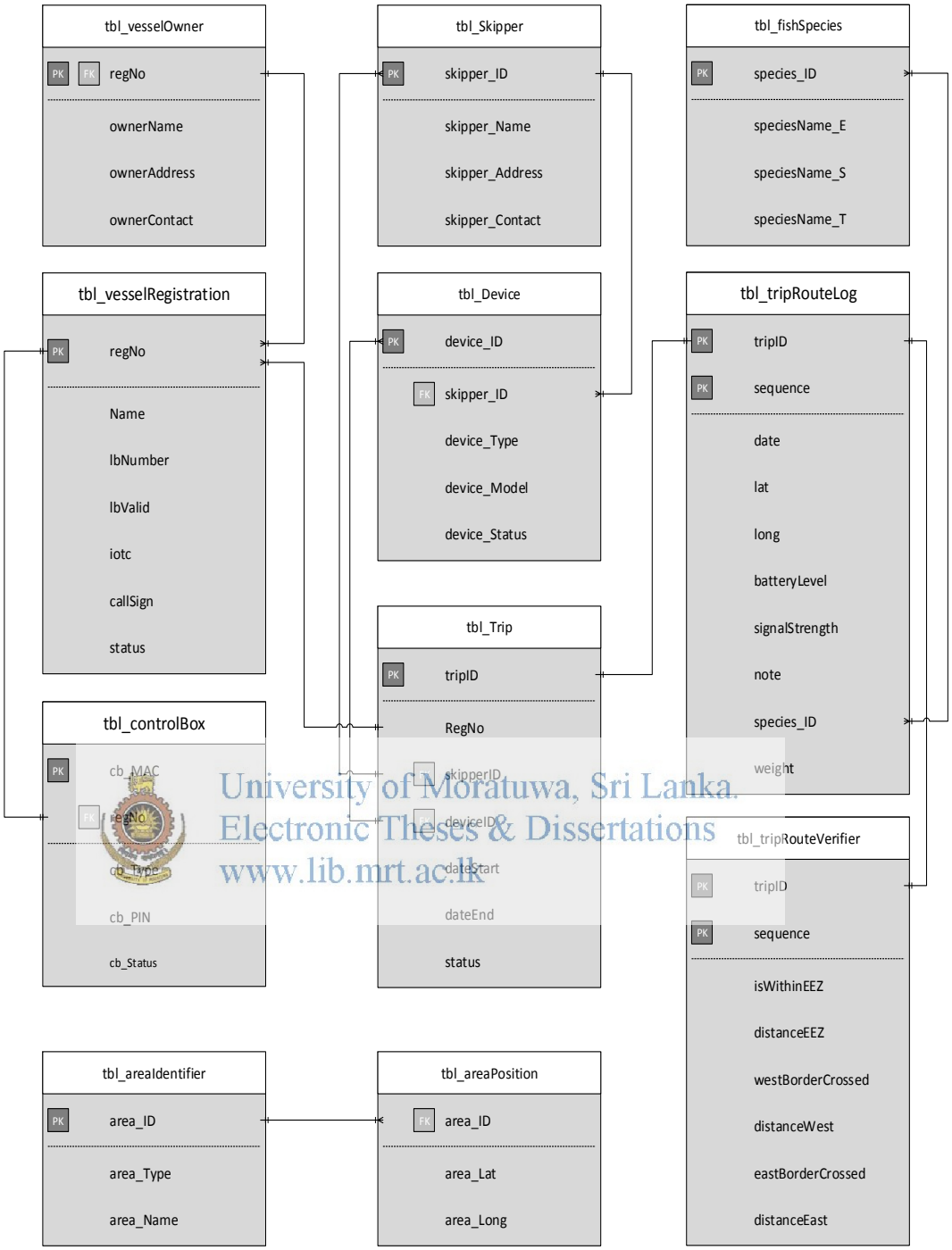

Figure 0.17 - Relational Schema

6.8 Summary

This phase has implemented all four components mentioned in system design. The mobile application development has used C# Xamarin to make the solution compatible for cross platforms such as Android, iOS and Windows Mobile. The desktop application has been developed by using visual basic .net version with the use of features in .net frame work 4.5. Web applications have been developed by using PHP. Google Maps API V3 has been used for this project and client side scripting handled by JavaScript queries with the use of AJAX. Finally the relational database has been developed using MySQL technology by extending spatial data support. The next Chapter discuss the evaluation of implemented solution comparing to objective.

Chapter 7

Evaluation

7.1 Introduction

The previous chapter discussed how the implementation of proposed system is done. Evaluation chapter describe how the solution has been evaluated to see whether objects have been achieved. Since this is a practical project, best way to evaluate is to execute trails and get users feedbacks. The evaluation has been done using three test cases and this chapter brings a summary of it. Please find text cases in Appendix.

7.2 Objectives set for this project

- Develop a cost effective vessels monitoring system with native language support.
- Introduce on-board catch recording system. (Logbook)
- Introduce a standard way of certifying the harvest against illegal fishing at harbor on arrival. (Check the trip route against marine borders, check the catch against allowed commercial fishing weights)
- Introduce fishing quota system to maintain higher sustainability rate.
- Introduce a system that exporters get the details of available legal fish at each harbor.
- Introduce a system that DFAR, IOTC and EU can get the details of each trip, vessel details, harvest, etc.
- Maintain high reliability and comfortability of the system.

7.3 How the evaluation organized

The evaluation of the system could not be done without executing proper trials. We manage to execute three trial trips and one pilot trip to test the software and check whether we have achieved the objective of this project.

7.3.1 Pilot Trip

The pilot trip was executed on 10th November 2014 at 09:30. The objective of this trip was to identify whether solution has errors to be fixed before trial trips.

Objective

Test the implemented solution before trial trips

Trip start date

10/11/2014 09:30

Trip End date

10/11/2014 13:30

Participants

Skipper: D.A.P. Fernando 621246320V

Vessel

IMULA0003CBO

Device used

Samsung Galaxy Grand, 355884059449965, Android

Trip Start harbor

Mutwal fishery harbor

Trip End harbor

Mutwal fishery harbor

Description

Pilot trip was conducted to identify issues in implemented solution before releasing for trial trips. All the administration processes were tested before starting the trip and trip registration was don at the harbor. GPS positions were taken in 10 minutes intervals. Ship was sailed below 5nmi per hour speed. Data transfer was in good condition since the sailed under GSM coverage. There were couple of instances that did not transfer data at first attempt, however everything was transferred before end the trip. An issues was rectified in Bluetooth data transfer from scale to smart device. The original sale was not Bluetooth supported. Made it Bluetooth enabled using HC06 serial to Bluetooth module. The scale's serial output was malfunctioning. Issue fixed with different baud. Overall satisfied with the implementation and recommended for trials.

7.3.2 Trial Trip - 1

Objective

Commercial fishing in southwest

Trip start date

27/12/2014 20:00

Trip End date

13/01/2015 08:00

Participants

Skipper: W.D. Shelton Pieris 752342318V

Vessel

IMULA0330NBO

Device used

Samsung Galaxy Grand, 355884059449965, Android

Trip Start harbor

Beruwala fishery harbor

Trip End harbor

Beruwala fishery harbor

Description

Existing crane scale (Mettler Toledo IND 221) with serial communication (9600,8,E,N) port was converted to Bluetooth enabled interface using HC-06 module. Smartphone was lended for testing purposes. Total initial cost was Rs. 3,500.00. The vessel sailed in southwest region of Sri Lanka Sea. GPS points were taken in 3 hour intervals. Vessel has left the harbor after 05:00 next morning (28/12/2014). Sinhalese used. It has reached the Sri Lankan boundary on 29th around 06:00. (After one day). They were engaged in fishing until 11/01/2015 and started way back. There were fishing with 220nmi to 280nmi distance from harbor. No boundaries crossed. Total catch was 34 pieces, total weight 1,136.5 Kg. No illegal fish species caught and all of them were above the commercial fishing minimum weight level. All of them were approved as legal fish and certified. *Please see the data set for evidence*

7.3.3 Trial Trip - 2

Objective

Commercial fishing in southwest

Trip start date

02/01/2015 08:00

Trip End date

23/01/2015 09:00

Participants

Skipper: S. Perera 782320502V

Vessel

IMULA0146KLT

Device used

Samsung Trend, 355571052984854, Android

Trip Start harbor

Beruwala fishery harbor

Trip End harbor

Beruwala fishery harbor

Description

Existing crane scale (Mettler Toledo IND 596) with serial communication (9600,8,E,N) port was converted to Bluetooth enabled interface using HC-06 module. New smartphone purchased for the cost of Rs. 21,899.00. Total initial cost was Rs. 25,399.00. The vessel sailed in southwest region of Sri Lanka Sea. GPS points were taken in 3 hour intervals. Vessel has left the harbor after 3 hours from application started. Tamil language used. It has reached the Sri Lankan boundary on 3rd after noon. They were engaged in fishing until 20/01/2015 and started way back. There were fishing within 275 to 475nmi distance from harbor. Application terminated on 15/01/2015 07:25 due to low battery and restarted after 5 minutes. No boundaries crossed. Total catch was 54 pieces, total weight 2,086.2 Kg. No illegal fish species caught and all of them were above the commercial fishing minimum weight level. All of them were approved as legal fish and certified. *Please see the data set for evidence*

7.3.4 Trial Trip - 3

Objective

Commercial fishing in Northeast

Trip start date

30/12/2014 06:30

Trip End date

03/01/2015 23:00

Participants

Skipper: Nadaraja 562483859V

Vessel

IMULA0385TCO

Device used

Samsung Core, 35627052937928, Android

Trip Start harbor

Trincomalee fishery harbor

Trip End harbor

Trincomalee fishery harbor

Description

Existing crane scale (Mettler Toledo IND 221) with serial communication (9600,8,E,N) port was converted to Bluetooth enabled interface using HC-06 module. Used skipper's phone. Total initial cost was Rs. 3,500.00. The vessel sailed in northeast region of Sri Lanka Sea. GPS points were taken in 3 hour intervals. Vessel has left the harbor immediately after application started. Tamil language used. Was fishing inside Sri Lankan EEZ from 100-180nmi from harbor. No boundaries crossed. Total catch was 5 pieces, total weight 96.3 Kg. No illegal fish species caught. Four out of five species were below the commercial fishing weight so those were not approved as legal fish. 80% of the harvest was illegal so trip was considered as an illegal trip. Skipper was rated with a red mark. *Please see the data set for evidence*

7.4 Evaluate the solution against implemented solution based on trial trip results

- Develop a cost effective vessels monitoring system with native language support.

Description	System initial cot			
	Trial Trip-1	**Trial Trip-2**	**Trial Trip-3**	**Cost of a commercial VMS**
Hardware cost		Rs. 21,899.00		Rs. 650,000.00
Installation cost	Rs. 3,500.00	Rs. 3,500.00	Rs. 3,500.00	
Software cost				
Miscellaneous cost				
Total cost	Rs. 3,500.00	Rs. 25,399.00	Rs. 3,500.00	Rs. 650,000.00

Above is the comparison of initial cost of smartphone based VMS and hardware VMS systems. The skipper at Trial trip-2 had to purchase a new android smart device and he spent Rs. 25,399.00 for the entire system. If the software development is cost around Rs. 50,000.00, still the cost is Rs. 75,399.00. Which is only 11.5% of cost of a hardware VMS system. 88.5% of the cost has waves off.

Available Languages	**Trial Trip-1**	**Trial Trip-2**	**Trial Trip-3**
English			
Sinhalese	Used		
Tamil		Used	Used

The smartphone application was implemented using all three languages. Two out of three fishermen used Tamil language and a fisherman used Sinhalese. No body used English. Native language used was 100%.

- Introduce on-board catch recording system. (Logbook)

Implemented E-Logbook concept by interoperating on-board scale has fulfilled this requirement of a logbook for fish catch records. 69 pieces were recorded during trial period. Cost of serial to Bluetooth interface conversion was only Rs.3,500.00.

- Introduce a standard way of certifying the harvest against illegal fishing at harbor on arrival. (Check the trip route against marine borders, check the catch against allowed commercial fishing weights)

Solution has implemented a standard way to certify fish catch at harbor as below

1- Check the vessel has gone beyond the Sri Lankan EEZ
2- Check the vessel has crossed west or east boundaries.
3- Calculate the distance between fish catch points and Sri Lankan coastal line
4- Check whether the vessel has illegal commercial fish species
5- Check every fish piece has qualify commercial size restriction

System certify harvest depend on above five conditions. *See Appendix*

- Introduce a system that exporters get the details of available legal fish at each harbor.

The web application can be used by fish exporters to see the available fish at ach harbor.

- Introduce a system that DFAR, IOTC and EU can get the details of each trip, vessel details, harvest, etc.

Range of reports have been introduced.

- Maintain high reliability and comfortability of the system.

Project has used Native API for mobile software developments to bring platform native features to the VMS application. Touchscreen operation make the system more comfortable on-board.

7.5 Summary

This evaluation chapter mentioned the evaluation strategy, three experiments and results obtained from them to see whether solution has achieved the set objectives. The conducted trial trips were successful and finished as they were planned. Captured data showed how the system worked and how it was interacting with fishermen. All fishermen used native languages and could not find any difficulty they found. User acceptance was in higher rate mainly due to low initial cost and native language support. Fishing and breeding ground identification need more data accurate prediction and hopefully that will come to an acceptable stage with one year complete data.

Chapter 8

Conclusion and Further Work

8.1 Introduction

Chapter 6 described the solution in detail in terms of users under different operating environments. In Chapter 7, the implemented solution has been tested using three trial trip data and check whether the implementation has achieved the target objectives. The conclusion chapter conclude the overall achievement and achievement of each objective. Also this chapter discuss the limitations of the solution and opportunities for further enhancement.

8.2 Conclusion

According to the experimental results mentioned in previous chapter, smartphone VMS application has slashed 80% of the cost of a hardware VMS system. Sri Lanka fishermen used Sinhalese and Tamil languages during trial trips. There are the two main reason why implementation of commercial VMS failed in Sri Lanka. Here we can conclude the smartphone VMS system had overcame the cost and localization challenges.

The previous chapter described how the trip details evaluated at the point of landing. The mechanism used based on trip positions, fish types and their weight was straightforward. That was highly standard way of certifying the catch. We simply conclude that solution has introduced a standard way of certifying the catch providing clear evidence.

The proposed solution in this project can be introduced to EU as the system that illuminates illegal fishing in Sri Lanka.

8.3 Achievement of primary objectives

This project was originally initiated to introduce a solution to stop illegal fishing in Sri Lanka. The actual need came into the scene after EU has taken steps to stop Sri Lankan fish imports to their countries by calming that Sri Lankan fishermen engaged in illegal poaching and authorities do not have any control their vessels. Further, EU demanded

Sri Lanka should provide evidence for legal catching for all exports to EU. Two things were highlighted.

- Sri Lanka should make sure all fish catch from legal zone.
- Make sure fish catch does not affect the sustainability of marine lives.

Projects to introduce commercial VMS systems were failed due to high initial cost and lack of localization support in Sri Lanka. In that situation, there were two main objectives highlighted for this project.

- Introduce low cost vessel monitoring system suitable for Sri Lankan fishermen.
- Introduce a system to maintain sustainability of commercial fish species.

This project managed to introduce smartphone based VMS system as the next generation of vessel monitoring system in the world. The solution was remarkable due to cost reduction by more than 80% of hardware VMS system.

According to the experimental results that were mentioned in previous chapter, fishermen do not need to spend much on purchasing hardware since the solution supports multiple smartphone applications. Three out of three fishermen used the system selected either Sinhalese or Tamil language. This gives the evidence the new solution has removed the language barrier in future VMS.

The solution has achieved one of its main objectives, Low cost and localized VMS

Sustainability of marine lives always comes in deferent viewpoints. Hence the domain of this project is fishery, the solution pointed out how to maintain fish catch under sustainability rate. As the researchers in the field have identified, harvesting commercial fish species below commercial size as one of the main reason for decline commercial fish species over the time, this project has focused on that particular point. To overcome the lack of organized catch details, the solution has designed an electronic logbook as a part of the VMS system to record catch on-board. Such data collection over a considerable time will open a new path for predicting where the commercial fish are. Going back to the data captured during trials trips, Southwest region in December-February season can be considered as a good fishing ground while Northeast should declare as a restricted area for fishing (A breeding ground where lots of small fish). This solution may not give very accurate figures for the moment but surely with previous data for couple years.

Also the introduced solution can apply size restriction for different species. That also can be used as a good control to maintaining sustainability of commercial fish species.

In brief, system has possibilities to identify fishing and breeding grounds and also it has features to apply size restriction.

These two option achieved the second main objects, a solution that maintain sustainability of commercial fish species.

If the trip route is monitored then no chance for poaching. If size restrictions are applied, then no chance for harvesting below commercial weigh, if fishing quota is applied, there is no chance for over fishing, if breeding grounds are clearly identified, we give freedom for them to grow. Then no illegal fish, Sri Lanka leads to a controlled fishery.

8.4 Problems encountered

There were several problems encountered during the evaluation phase.

The evaluation was limited to three trial trips specially due to the short time frame. A fishing trip takes more than 14 days to complete. So had to wait weeks to the response.

Change fisherman's ideology to get use to a VMS system is hard. Actual user response may not come out.

Operating logbook during the operation can be difficult as most of smart phone touch screens do not support wet hand and glouse.

8.5 Limitation of the solution

- The smartphone VMS need a data communication link to transfer captured data to the system database. This project used cellular network as the media for data communication. VMS application loses the cellular network when vessel sailing away from harbor (10-20Km) and then data transfer will stop. System store data locally and will resume data transfer once the vessel back to cellular coverage. So this solution does not provide on time vessel monitoring unless the data communication happen through satellite link. Present cellular data communication can be transferred satellite communication with zero

modifications. System will shift between satellite and cellular networks depend on availability.

- MAC address authentication has been used to ensure portable device on correct board. Limitations of MAC address authentication have not been addressed in this project.

- No alternative solution provided for authentication and communicate with scale in case of a control box failure.

8.6 Further work

- The Smartphone VMS application can be incorporated with satellite data transmission to provide real time monitoring.
- Log book data can be incorporated with intelligent system to predict breeding and feeding ground in different period of year.

8.7 Summary

The beginning of this chapter, it is discussed the interpretation of the results obtained from the evaluation chapter to conclude the solution. The conclusion mentioned about the succession of the overall objective of the project. Achievement of main objectives section discussed how this solution has overcome the challenge of low cost and localized VMS and maintain sustainability of commercial fish species. Lack of past data to identify fishing grounds and limited time frame for evaluation have been discussed as main problems encountered in this project. Inability of real time vessel monitoring without satellite data connection has identified as one of the major limitation of this solution. The solution leaves a good provision to further develop fishing ground identification module as an intelligent system incorporating other relevant parameter to provide highly accurate decision.

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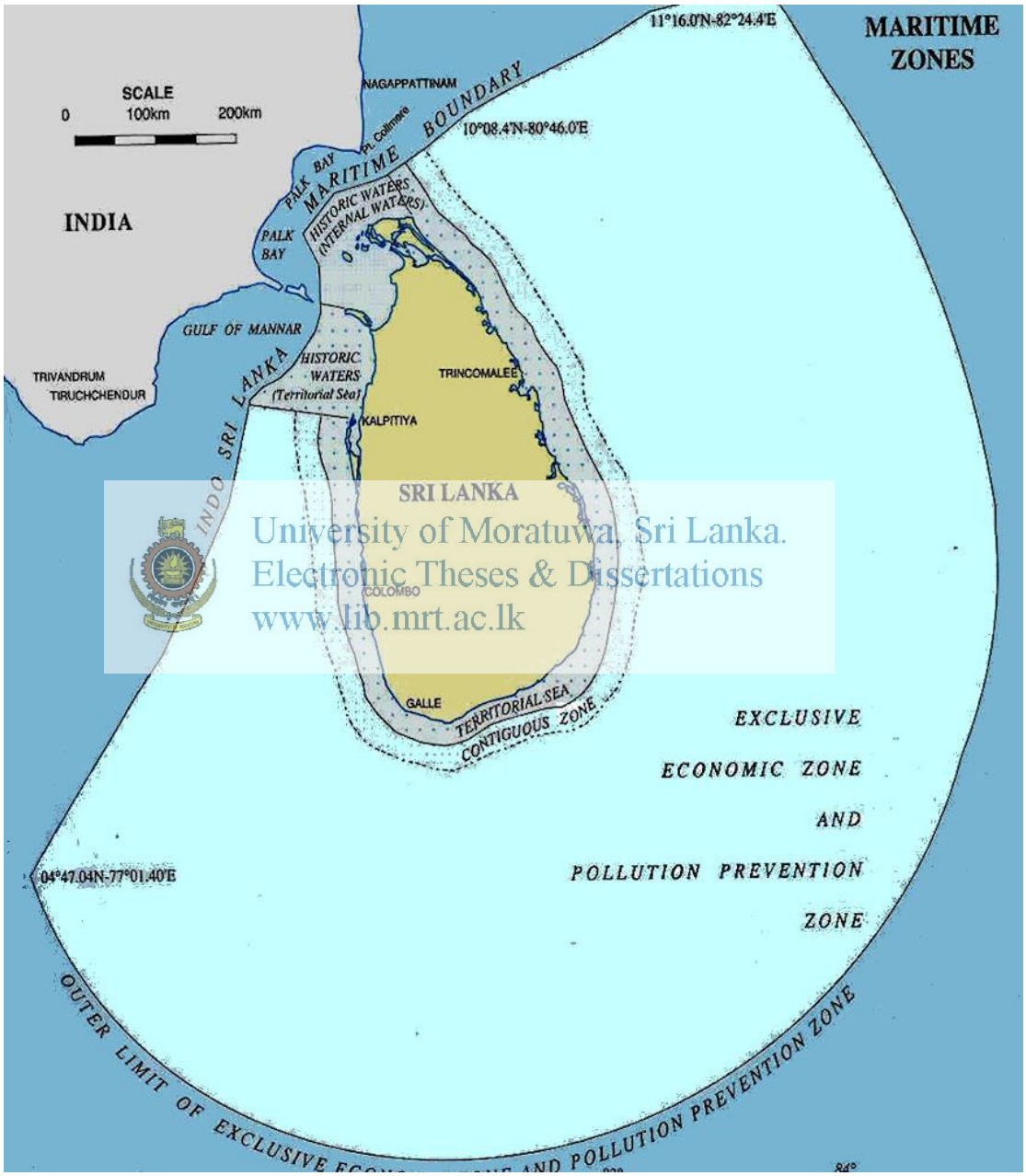
Appendix A – Further details Chapter-2

A.1 Sri Lankan maritime zones



A.2 Sample operation license

Licence No: 13/HS/228/CHW

Department of Fisheries and Aquatic Resources
Colombo, Sri Lanka.
T.P./ Fax No: +94 112449170
email: depfish@fisheries.gov.lk

FISHING OPERATIONS LICENCE FOR HIGH SEAS FISHING

Licence for engaging in fishing operations in high seas is hereby granted to Mr/Ms. Warnakulasuriya Antony Chinnarus Fernando of Dilim Thoduwawa Central Thoduwawa 12/02/2013 to 31/12/2013 in terms of the provisions of UN Law of the Sea Convention 1982, UN Fish Stock Agreement 1995 and Resolutions of IOTC, and the Specific Conditions of this license.
(For Specific Conditions Please see overleaf)

1. Registration number of the boat for which License is issued:
IMUL-A-0144 CHW

2. Length of the fishing boat: 38

3. Authorized Fishing Operations under the Licence

Authorized fishing gear	Length of fishing nets & Mesh size (Maximum length should be 2.5 km)	No. of hooks, Length of the floating line & Length of the branch lines	Authorized species of fish	Area of fishing in high seas
Long line		1000 Hooks		In the high seas of the Indian ocean out side the EEZs of another coastal state
		FL- 48 km		
		BL - 30m		

4. Home port landing : Negombo
5. Fishing duration : Whole day

Taking , keep in possession, transporting and transshipping of Marine mammals, Turtles, Thresher Sharks, species of Sea birds are totally prohibited. No fishing operation should be conducted within the radius 01 km of the data buoys installed in high seas.

12/02/2013
Date

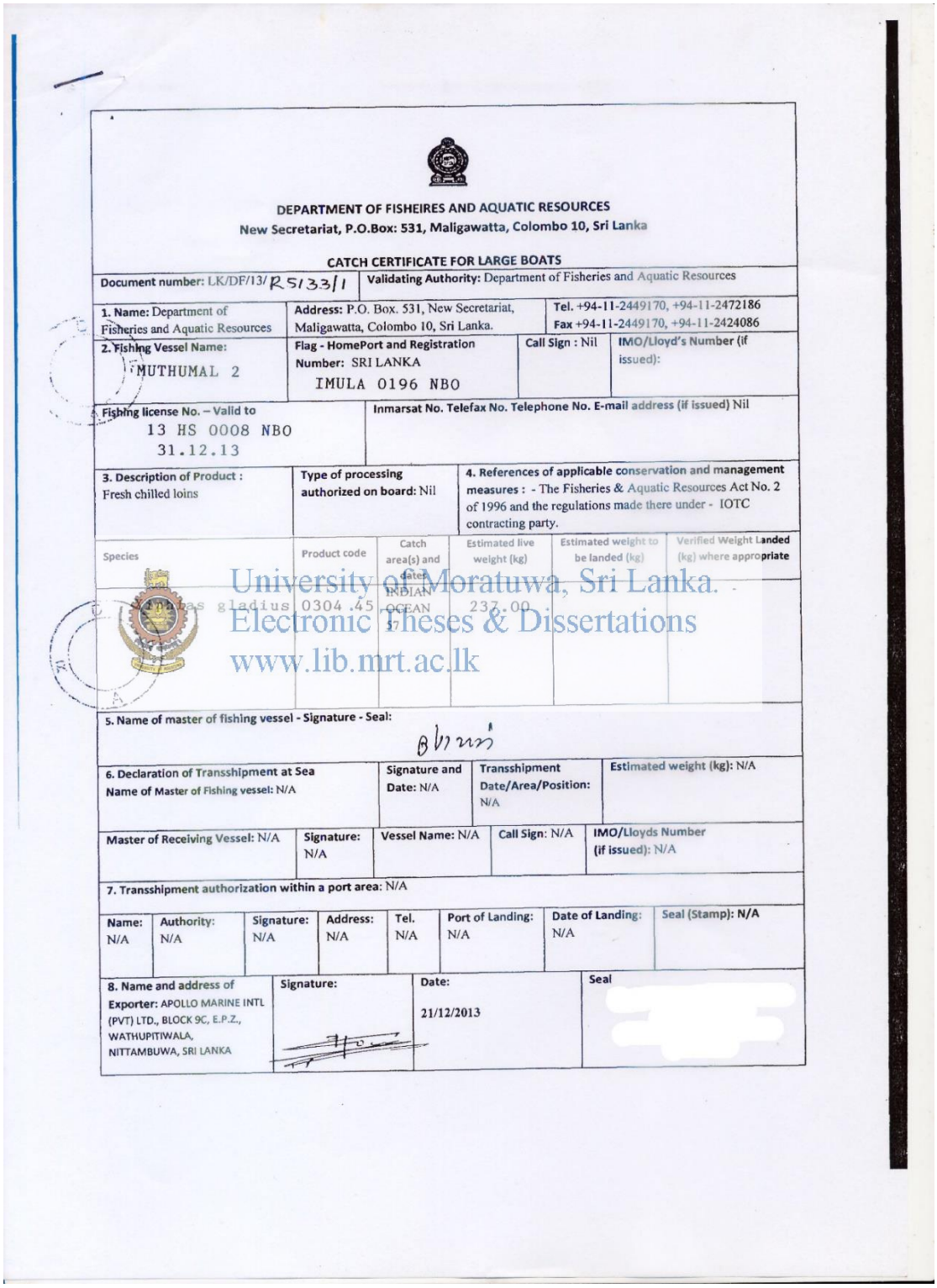
Director General / Licensing Officer

(This permit should be carried onboard in each and every fishing trip and is not transferable.)

Assistant Director (Chilaw)
For Director General
Department Of Fisheries & Aquatic Resources
District Office

A.3 Sample manual Logbook

A.4 Sample Catch Certificate



DEPARTMENT OF FISHEIRES AND AQUATIC RESOURCES
New Secretariat, P.O.Box: 531, Maligawatta, Colombo 10, Sri Lanka

CATCH CERTIFICATE FOR LARGE BOATS

Document number: LK/DF/13/R5133/1	**Validating Authority:** Department of Fisheries and Aquatic Resources	
1. Name: Department of Fisheries and Aquatic Resources	**Address:** P.O. Box. 531, New Secretariat, Maligawatta, Colombo 10, Sri Lanka.	**Tel.** +94-11-2449170, +94-11-2472186 **Fax** +94-11-2449170, +94-11-2424086
2. Fishing Vessel Name: MUTHUMAL 2	**Flag - HomePort and Registration Number:** SRI LANKA IMULA 0196 NBO	**Call Sign :** Nil / **IMO/Lloyd's Number (if issued):**
Fishing license No. – Valid to 13 HS 0008 NBO 31.12.13	**Inmarsat No. Telefax No. Telephone No. E-mail address (if issued)** Nil	
3. Description of Product : Fresh chilled loins	**Type of processing authorized on board:** Nil	**4. References of applicable conservation and management measures :** - The Fisheries & Aquatic Resources Act No. 2 of 1996 and the regulations made there under - IOTC contracting party.

Species	Product code	Catch area(s) and date	Estimated live weight (kg)	Estimated weight to be landed (kg)	Verified Weight Landed (kg) where appropriate
Thunnus albacares gladius	0304.45	INDIAN OCEAN		237.00	

5. Name of master of fishing vessel - Signature - Seal:

6. Declaration of Transshipment at Sea **Name of Master of Fishing vessel:** N/A	**Signature and Date:** N/A	**Transshipment Date/Area/Position:** N/A	**Estimated weight (kg):** N/A	
Master of Receiving Vessel: N/A	**Signature:** N/A	**Vessel Name:** N/A	**Call Sign:** N/A	**IMO/Lloyds Number (if issued):** N/A

7. Transshipment authorization within a port area: N/A

Name:	Authority:	Signature:	Address:	Tel.	Port of Landing:	Date of Landing:	Seal (Stamp): N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	

8. Name and address of Exporter: APOLLO MARINE INTL (PVT) LTD., BLOCK 9C, E.P.Z., WATHUPITIWALA, NITTAMBUWA, SRI LANKA	**Signature:**	**Date:** 21/12/2013	**Seal**

Appendix B – Test Results

B.1 Fish catch records – Trial Trip – 1

Trip ID	Sequence	Date Time	Latitude	Longitude	Battery Level	Signal Strength	Note	Fish Species ID	Weight
1010	1	27/12/2014 20:27	6.47444	79.9775	100%	15	Registered	0	0
1010	23	30/12/2014 14:45	3.16245	77.091	100%	99	Fish	2	60.7
1010	24	30/12/2014 15:50	3.09115	77.0402	92%	99	Fish	6	38.1
1010	25	30/12/2014 16:20	3.03492	77.0127	88%	99	Fish	5	23.5
1010	26	30/12/2014 16:47	2.92521	76.9729	86%	99	Fish	5	21.9
1010	32	31/12/2014 10:10	3.1268	77.25508	100%	99	Fish	5	38.2
1010	52	02/01/2015 18:05	3.82402	77.39456	100%	99	Fish	1	33.2
1010	53	02/01/2015 19:12	3.82451	77.37945	100%	99	Fish	1	30.8
1010	55	02/01/2015 22:00	3.81698	77.37052	100%	99	Fish	1	33.6
1010	57	02/01/2015 00:28	3.80053	77.3767	100%	99	Fish	2	39.7
1010	58	02/01/2015 00:50	3.79574	77.39593	100%	99	Fish	1	35.2
1010	59	02/01/2015 01:01	3.79163	77.4179	100%	99	Fish	1	28.8
1010	78	05/01/2015 06:30	2.906381	77.55661	100%	99	Fish	6	34.2
1010	79	05/01/2015 06:53	2.95478	77.57583	100%	99	Fish	6	37.8
1010	85	05/01/2015 20:40	2.80213	77.95676	100%	99	Fish	6	32.6
1010	86	05/01/2015 21:22	2.77581	78.04567	100%	99	Fish	6	25.3
1010	87	05/01/2015 22:38	2.76545	78.09884	100%	99	Fish	6	28.7
1010	91	06/01/2015 05:33	3.043154	78.0661	100%	99	Fish	5	68.6
1010	95	06/01/2015 15:42	3.00745	78.276214	100%	99	Fish	6	45
1010	97	06/01/2015 17:30	2.716724	78.44787	100%	99	Fish	2	25.9

1010	98	06/01/2015 17:48	2.715352	78.442382	100%	99	Fish	1	30.3
1010	99	06/01/2015 19:25	2.64813	78.476715	100%	99	Fish	1	28.2
1010	112	08/01/2015 06:30	2.6303	78.69094	100%	99	Fish	1	25.3
1010	113	08/01/2015 06:42	2.6591	78.67721	100%	99	Fish	1	25.9
1010	114	08/01/2015 06:48	2.69066	78.66416	100%	99	Fish	1	24.5
1010	115	08/01/2015 07:28	2.71123	78.6559	100%	99	Fish	1	26.1
1010	131	10/01/2015 03:10	2.53289	78.69524	100%	99	Fish	2	25.4
1010	132	10/01/2015 03:16	2.53598	78.69283	100%	99	Fish	2	35.5
1010	133	10/01/2015 03:48	2.53889	78.69077	100%	99	Fish	2	21.9
1010	134	10/01/2015 04:10	2.53975	78.69026	100%	99	Fish	1	38
1010	135	10/01/2015 04:35	2.54215	78.68871	100%	99	Fish	1	30
1010	136	10/01/2015 04:58	2.5437	78.68734	100%	99	Fish	2	62.5
1010	137	10/01/2015 05:22	2.54507	78.68648	100%	99	Fish	1	23.9
1010	138	10/01/2015 05:26	2.54747	78.68476	100%	99	Fish	1	39.1
1010	147	11/01/2015 05:20	2.4101	78.68957	100%	99	Fish	3	18.1
1010	165	13/01/2015 08:11	6.47462	79.97768	62%	14	Finished	0	0

B.2 Fish catch certificate – Trial Trip – 1

VESSEL TRIP / FISH CATCH CERTIFICATE

Vessel Registration Number	:	IMULA 0330 NBO	Skipper	:	W.D.S. Pieris, 752342318V
Trip Start Date	:	27/12/2014 20:27:23			
Trip End Date	:	13/01/2015 08:11:36			
Number of Days	:	17 Days			
Trip Status	:	Legal in International waters	Distance from harbor	:	288nmi
			Distance nearest west border	:	108nmi
			Distance nearest east border	:	1,202nmi

Fish Catch

Number of fish species	:	5 species	Weight<15Kg Pieces	:	0 (0%)
Number of fish pieces	:	34 pieces	Weight>=15Kg Pieces	:	34 (100%)
Overall status	:	100% Catch accepted			

Fish Catch Details

Date/Time	*Latitude*	*Longitude*	*Fish Species*	*Weight*	*Status*
30/12/2014 14:45	3.16245	77.091	Big Eye Tuna	60.7	Accepted
30/12/2014 15:50	3.09115	77.0402	Swordfish	38.1	Accepted
30/12/2014 16:20	3.03492	77.0127	Marlin	23.5	Accepted
30/12/2014 16:47	2.92521	76.9729	Marlin	21.9	Accepted
31/12/2014 10:10	3.1268	77.25508	Marlin	38.2	Accepted

02/01/2015 18:05	3.82402	77.39456	Yellowfin Tuna	33.2	Accepted
02/01/2015 19:12	3.82451	77.37945	Yellowfin Tuna	30.8	Accepted
02/01/2015 22:00	3.81698	77.37052	Yellowfin Tuna	33.6	Accepted
02/01/2015 00:28	3.80053	77.3767	Big Eye Tuna	39.7	Accepted
02/01/2015 00:50	3.79574	77.39593	Yellowfin Tuna	35.2	Accepted
02/01/2015 01:01	3.79163	77.4179	Yellowfin Tuna	28.8	Accepted
05/01/2015 06:30	2.906381	77.55661	Swordfish	34.2	Accepted
05/01/2015 06:53	2.95478	77.57583	Swordfish	37.8	Accepted
05/01/2015 20:40	2.80213	77.95676	Swordfish	32.6	Accepted
05/01/2015 21:22	2.77581	78.04567	Swordfish	25.3	Accepted
05/01/2015 22:38	2.76545	78.09884	Swordfish	28.7	Accepted
06/01/2015 05:33	3.043154	78.0661	Marlin	68.6	Accepted
06/01/2015 15:42	3.00745	78.276214	Swordfish	45	Accepted
06/01/2015 17:30	2.716724	78.44787	Big Eye Tuna	25.9	Accepted
06/01/2015 17:48	2.715352	78.442382	Yellowfin Tuna	30.3	Accepted
06/01/2015 19:25	2.64813	78.476715	Yellowfin Tuna	28.2	Accepted
08/01/2015 06:30	2.6303	78.69094	Yellowfin Tuna	25.3	Accepted
08/01/2015 06:42	2.6591	78.67721	Yellowfin Tuna	25.9	Accepted
08/01/2015 06:48	2.69066	78.66416	Yellowfin Tuna	24.5	Accepted
08/01/2015 07:28	2.71123	78.6559	Yellowfin Tuna	26.1	Accepted
10/01/2015 03:10	2.53289	78.69524	Big Eye Tuna	25.4	Accepted
10/01/2015 03:16	2.53598	78.69283	Big Eye Tuna	35.5	Accepted
10/01/2015 03:48	2.53889	78.69077	Big Eye Tuna	21.9	Accepted
10/01/2015 04:10	2.53975	78.69026	Yellowfin Tuna	38	Accepted
10/01/2015 04:35	2.54215	78.68871	Yellowfin Tuna	30	Accepted
10/01/2015 04:58	2.5437	78.68734	Big Eye Tuna	62.5	Accepted
10/01/2015 05:22	2.54507	78.68648	Yellowfin Tuna	23.9	Accepted
10/01/2015 05:26	2.54747	78.68476	Yellowfin Tuna	39.1	Accepted
11/01/2015 05:20	2.4101	78.68957	Sailfish	18.1	Accepted

B.3 User Feedbacks

Trial Trip-1

USER FEEDBACK RECORD FORM			
SMARTPHONE VMS APPLICATION			
Date/Time	15/01/15 12:10	Location	Beruwala.
Skipper Name	W.D.S. Piris	Skipper ID	752392318V
Vessel Number	IMUL A0330 NBO	Trip ID	1010

What is Skipper's native language	Sinhalese
Has he selected same language	Yes, Sinhalese used
Has he got a Smartphone	NO
What is the platform	N/A
Is he comfortable with device	N/A
How did he find a Smartphone for VMS APP	Lended by the project
Device used for VMS application	Samsung Smartphone
Platform	Android Gingerbread.
Screen size	5.1"
RAM	512 MB
Internal memory	2 GB
Has GPS Receiver	Yes
Has Bluetooth Adapter	Yes
Method of power supplied	Both 12VDC & 230VAC
Other features	
Does he feel VMS is important	Yes
Why	Provide details to EU
Does he feel VMS APP is hard to follow	NO
Why	Interfaces are in Sinhalese
Does he feel VMS is user friendly	Yes
Why	Sinhalese / Touchscreen
Has he used other applications while VMS APP running? What type of application	NO
Has he used E-Logbook	Yes
Has he used paired scale	Yes
Does he feel E-Logbook is important	Yes
Why	No manual record keeping
Does he feel E-Logbook is user friendly	Yes
Why	Simple & easy to use

Other Comments

-NO comments- Need to get use to the system.

Data recorded By	TR	Skipper's Signature	

Trial Trip-2

USER FEEDBACK RECORD FORM

SMARTPHONE VMS APPLICATION

Date/Time	22/01/15 10.00	Location	Beruwala
Skipper Name	S. Perera	Skipper ID	785220502V
Vessel Number	IMULA0146KLT	Trip ID	104

What is Skipper's native language	Tamil / Sinhalese
Has he selected same language	Yes Tamil selected
Has he got a Smartphone	Yes
What is the platform	Android
Is he comfortable with device	Yes
How did he find a Smartphone for VMS APP	New device purchased
Device used for VMS application	Samsung Trend Phone
Platform	Android Jelly bean
Screen size	4.0"
RAM	256MB
Internal memory	1GB
Has GPS Receiver	Yes
Has Bluetooth Adapter	Yes
Method of power supplied	230V AC
Other features	
Does he feel VMS is important	Yes
Why	To confirm the trip route
Does he feel VMS APP is hard to follow	No
Why	Familier with smart phones
Does he feel VMS is user friendly	Yes
Why	Easy to follow with Tamil
Has he used other applications while VMS APP running? What type of application	Yes, Music player
Has he used E-Logbook	Yes
Has he used paired scale	Yes
Does he feel E-Logbook is important	Yes
Why	To know fish on-board
Does he feel E-Logbook is user friendly	Yes
Why	Easy to follow

Other Comments

New device purchased for the cost of Rs. 21,899

Data recorded By	TR	Skipper's Signature	

Total Trip - 3

USER FEEDBACK RECORD FORM

SMARTPHONE VMS APPLICATION

Date/Time	10/01/15 09:00	Location	Colombo
Skipper Name	N. Madagulu	Skipper ID	562483859V
Vessel Number	IMUL A0385 TCO	Trip ID	1012

What is Skipper's native language	Tamil
Has he selected same language	Tamil language selected
Has he got a Smartphone	Yes
What is the platform	~~Yes~~ Android
Is he comfortable with device	~~Android~~ Yes
How did he find a Smartphone for VMS APP	Used his mobile phone
Device used for VMS application	Samsung Core
Platform	Android Jelly bean
Screen size	5.1"
RAM	512 MB
Internal memory	2 GB
Has GPS Receiver	Yes
Has Bluetooth Adapter	Yes
Method of power supplied	12 V DC
Other features	
Does he feel VMS is important	Yes
Why	As set by the law
Does he feel VMS APP is hard to follow	Sometimes
Why	Can't work with wet hands
Does he feel VMS is user friendly	Yes
Why	—
Has he used other applications while VMS APP running? What type of application	NO
Has he used E-Logbook	Yes
Has he used paired scale	Yes
Does he feel E-Logbook is important	Yes
Why	Easy to record catch
Does he feel E-Logbook is user friendly	Yes
Why	Simple

Other Comments

Found that difficult to operate the system with wet hands. Screen doesn't respond.

Data recorded By	TR	Skipper's Signature	

USER FEEDBACK RECORD FORM

DESKTOP APPLICATION

Date/Time	27/12/14 11:10	Location	Beruwala Harbor
Officer Name	Mr. M. Fernando	Level	Clerk

What does he/she do with the application	* Vessel registration * Skipper registration * Device registration * Create Trips
Does he/she feel easy to use	* Yes. Simple
Does he/she has idea where we should improve	No
Does he/she happy with system performance	Yes

Other Comments

Accepted.

Data recorded By	TR.	Officer's Signature	

USER FEEDBACK RECORD FORM			
DESKTOP APPLICATION			
Date/Time	27/11/14 12.00	Location	Beruwala
Officer Name	Mr. Sumana Palen	Level	Manager
What does he/she do with the application		- Create Trips - Get evaluation	
Does he/she feel easy to use		- Yes	
Does he/she has idea where we should improve		- Evaluation rules should be selectable	
Does he/she happy with system performance		Yes	
Other Comments - Evaluation rule set need to be selected rather than pre defined			
Data recorded By	TR	Officer's Signature	