ICT integration of public protection and disaster relief: services for fire and rescue personnel

Jyri Rajamäki, Taina Hult and Paulinus Ofem

***Abstract*—**In field operations of Public Protection and Disaster Relief (PPDR) services, vehicles are the most important tools. Today, the vehicles are increasingly dependent on ICT systems. PPDR responder's need is to enhance mission critical voice with broadband data. Command and control applications aboard a vehicle are commonplace. There is a need to ease situational awareness and decision making by utilizing sensor information, such as satellite or network based position information, living video images. However, each country and even every single user organization is developing their own solutions according to their legislation and requirements, because uniform standards are missing. The Mobile Object Bus Interaction (MOBI) research project is a kick off for creating a common international ICT infrastructure for all PPDR vehicles. MOBI researches possibilities to further develop and integrate ICT systems, applications and services of PPDR vehicles. MOBI aims at starting the development of standards used by like-minded countries and possibly with the European Commission, the European Law Enforcement Agency EUROPOL and the European Agency for the Management of Operational Cooperation at the External Borders FRONTEX. This paper concentrates on services for fire and rescue personnel and researches the Finnish fire and rescue environment and the ICT systems used in action. PPDR services constitute a distributed system. Software development paradigms which have been used in the past for distributed systems have inherent limitations that do not support integration, interoperability and reusability. To contribute towards resolving the well known issues of integration and interoperability between ICT systems in emergency vehicles which often work in a collaborative fashion, a preliminary investigation of the applicability of SOA and Web Services Standards towards the optimization of ICT systems and services provided by emergency vehicles is presented.

***Keywords*—**Data communications, Fire and rescue services, ICT, Professional mobile radio, Public safety, Search and rescue, Service-oriented architecture, Systems integration, Web services

I. Introduction

PUBLIC Protection and Disaster Relief (PPDR) services such as law enforcement, fire fighting, emergency medical, and disaster recovery services, bring value to society by creating a stable and secure environment. The protection to be ensured by PPDR responders covers people, the environment and property. It addresses a large number of threats both natural and man-made. One important task of PPDR services is to deal with emergency and surveillance situations on land, sea and air. The most important part of this work is done in the field, so all the tools must match the needs accordingly. When working in the field, vehicles with their devices, systems and the services they provide are the most important tools, in which occupational safety, efficiency and ergonomics must be taken into account. The vehicles used and devices installed must be robust, secure and suitable for very demanding and variable conditions. [1]

The amount of technical devices, applications and services in PPDR vehicles has increased during the past few decades. This progression has also increased the volume of different user interfaces and generated new problems, e.g. vehicle airbags have less room to fill. Also technical problems especially with power consumption and cabling have been reported.

Another problem is the poor documentation of applied solutions because there has been no standardization in the field. This is partially because of the diversity in equipments and the vendors who supply them. The diversity in the equipment supplied raises issues of system integration and interoperability between collaborating units such as the emergency control unit or the command control with the emergency vehicles in the field. The issue of interoperability also negatively impacts the administration of the emergency services since services are observed to be managed on national regional and local basis. Information inter-change is therefore critical. For instance, in fire and rescue service field in Finland, the country is divided into multiple regions, where each and one of those regions have their own fire and rescue departments responsible to deliver fire and rescue services to the public. As the technology develops and becomes more utilized in everyday life, so it does in fire and rescue environment. These technology advancements would help to develop services, make them more efficient and especially help the rescue services unit to better deliver effective and efficient service. Unfortunately so far, there has been no standardization in the equipment and systems utilized by these emergency service vehicles. The number of equipment suppliers is large and complex. Yearly delivery volumes have not been helping development of standardization. The aforementioned problems present the need for new business models [2], [3].

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More so, with the increased number of applications, the amount of transferred data has exploded. In the field, wireless communications' role is to support the mobility of first time responders by providing continuous connectivity among responders and with the headquarters. The support includes: maintain voice communication to coordinate the relief efforts for the resolution of the crisis; creation and distribution of a common operational picture among all the responsible parties; collect and distribute data on the operational context or the environment from sensors; retrieve data from central repositories (e.g. building plans, inventory data) to support their activity; support the tracking and tracing of the supply chain of goods and materials needed in the response and recovery phases of a crisis. [4]

In Europe, many dedicated and secured network infrastructures have been built and deployed to provide the necessary capabilities for PPDR organizations. These networks, generally realized by TETRA/TETRAPOL are narrowband. Lack of broadband connectivity of wireless communications for existing and future PPDR applications is a real problem [4]. Many new applications require wideband data rates usually provided by commercial operators. For that reason, separate parallel data communication channels are needed. A robust multichannel data communication concept that is independent of single operators is presented in [5] and the protocol enabling this, in [6].

The European Commission, the European Law Enforcement Agency EUROPOL and the European Agency for the Management of Operational Cooperation at the External Borders FRONTEX have recognized that lack of interoperability limits the effectiveness of PPDR practitioners in actual operations, and an evident lack of understanding as to whether these limitations arose from technology, operational procedures, gaps in procurement or research [4]. A scientific proven fact is that standardization strongly affects businesses that develop and sell technologies and technology-based products and services; standards are one main enabler for fast growth [7]. Towards improving interoperability, standardization development with like-minded countries should be started.

Chapter 2 of this paper illustrates the operating environment especially from end-users' perspective. Chapter 3 presents the research, development and innovation programme 'Mobile Object Bus Interaction (MOBI)' being made up of two industrial projects and a research project. Chapter 4 describes the research project in more detailed. Chapter 5 presents an initial investigative report on the applicability of SOA and Web services standards in the emergency services domain for the purpose of realizing standardization while tackling software system integration and interoperability concerns across domain. Chapter 6 presents the needs for further research and discussions.

II. ICT SYSTEMS OF PPDR SERVICES

Information systems integration is a current trend in all businesses and organizations [8]. Working manners are trending toward more of mobility and the Web plays a major role in providing critical business data, applications and services to mobile users. In this respect, service-level requirements play an important role in the process. However, service-level requirements are difficult to quantify during the project planning phase. As an example, only the following intangible values could be used as guide lines for drawing up the operational constraints and goals required: 1) usability, 2) performance, 3) scalability, 4) reliability, 5 availability, 6) extensibility, 7) maintainability, 8) manageability, and 9) trustworthiness and security. These attributes can be quantified only after the real deployment. To meet pertinence requirements, the production system needs changing and tuning; if not possible, service-level requirements should be readjusted to conform the operational environment. The reasons for existence of any Web system are to support business and organizational needs. A shift in focus is needed, so that Web architecting activities in any new project can be given more effort, attention and seriousness. [9]

A. End-User Perspective

PPDR field operations are increasingly dependent on ICT systems, especially on wireless and mobile communications. In PPDR vehicles, data communication is mission critical. It is necessary to ensure that information and "on-demand" services provided by these technologies are delivered reliably and securely through one or more of the recently developed wireless architectures.

According to [4], the main effort in developing ICT systems of PPDR should be to standardize the interoperability architecture for applications (e.g. command and control) and infrastructure (e.g. interface gateways, mobile unit). Usability is also a main concern as many solutions are not ergonomic or easy to adapt to existing vehicles or infrastructures. The following recommendations are provided: 1) Inter-System Interface (ISI) is an open interface standard used to connect two TETRA networks together. A joint ISI development should be started with roaming as a primary objective. 2) Harmonized frequency bands for PPDR broadband data services should be investigated and identified. 3) There is the need to conduct a feasibility study of TETRA Enhanced Data Service (TEDS) services to confirm if they are able to address the needs of PPDR organizations in Europe. 4) PPDR broadband data network needs standardized and harmonized technologies. [4]

B. Main PPDR Practitioners in Finland

There are 24 regional police departments in the organization of Finnish police with the National Bureau of Investigation and the National Traffic Police as national units. Modern police vehicles hold more ICT systems and other technical devices than ever. Police vehicles are nowadays mobile offices, in which all kinds of customer contact–related issues ranging from fining can be resolved. Police vehicles also contain numerous systems including cameras and other technical devices for speed monitoring and control together with other traffic surveillance.

Finland has been divided into 22 regional rescue departments, which are responsible for areal emergency and rescue services. In the biggest cities and towns, hired professionals carry out the major part of the fire and rescue missions while in other parts of Finland, the rescue work rests mainly within the provisions and the functions carried out by the volunteer fire-brigade. The use of ICT in fire and rescue operation management has increased and there are already several different systems in use for different purposes in the field.

In Finland, Emergency Medical Services (EMS) has been outsourced to private companies in 200 municipalities. In 60 out of the 200 municipalities, EMS are being carried out by regional rescue departments and in 40 municipalities the EMS are provided by the municipality itself. Nowadays, patient examination, treatment and condition stabilization is started in the field thus making the possibility for condition deterioration more unlikely during transportation. Patient's treatment in the field sets own requirements for the EMS vehicle. Information technology is replacing the traditional paper forms and the use of technology has increased in other processes as well.

III. MOBI Programme

The target of a Finnish national research, development and innovation programme 'Mobile Object Bus Interaction (MOBI)' is to create a common ICT hardware and software infrastructure for all emergency vehicles. This infrastructure includes devices for voice and data communications, computers, screens, printers, antennas, cablings, and additionally, interlinking with factory-equipped vehicles' ICT systems is researched.

The programme consists of two industrial projects and a research project that generates research data for industrial projects by researching and documenting the needs and requirements of the users, power generation and supply and specifying the existing solutions. One industrial project, led by Cassidian Finland Ltd., implements a vehicle-installed professional mobile radio concept for law enforcement, fire and rescue operations. Another industrial project, led by Insta DefSec Ltd., develops secured software services. The project utilizes the results of the related research project and aims to develop product concepts which have potentials in both domestic and export markets. Additionally, Insta DefSec Ltd. will further develop its business model in order to be able to utilize growth potential of the product concepts. [10]

This research, development and innovation work starts in Finland, because Finland has

- evidences of success in developing wireless telecommunications, e.g. 1G - Nordic Mobile Telephone (NMM), 2G – Global System Mobile (GSM), 3G – Universal Mobile Telecommunications System (UMTS) [7].
- the world's first nationwide TErrestrial TRunked RAdio (TETRA) network - the "Viranomaisradioverkko" or VIRVE network - commonly used by Finnish authorities. The VIRVE network is used by the emergency, fire and rescue services, the police, the Finnish Defence Forces, the Frontier Guard, social and health services, the Finnish Maritime Administration and different government departments. Today, the VIRVE network enables the world's best interoperability between different PPDR services network-wise.
- extensive experiences in field command systems, e.g. the Police Field Command System POKE has been in operational use since 2006 [11], [12]. From the base of the POKE system, a dedicated system 'PEKE' for fire and rescue work has been developed.
- well operating and organized co-operations between authorities at different levels, e.g. national police – customs – border guard cooperation [13].
- an atmosphere which supports successful innovation; e.g. Finnish companies are doing R&D with universities including their competitors, with the popular slogan: "Finland is a club, rather than a country" [14].

IV. MOBI Research Project

As it has been acknowledged, the number of different ICT systems in emergency vehicles has been growing significantly which to a considerable extent has caused problems for example in vehicles safety systems and power supply. Documentation of existing solutions varies and there are no standards in the business. There is also the problem of integration and interoperability between these varying ICT systems since emergency vehicles need to collaborate during an incident for the purpose of information sharing. The research project generates research data for industrial projects by researching and documenting the needs and requirements of the users, power generation and supply together with specifying the existing solutions. The research also investigates how SOA and Web services standards can support the software application requirements of these vehicles in order to enable standardization, integration and interoperability between the vehicles and their control centers. Based on the research a demo vehicle with working ICT-integration would be made. A commercial product including commercializing plans to be offered in the European market is going to be the final outcome of the project. This three-year project started in September 2010.

A. Consortium and Founding

The project consortium, led by Laurea University of Applied Sciences, consists of three research institutes, two industrial partners, three small and medium size enterprises (SMEs), several end-user organizations and a public financier; Tekes – the Finnish Funding Agency for Technology and Innovation. The budget of MOBI research projects is 800 000 € and Table 1 shows funding shares.

Table 1 Funding of MOBI Research Project

Participant	€	%
Tekes	480 000	60
Research institutes	108 000	13
Industrial partners	110 000	14
SMEs	63 000	8
End-users	39 000	5
TOTAL	800 000	100

B. *Work Packages*

Fig. 1 shows MOBI's Work Packages (WPs). The project starts by researching user requirements (WP2). The common ICT infrastructure is composed of four layers and their standardized interfaces: vehicle ICT infrastructure and power generation (WP3), data communications (WP4), common software infrastructure (WP5), and ICT services for PPDR practitioners (WP6). Also, a demonstration vehicle is equipped (WP7), new business models studied (WP8) and coordination taken care of (WP1).

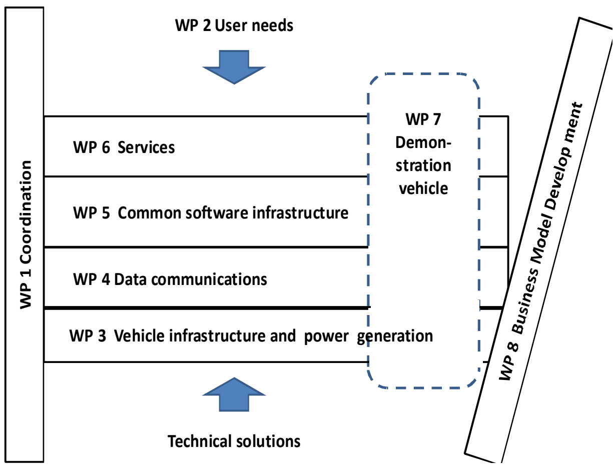

Fig. 1 Work Packages of MOBI Project

1) *Coordination*

Work package 1 includes tasks considering project management, of which the main objective is to ensure that MOBI research project generates research data for the parallel corporate projects. This work package includes cooperation and exchange of information with other relevant projects, such as MOBI-projects parallel corporate projects, EU FP7/SEC Project AIRBorne information for Emergency situation Awareness and Monitoring (AIRBEAM), EU FP7/SEC Project Policy-oriented marine Environmental Research in the Southern European Seas (PERSEUS) and Scientific innovation Product concept (SCOPE).

WP1 uses Wise Guys-panels that are also common sessions for all the work packages to present what has been done and to plan the future actions. Results from other work packages will be brought to the Wise Guys-panels to be presented. Wise Guys-panels would be scheduled so that they can be arranged before the deadlines of other work packages.

2) *User Requirements*

In this work package the present electrical- and ICT-systems are being surveyed (for example in case of police vehicles: power supply technologies, radio equipment, video equipment, radars and other speed monitoring devices, IT-workstations, printers, biometric devices, navigation and tracking devices). User and authority requirements for these systems and devices are also being surveyed. Former studies will be used as a source for information.

In this work package administrative and operative systems will be identified and priority and manageability requirements for these systems will be defined. Different authority adoptions (e-adoption, RTTE- and EMC-directives) required for different systems will also be researched. This work package delivers an updated description of the IT-solutions of Finnish emergency vehicles. In this description the requirements are being organized to be used by the companies involved in this research project.

3) *Vehicles Infrastructure and Power Supply*

Power consumption is one of the biggest challenges of emergency vehicles and their ICT-systems. The number of ICT systems needed to be optimized and power consumption of the other electrical devices in different operational modes will be researched in this work package. Different kinds of power generating possibilities, such as fuel cells, will also be researched. How to ensure that power supply, power control and sleep-mode control is done in a consistent manner would be researched in this work package.

4) *Data Communications*

The capability of exchanging information (e.g. voice or data) is essential to improving the coordination of PPDR officers during their operations; especially, wireless communications are important in the response and mitigation of emergency crisis to support the mobility of first responders [4].

Data communications of PPDR vehicles can be divided into three levels. The first level is represented by long distance communications e.g. between vehicles and command and control rooms often realized by narrow band TETRA or TETRAPOL systems, but also e.g. @450, 2G, 3G, 4G and WiMAX are used. Also, FM radio and GPS systems could be referred to as long distance communications. Normally, the media used depends on the application or is selected manually by the user.

The second level is represented by local network data communication including e.g. CAN, LAN, WLAN and wide band ad-hoc –communications between vehicles. The third level is the accessory communications of different data systems used in vehicles.

The ICT-solutions of PPDR must be robust and easy to install. Misinterpretations or connectivity failures can cause loss of life or delay the resolution of the crisis. Information security and reliability must be properly considered and taken care of. Different encryption methods of different systems cause their own challenges. In addition, different organizations have their own requirements for managing the information security of their vehicles' systems.

Research of the requirements to be set for data bus and the planning of on-line systems' basic and back-up connections and connections used in off-line systems synchronizing will be carried out in this work package. Different antennas and cabling solutions will also be researched while considering placement, possibilities of interference and possibility of joint cabling.

5) *Common Software Infrastructure*

In this work package the ICT-integration of emergency vehicle will be planned. Overview of the vehicle's IT-architecture both in online and off-line situations will be created. In this matter the security of the data in local storing and classified data that can be replicated must be taken into consideration. When planning the vehicle, safety matters must also be considered (such as functioning of vehicles safety devices). This would be one of the major improvements that the integration of systems will bring. Results of the work package 2 will be used as a base for planning of the architecture and user interfaces.

The objective of this work package is a description of the architecture which includes a description of the components the system consists of and how they are being placed. This description would consist of an application architecture, IT-architecture, technical architecture and layout diagram –levels. There will also be an interface definition which describes applications' connectivity to the system. Light-control systems available in present markets would also be studied.

6) Services

The main applications and the services they offer for each end-user group (e.g. video surveillance and speed radars for police) will be chosen for further research. The objective of this work package is to define the emergency vehicles' main applications' functionality and to plan the technical realization of these main applications.

7) Equipping the Demonstration Vehicle

Industrial participants and end-user organizations are able to test chosen solutions in a research environment. Test vehicle built by industrial participants of the project will act as testing environment for the representatives of end-user organizations. A demo-vehicle will be made in cooperation with different participants. Demo-vehicle will be made according to one user-group's requirements meaning that the vehicle would not be a model representing the requirements of both police vehicles and rescue service vehicles. This vehicle will be made for one authority only.

Field testing for the demo-vehicle would be carried out either in the Police College of Finland or in the Rescue College of Finland.

8) Business Models

Development of an ICT-concept is significantly expensive so access to the international markets is desirable. There are good chances to develop the industry in Finland because cooperation between different authorities is efficient and highly developed. The problems mentioned above are similar in all countries: new IT-equipments must be added to authorities' vehicles. A much needed standardization has not been introduced in the industry. The purpose is to create an International Standard Industry's De facto and/or de jure to the industry which makes cooperation between authorities easier and more efficient. The objective is to also make the final result suitable for others than just the authorities. For example, some companies in the industry, private security services and fleet management services could have the need for a moving office-type of vehicle solution. These varying needs would be considered especially when developing commercial solutions.

Question: how a developed solution or part of it could be sold as a compatible set, will be studied in the work package of business models. Industry's market and volumes, national and international public-private partnership regulations will be studied in this work package. One of the main tasks is to monitor the development of markets in this industry within the EU. There is an attempt to create scenarios from the business models which will help one to find out who should be responsible for integration work and further equipment acquisition and administration. A Finnish model to act as a base for creating RFQ-documents would be developed and documented in this work package. Developments in EU-area (for example EUROSUR) as well as markets and regulations (for example outer borders' exit-entry-system which creates new challenges for identification of persons and which is currently being processed by the EU parliament) would be monitored in this work package. Laurea has become a member of the Centre for Identification Research, CITeR, and a partner of the University of Arizona.Developments in the field of CITeR would also be monitored.

This work package produces new business models for the security and safety industry to be used. These new concepts, business plan and possibly an FP7-application user requirement definition would be done in Finland and market research internationally.

C. Requirement Analysis

This phase determines and defines what the system should do. Requirement Analysis would be based on the results of requirements research. The goal is to recognize requirements and to do functional specification for the system. Requirements will be divided in two groups: Functional Requirements and Non-functional Requirements. These requirements define operations, functions and constraints of the system. [15]

Functional Requirements define the expectations of systems behavior or functions. It describes how it works, how it will communicate with other systems, what kind of stakeholders or users it can accommodate, how stakeholders and users can use it. Generally these are the actions that this system must be able to perform. Non-functional requirements also known as quality requirements define features and constraints of the system. The requirements define non-functional quality attributes for the system like usability, reliability, performance and support. [16].

The purpose of this work package processes is to ensure that the project outcome meets the expectations of the customers and other (internal or external) stakeholders. After Requirement Analysis process there will be naturally a design process. The purpose of these two processes is to translate the requirements into a specification that describes how to implement the system [17].

V. SERVICES FOR FIRE AND RESCUE PERSONNEL

The main objective of this chapter is to commence a preliminary investigation into the applicability of Service Oriented Architecture (SOA) and Web services standards in the emergency vehicles domain. It would seek to explore whether SOA and Web services can support integration, interoperability and reusability of ICT systems and services in emergency vehicles. The knowledge gained could enable us determine whether SOA can be adopted to fulfill the software application requirements of emergency vehicles.

A. ICT Systems and Services in the Fire and Rescue Department

The way and manner emergency vehicles such as medical ambulances, fire and rescue vehicles deliver their services represents a distributed system. This is further buttressed by the fact that emergency services provision and administration is performed in Finland under national, regional and local basis [18]. When an emergency occurs, ICT systems which are manned in various emergency vehicles are called to play in resolving the incident. These vehicles must network with their command and control centers while they are on the field. It has been acknowledged that past software development paradigms do not provide adequate support for standardization, integration and interoperability between systems in a distributed platform such as the one envisaged by this research. As evident in [18], real-time information interchange between collaborating systems and the headquarters during an emergency is critical. SOA is thought to hold the promise of resolving the aforementioned issues.

When considering a transition to a SOA solution in order to enable the day-to-day operations of fire and rescue personnel and the optimization of the ICT systems that enable these operations, it would be worth to take stock of the existing services and the business requirements of the fire and rescue department since SOA attempts to align business with technology. There are some major pertinent questions that would give direction to the overall research concerning SOA application in our problem domain. Because the project is in its preliminary phase, we would not answer some of the questions in this paper but in a later paper. The questions include:

- Did fire and rescue department adopt the SOA paradigm when developing their ICT systems or any aspect of their system?
- If yes, to what extent does this architecture support standardization , integration, interoperability, reusability and extensibility for future services and how can SOA support via Web services provide for mobile or internet support while allowing access to emergency vehicles and personnel?
- If no, what kind of solution can we manage?

Based on the interview that was held with some personnel of one of the Finnish fire departments, rescue service chain starts when a call is placed to the emergency rescue centre. This centre receives the call, processes it and forwards same to the scheduled rescue units. These units can be for example fire units, ambulance and emergency medical units and the police units. The calls to either of the units are prioritized based on the severity of the situation. The emergency rescue centre usually makes the decision of how many units are sent to the scene of an incident. As the mission is delivered to the units and departments, the chain does not break up. Moving units and rescue centre are in constant contact with each other. Units can therefore move in advance to the location while at the same time receives more information about the mission. It is possible to have an incident which would not only require fire and service vehicles but ambulance vehicles at the same time. This means that all units involved would be reporting to their various control centers and they would need to share information about the situation.

The above description partly defines the process and information flow when the control centre receives a call. The rescue centre can receive new information from the caller and convey the same information directly to the fire officers who are already on the move thus; previous knowledge about the situation is updated with current information. While in the rescue vehicles, rescue personnel are also able to monitor the situation via different user interfaces on their laptops. These interfaces display a series of vital information that they need to accomplish the task. They work in union with the emergency rescue centre which commands the mission.

Every emergency call that is placed to the command centre has its designated code which describes the severity of the incident being reported. This call code is directly received by the fire Chief in-charge who is presented with the corresponding mission and objective regarding the code on his terminal. He is able to gauge the scale of the incident and the number of units to be deployed. The vehicle has on-board a computer which runs an application called Merlot Mobile 4.1 provided by Logica. The Merlot Mobile system essentially enables the field personnel to receive up to date information about the reported incident. The ambulances and rescue helicopters use an extended version which includes the patient personal data and his or her medical history. This is a highly restricted system which permits access to only the doctor or a designated person.

In some cases the character or nature of the mission changes and if the fire Chief at the controls needs to make any changes, system automatically refreshes itself at the field terminals. The control centre is able to monitor the field events in real-time. When the unit arrives at the incident scene, the field commander must scroll the blueprints of the building, and what area to turn out. One major issue is that the objective cards (blueprints) are not current while some suffer from wear and tear. This has a great impact on how fast the fire is turned off. This manual process that involves looking up blueprint would require improvement.

The rescue personnel have VIRVE which they can use in large operations. It is a dedicated network for army, police, fire and rescue department, sea patrol, rescue helicopters and other public safety practitioners. There also exists a system which automatically sends a warning signal to the 112 centre if it detects fire or smoke. This is also related to the blueprint section where the blueprints are currently manually used and if this could be viewed digitally in the Merlot system or added as a Web service it would be of immense benefit as losses are reduced and process improved.

B. Challenges within Fire and Rescue Services and Emergency Services in General

It has been established that, PPDR services are supported by different agencies which include the police, fire and rescue, emergency medical services etc. It is also well known that the provision and management of PPDR services is not central as it is performed on national and regional basis. All these agencies have different ICT systems which enable them to carry out their roles. During an emergency, field officers and their systems on-board the vehicles are required to collaborate in resolving the emergency. A well known challenge within PPDR services is the integration of all potential ICT systems and services that are needed to support an incident and their command and control centers. This would bring about efficient and effective real-time information exchange and provide a common pool of shared services among collaborating partners.

Currently, the fire and rescue service as we have earlier on stated runs a software application known as Merlot Mobile. This software essentially enables the effective deployment and monitoring of field units which provides a means of updating field officers as situation changes. One key aspect that this current system does not support is the electronic availability and management of blue prints of buildings. This gap is evident when field officers are only able to locate areas of an affected building by flipping books that hold the building's blue prints at the scene of incident. It is possible to have a consolidated and integrated database of electronic blue prints of all buildings which is updated on regular basis. This would enable the command and control centre to have the exact locations of concern within the building well in advance before the field officer arrive the scene.

However, it is common knowledge that, PPDR services such as the medical emergency services are tilting towards the adoption SOA for an effective and efficient healthcare delivery. The Finnish government has already adopted SOA for the national health archive and still considering its adoption other health care domains. It is possible to have a private or public service registry which would contain Web services that can be shared between PPDR services. Common Web services that enable the resolution of emergency crisis can be shared by EU member countries who wish to pursue a similar business model for PPDR services. In order to benefit from a future adoption of SOA, PPDR services would need to investigate the feasibility of SOA application towards achieving standardization and integration. Part of this study sets out to achieve this.

C. What Role can SOA and Web Services Play in the Fire and Rescue Domain Including Emergency Vehicles in General?

In order to answer the above question, we would first present a brief overview of what SOA and Web services entail.

SOA is an architectural paradigm of which main characteristic is to promote loose coupling during the design and implementation of a software system. According to the World Wide Web Consortium (W3C), SOA is ''a set of components which can be invoked, and whose interface descriptions can be published and discovered''. The SOA paradigm creates room for loose coupling, interoperability and standards-based computing. SOA is also a way of designing new applications which involves the incorporation of "services" from existing systems and provides a key solution to overcoming the challenge faced by organizations in their desire to display data in a way that involves effective and efficient human interaction [19]. Also in [20] and [21] loose coupling is a key property of SOA which enables interoperability and effective design and management of systems. This research would adopt the SOA definition giving in [22] and which defines SOA as "an [enabling] framework for integrating business processes and supporting information technology infrastructure as [loosely] coupled and secure, standardized components-services-that can be reused and combined to address changing business priorities". Fig. 2 shows a typical SOA architecture which consist of a registry of Web services that are made available by the Service Provider and consumed by the Service Requesters. It also depicts the collaborations between these three major components.

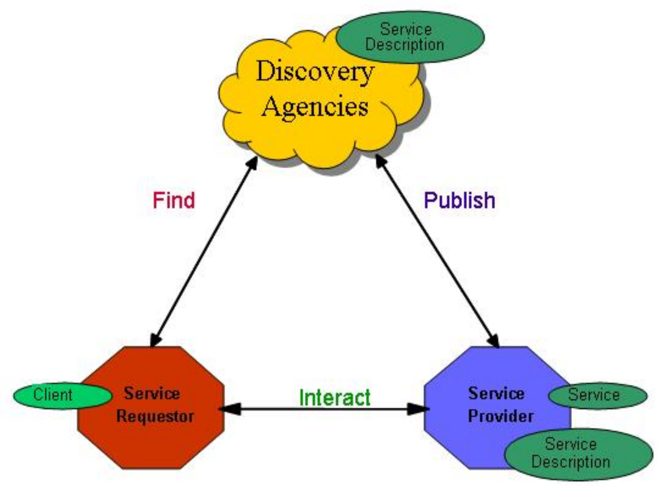

Fig 2 SOA Architecture [23]

Web services though not quite new have witnessed a remarkably wide acceptance in the industry as a very vital means of implementing SOA. This acceptance is owing to the fact that, Web services are able to provide a distributed computing style which makes it possible to integrate heterogeneous applications across the Web. The Web services specifications are such that they are totally independent of any programming language, hardware and operating system thereby enhancing loose coupling between service requesters and providers hence fulfilling the loose coupling principle of SOA.

According to W3C Services Architecture Working Group, "a Web service is a software application identified by a URI, whose interfaces and bindings are capable of being defined, described, and discovered as XML artifacts. A Web service supports direct interactions with other software agents using XML-based messages exchanged via Internet-based protocols." In [23] Web services are defined as "a family of technologies that consist of specifications, protocols, and industry-based standards that are used by heterogeneous applications to communicate, collaborate, and exchange information among themselves in a secure, reliable, and interoperable manner." It is also worth to add that, SOAP and REST are currently the major paradigms which can be used to further implement Web services.

The Web services technology is based on open source technologies which include: eXtensible Markup Language (XML), Simple Object Access Protocol (SOAP), REST, Universal Description, Discovery and Integration (UDDI) and Web Services Description Language (WSL). As earlier mentioned, the use of the above named open standards enables the applications that have been developed using different vendor platforms to easily interoperate. The attainment of interoperability between vendors implies that, public and private organizations do not need to have knowledge about the would-be service requesters before they consider or implement Web services and vice versa. The benefit as we would explain later is easy integration and adaptation to changes in the business goals of the organization.

Given the overview of SOA and Web services above, there is no doubt that their application in a distributed domain like the one presented in this research could be of immense benefit.

D. SOA Standards

The success of the application of SOA as a key to resolving issues of standardization, integration and interoperability across our problem domain mainly begins with the incorporation of SOA principles to the analysis and design of the intended SOA solution. We would now briefly look at these key principles as given in [24].

1) The Standardized Service Contract Principle

This principle is mainly about the compliance of service descriptions with design standards. The description of service capabilities must be understood by other parties who are interested in using such service. The properties of such service should conform to the service contract which in this case is the design standard. The service contract would usually carry information which can be used to identify any service such as textual description, URL, name etc.; it would also have functional properties, like the type of input/output parameters, interaction model; also non-functional properties which include, QoS, the location of service, security constraints just to mention a few.

The provision of standardization enables the interpretability of services, which gives rise to the predictability of the service behaviour. This prediction of the future behaviour of services is an important mechanism which enables the attainment of scalability owing to the fact that, it makes room for the evaluation of the vital computational resources required to authenticate a targeted service. This key mechanism facilitates smart provisioning of resources so as to prevent a decline in software resources.

2) Loose Coupling Principle

According to this principle, the interface of a service should impose low consumer coupling and should also be orthogonal to its surrounding environment. In [25], loose coupling is intended to replace precision in the description of the interfaces of service for a better reason which is achieving flexibility in the interoperability between systems which are heterogeneous with respect to technology, location, performance and availability. This principle enables the development of loosely coupled applications which are more reusable and can better adapt to changing requirements. Tightly coupled systems are not highly scalable and as explained in [26], even-driven systems which are loosely coupled and also in [27]; space-based systems have been proven to be more highly scalable than the tightly coupled systems.

3) Abstraction Principle

This principle states that, the details of software artifacts which are not indispensable for others to effectively use it should be hidden. It therefore means that all the important information which is required to invoke a service is contained in the service contract while the entire knowledge of the underlying loge, technology, etc. should be completely hidden. Some authors have termed this principle "black boxing" which is synonymous with the concept of black boxing in the old software engineering concept. The principle of abstraction facilitates replaceability.

4) Reusability Principle

The principle states that, the functionality that is provided by services is as domain and context independent as feasible, enabling reuse. The application of this principle results in the provision of the logic of a service that is highly generic, independent of its original usage situation. This principle is one of the keys to enabling SOA infrastructures due to its ability to make room for the creation of huge libraries of domain-independent services that leverages the construction of new complex context-dependent services.

5) Autonomy Principle

The principle of autonomy posits that, the processes that are attached to services should be carried out in such a way that, they are independent of any external influences. Therefore, if in any way the outcome of any service is to be changed, it has to be via the modification of the input parameters as stated in the service contract.

6) The Statelessness Principle

The principle of Statelessness specifies that, services should minimize resource consumption by deferring the management of state information when necessary. This principle has been redefined and taken beyond its limits courtesy of the REST architectural paradigm by [28]. REST has been effectively and successfully applied to SOA in the past. In order to achieve any reasonable scalability of a given SOA infrastructure, it is very important that there exist a conformance with this principle. This is due to the known fact that state maintenance is among the most difficult resource consuming tasks in computing. Any ample reduction in the amount of state information that is to be taken into account by any given service results in a large reduction of the resources that would be used by the entire SOA system.

7) The Discoverability Principle

This principle which is closely related to the principle of Standardized Service Contract states that, there should be annotation of services with metadata so as to enable their discovery by parties who may be interested in any of the services. Collaborating emergency vehicles and their control centers are able to find these services and use on a 24hr basis since they are hosted online.

8) The Composablity Principle

As stated in [24], this principle identifies services as effective composition participants without minding the size and complexity of the composition. This composition could be in two perspectives; a bottom-up perspective would consider a combination of small and simpler services into larger and complex services while a top-down perspective would the other way round. Based on literature, the latter service composition perspective is the most effective way to resolve the complex nature of some given processes. This principle has been noted to be one of the core elements within the definition of a Web Service due to the fact that, the ability to easily create new services is preliminary requirement to the global adoption of SOA.

The incorporation of the above principles in any SOA solution is fundamental to realizing the much needed interoperability among collaborating systems in an enterprise.

E. Web Services Standards

In this section we would to a large extent focus on two prominent Web services implementation standards (SOAP and REST) though we would still explore other standards that enable SOA realization. These two standards are currently generating a debate within the Web community concerning which of them should better be adopted.

1) SOAP

SOAP is originally an acronym for Simple Object Access Protocol now just known as SOAP rather than an acronym. It is a Web service standard which supports communication between Web services (www.w3.org/2000). SOAP was initially developed by Microsoft and thereafter further developed in collaboration with UserLand, Lotus, IBM and Developmentor. SOAP is typically an XML-based specification which can be used for messaging and remote procedure call (RPC). The SOAP protocol depends on already existing transport protocols which include Hyper Text Transfer Protocol (HTTP), Simple Message Transfer Protocol (SMTP) and Message Queue Series (MQSeries)

The SOAP standard specifies a messaging model which establishes the way message recipients must process messages sent via SOAP. The specification also provides for actors that can process the message. SOAP messages are able to locate and identify their respective actors that are required to process various parts of the message. There could therefore be an exchange between actors for the message to be processed.

According to [29], the WWW is such that it is "intrinsically distributed and heterogeneous in nature, communication mechanisms must be platform-independent, international, secure, and as light as possible". In order to address these issues, XML came to the fore. XML has been established as a machine readable language which supports data and information encoding in a way that addresses systems independence. They opined that, communication protocols which are developed based on XML are primarily the answer to realizing Web services. XML provides a common representation of information thereby enabling information interchange between heterogeneous systems. The SOAP protocol which is built based on XML and operates on HTTP therefore holds the promise for Web services implementation. We now look at the two core benefits of SOAP.

2) REST

REST is an acronym which stands for Representational State Transfer. Roy Fielding of the University of California, Irvine U.S.A first coined the acronym and introduced REST in his 2000 PhD thesis. Though REST was not embraced in its early years of conception, it has now enormously achieved wide acceptability across the Web community. In the past few years, REST has witnessed global adoptions as it is perceived to be a true representation of the Web, simple and more viable option to SOAP-WSDL based Web Services. This recent and rapid trend of REST adoption has triggered an ongoing debate about these two leading SOA implementation paradigms. Some aspects of this study would attempt to weigh into this debate based on the feedback we would receive from experts in the industry via questionnaire and interviews. This feedback would help inform decision makers in the health sector on which paradigm to adopt in transitioning to a SOA infrastructure.

The motivation for the REST paradigm is to reap from the WWW characteristics which make the WWW successful. It is these characteristics that actually guide and enable the way the WWW has evolved and continuing to evolve. Moreover, REST views the WWW as an information system and expects other information systems to be integrated into it via Web gateways. The main goals of REST are:

1. The scalability of components or resources interactions
2. Achieving uniform interfaces
3. The independence of the deployment of resources
4. The provision of intermediate components to lessen interaction latency, improve security and enable legacy system encapsulation.

We next look at how these goals are achieved. The following key constraints and architectural principles which form the REST paradigm and achieve the REST goals stated above have been derived by [28]

a) Statelessness of RESTful Services

In this principle, Fielding opines that, individual requests that emanate from client applications to any specified server must have all the vital information which is necessary for it to be able to understand the client's request. However, this request must not depend on any information that resides or stored on the server. Clients must therefore be able to successfully complete their request independently of states that are stored on the server.

Since this principle does not require Web service clients to take advantage of any states that are stored on the server for them to complete a request, a RESTful service client is expected to provide all the information such as state, parameters and other data which the server needs to generate and issue a response it. This important information must reside within the HTTP headers and BODY of the client's request. This principle has been acknowledged to be very useful as it adds to the effective performance of the Web service. Moreover, the design and implementation of components that reside on the server is made simple since it has also been acknowledged that, the non-existence of states on the server means that session data need not be synchronized with outside applications.

b) Uniform Interface of RESTful Service

This principle requires that a RESTful service be able to explicitly use HTTP operations according the defined RFC 2616 protocol. These HTTP operations or methods which include GET, POST, PUT and DELETE must be the only methods that are allowed within the HTTP protocol. They must also be strictly used as they are originally meant to be used.

This principle is coming on the heels that, the same HTTP methods have been grossly used for purposes which they are not intended for. For instance, the GET method is specifically required by clients to retrieve information from the server but it is being misused by developers to execute queries and also perform remote procedure calls. This however introduces design flaws which inhibits the achievement of uniform interfaces for all RESTful service clients.

It is there beneficial to incorporate this design principle in any RESTful service realization.

c) Resources and Resources Identification

In (Fielding, 2000), resource is the main representation of information for REST paradigm. He opines that, certain information that one can name could represent a resource. A resource could therefore be a document, an image, a collection of resources and all other things that can be considered as resources. It therefore holds that, the whole REST architecture revolves around the concept of resources. The next concept is that of URIs. Any resource that can be named must have its own URI which uniquely identifies it. This is another fundamental characteristic of REST.

As explained in [30], RESTful client applications utilize resources via URIs. The URIs facilitates the intuitiveness of the Web service when they are well defined. The URIs used by RESTful services should be able to point to specific resources without much ambiguity. This according to Rodriquez encourages usability which can be achieved the more by exposing URIs in the form of a directory structure that is more readable and understandable. An invoice submission service in our problem domain can therefore have a URI which represents and invoice document.

d) Exchange of Resource Representations

Information is represented as a resource. This representation could mimic the context state of the resource and all its attributes at the time a client application sends a request to the server. The components that constitute a RESTful service are operated upon via the exchange of representations of the resources that are involved. One could have a representation of an order record in a database. This representation would have direct relations between the field names and the XML tags respectively together with the location of elements that contain a given row of values. In contrast to SOAP-based architectures communication, states that "REST-based architectures communicate primarily through the transfer of representations of resources…" This according [31] is primarily distinct from the Remote Procedure Call (RPC) which tends to hide the invocation of a procedure on the remote server.

In order to accomplish effective exchange of representations, RESTful services are encouraged to adhere to appropriate formats of the data which the client application and the Web service exchange within the request and response payload and even within the HTTP body.

REST goal of achieving scalability of component interaction has been achieved since the exponential growth of the WWW has not gone low in performance. One instance is in variety of client software applications that are made available for other applications and can also be accessed by other applications. More interestingly is the goal of uniform interfaces which pitches REST advocates and SOAP advocates. The advocates of REST believe that the REST paradigm is better than SOAP paradigm since HTTP client applications can communicate with HTTP remote server without the need for re-configuration. SOAP on the hand requires knowledge of the methods to invoke and is also a protocol framework unlike HTTP which is an application protocol.

As we have pointed out earlier, there is an ongoing debate on whether REST is better to adopt than SOAP. Some experts in the industry and in research have advised that, REST cannot always be the appropriate style to use in designing and implementing Web services in some circumstances. In the face of this debate, experts agree that, the introduction of REST makes it possible to design and implement Web services that are independent of proprietary middleware such as the Oracle Application Server and similar servers. This however contrasts SOAP-WSDL based implementations of Web services. REST is however a true representation of the WWW as its principles encourages a strict adherence to the original WWW, URI and HTTP standards. In (Richardson & Ruby, 2007), the realization of Web services via REST makes it possible to achieve integration requirements which are necessary when building enterprise systems. Enterprise system resources can therefore be exposed through RESTful services which are able to provide different client applications with data which is formatted according to standards.

3) SOAP OR REST

SOAP and REST are currently the two competing standards for implementing Web services. The problem with developers does not stem from a lack of understanding of these implementations but rather the choice of implementation to use. As [31] acknowledges, SOAP and REST only two styles of interfacing the WWW with Web services. These two approaches really work but have pros and cons. The onus on the developer to chose which approach is suitable for his or her use. The decision making process is perhaps what translates into a debate and brings about the need to consider the various benefits the two specifications bring. SOAP which is a is widely used for Enterprise Application Integration (EAI) for a host of different web-based applications coupled with legacy system integration. Google is a well known implementer of Web services using SOAP. On the other hand, REST primarily provides standardization for URI which is used to represent resources. HTTP operations such as GET etc are used to manipulate these resources. Though SOAP has been around before REST, REST has proved itself to be the most popular. Currently, key Web services that are available online make use of REST. These Web services are provided by Yahoo, Flickr, pubsub, bloglines, del.icio.us, Twitter among several others. Amazon and eBay provide Web services that utilize SOAP and REST.

We now focus on issues surrounding this debate in the following headings:

a) Security

Security is one significant aspect of the SOAP-REST debate. We have seen earlier that, SOAP can be used for RPC calls over HTTP. Forwarding RPC calls over HTTP standard ports has been considered a better way to support Web services within the length and breadth of an organization's boundaries. This is the position of the proponents of SOAP which the REST proponents believe that this compromises the security of the network. Though REST RPC are carried over HTTP, a firewall is able to detect the motive of client messages by filtering the HTTP command used in the client request. Since REST is strict about the HTTP operations it allows, a GET command cannot do more than query the server for information retrieval. This is not the case for SOAP which is not strict about HTTP verbs and which for instance uses POST to serve up client requests.

When it comes to security such as authentication, the REST style takes advantage of the authentication and authorization processes which are already provided by Web servers. Industry-standard security certificate coupled with identity management systems can be enable developers secure the network layer. The Lightweight Directory Access Protocol (LDAP) is an example of such of a system and developers can afford to utilize Access Control List (ACL) file to manage Web services and similar to URIs.

Both proponents agree that, for better security, sensitive data should not be passed as parameters via URIs while enormous packets of data on the URI should be discouraged as the URI may not accommodate it. Concerning attachments, SOAP performs better than REST but it is generally thought that SOAP for attachment should be considered only when necessary this because it does not still providefor the simplicity that REST provide.

b) Handling of Types

SOAP supports a fixed set of data types. This makes SOAP to provide a tougher typing than REST. The benefit of this is that, in any given platform, a value that is returned is made accessible in a corresponding native type.

c) Caching

SOAP client requests make use of the POST HTTP verb which often need a sophisticated XML request to be formulated thus making caching of client responses herculean. REST APIs can easily be consumed by clients via the GET operation which make it easy for proxy servers to cache responses. SOAP messages are therefore not easily cacheable.

d) Server-side /Client Side Complexity

It has been generally agreed that REST is easier to use than SOAP. Even at this, it is evident that, many of the programming languages enable developers to expose their class methods via SOAP since the serialization and deserialization is managed by the SOAP's server library. This is not so simple with HTTP API as the method to be exposed would sometimes need the resulting XML to be serialized. This however brings an overhead task of having to map URIs of resources to specified handlers and then import the representation of the HTTP request within the same scheme. SOAP therefore makes it easier to expose class methods rather than REST.

On the client side, it is understood that, placing service calls to HTTP APIs is far easier to accomplish compared to SOAP APIs. SOAP APIs would usually need a client library, a stub and lots of necessary skills to realize it while REST on the other is already local to a variety of programming languages and therefore very easy to create HTTP client request. Because REST resources are usually easy to be called from client interfaces which makes REST more beneficial than SOAP which finds its strength at the server-side.

e) Limited Bandwidth

REST is agreed to be a lightweight architecture which shortens client requests and responses and more suitable for the Web. SOAP normally needs an XML kind of wrapper to wrap client requests and response. The SOAP camp are of the opinion that, the provision of strong typing by SOAP makes service client and the service provider to have a fore knowledge of the types involved which makes it very beneficial. This is the question posed to the REST advocates. It is argued that, REST like SOAP need a document which defines the input and corresponding output parameters. REST proponents feel that, since REST is flexible, developers are still able produce WSDL files for Web services that would necessarily need an explicit declaration of parameters. This would be on-demand basis only.

In the light of this debate and based on the opinions of both proponents, this study does not see both REST and SOAP replacing each other. This study also agrees with both proponents about the complexity of implementing SOAP on the client-side and the complexity of implement REST on the server-side. Given the merits and demerits of both styles, there is a general consensus that the adoption of either SOAP or REST implementation should best be determined by the domain of application and those characteristics of either SOAP or REST that are perceived to be of benefit to the domain.

We have developed a questionnaire which would enable assess the feasibility of either of these two standards.

F. Perceived Benefits of SOA

In this section we present the promised benefits of SOA and the rationale behind our proposal to investigate it for its probable adoption as an enabler for achieving systems integration and interoperability in the case of ICT systems and services in emergency vehicles and the control centre as opposed to other architectural paradigms.

It is a well-known fact that, company CIOs and top IT executives have been experiencing challenges which include: reduction in costs while maximizing the usage of technologies that have been in existence; achieving a better customer experience; having a better competitive advantage; and be more proactive and responsive to actualizing business goals. Heterogeneity and change are the underlying factors that have caused these challenges [32]. The enterprises that are currently in existence are a product of different architectures and technologies that have changed over time. The integration of these varying systems which are from different vendors is still a nightmare for organizations. This results in the heterogeneity problem. More so, improvements in technologies have accelerated in recent times and organizations need to change and adapt quickly to these improvements if they desire to gain competitive advantage and meet changing client's requirements including reduced cost in the provision of services.

The above named challenges gave rise to SOA and [32], [24] among others have identified the following benefits of SOA:

1) Leveraging the existing assets of organizations

Since SOA is service and business centric, it provides an abstraction layer which makes it possible for organizations to effectively leverage their IT investments via the wrapping of their existing infrastructure as services which would represent business task as is explained in [24] and [32]. This is where SOA aligns business goals with technology. Therefore, without rebuilding new IT infrastructures, companies can still profit from using their existing technologies. The services which have been identified have interfaces. The interfaces for the services are designed by adopting an outside-in approach instead of following the details of their implementation. The idea is to design the interfaces with a main focus on how the services could suit in a bigger business process environment. SOA is acknowledge to be business process centric instead of technology centric when compared to other architectures hence a service would usually align itself with a given business task. Following from the design principles of SOA, the interface of a service would mostly be coarse-grained and stateless. It is also based on messages and document interchanges. The object oriented paradigm is different since it does not support this aspect of service orientation. It rather deals with individual objects and their attributes in a tightly coupled manner.

2) Integration, interoperability and management of complexity

OA enables easy integration and management of complexity due to the provision of service specifications which in turn brings about transparency in implementation thereby reducing the impact which arises when implementation and IT infrastructures are changed. The service specification which wraps the existing infrastructure makes integration easier since the complexities have been isolated. SOA enables the design and development of software systems that are interoperable based on standards that have been defined and agreed to by key industry players. Major players include: IBM, Oracle, Microsoft etc. Since "service" is the key in an SOA-based solution, interoperability is supported via the abstraction of the interface that a given service exposes from the implementation of the service itself.

According to (Wright and Reynolds, 2009) [33], the consistency in the SOA architecture together with SOA standards helps to achieve interoperability between heterogeneous systems. SOA is not however, not technology-specific and its principles can be utilized via assembler just as it is obtainable in high level languages. Adopting the SOA model makes development easy as it is supported by tools that are interoperable and portable across different software vendors. Since web services which are standards controlled by notable groups including OASIS is the familiar and most common way of implementing SOA, these standards makes it possible to achieve interoperability between different vendor technology stacks. Erl opines that, SOA provides for native interoperability among services for the purpose of reducing the degree of integration.

Among other definitions of SOA is the inclusion of the property of "autonomy". It is stated that, the interoperable systems are also autonomous. This property according to [33] contradicts the interoperability property though the same authors went further to describe how the contradiction is addressed via the service-centric architectural principles which we have talked about under the section "principles of SOA" earlier in this chapter.

3) Cost and reusability

Service oriented computing through SOA purpose to support the creation of solution logics which are not tied to any particular purpose [34] and [32]. These solutions are therefore agnostic in nature and reusable solutions which in turn leverage the interoperability of SOA as it is realized during the design of services. The adoption of SOA makes it possible for major business services to be exposed in a loosely coupled fashion unlike the case in other architectural paradigms that are tightly coupled. This facilitates easy use of services and they can be combined as business needs arises. The duplication of software resources is reduced as resources can be reused thereby bringing about reduced cost.

Organizations that seek to determine the cost effectiveness of the IT platforms they run would usually take a measurement of the return on investment. If the return on investment is high, the more they stand to benefit from the solution they have adopted. The adoption of SOA is seen to cut-down organizations budget and gives a greater return on investment than the traditional software paradigms.

4) Business and Technology alignment coupled with faster time-to-market

Business alignment and agility are well supported when SOA is adopted [34]. The idea of going through the SOA phases of analysis and modeling which conceives the conceptual service inventory blue print requires the services of business analysts or experts who have the know-how of the business case that needs SOA solution. The SOA design which follows provides the capability to clearly align the business goals with technology. This alignment is further supported by the interoperability which SOA provide via the design of interoperable services there by facilitating easy business changes.

Organizations that aim to be agile while responding to demanding business needs would have to take advantage of SOA which enables the composition of new services from existing ones. Using SOA to leverage existing company infrastructure reduces the time required to undertake a fresh software development which involves going through all the phases of the software development cycle (SDC). By-passing the SDC via SOA brings about a faster development of fresh services and makes it possible for organizations to respond and adapt quickly to change and the time-to-market is also reduced.

5) Adapting quickly to future changes and Vendor Diversification Alternatives

Also in [32], SOA adoption enables organizations to be better positioned and ready for future changes. Since organizations would have business processes that consist of a range of business services. These processes can be easily created and where need be, changed or managed to reflect current and future needs. The flexibility and responsiveness which SOA provides makes it adoption necessary for companies to survive, thrive and compete favorably.

It has been generally acknowledged that, while it is not a necessary benefit for organizations to have an IT platform with diversified vendors, it would however be beneficial if organizations can have the option to vendor-diversify when the need arises. The adoption of SOA makes this option possible since the architecture ensures that technologies which can be used to implement SOA solutions are independent of vendors or non-vendor specific. This makes organizations to easily change or extend their IT platforms. The vendor-neutrality provided by SOA further strengthens the ability of companies to make constant changes to their IT platforms since physical service contracts are shaped into standardized endpoints while service implementation details are abstracted in order to provide a consistent inter-service communication framework. In addition, the standards-based and vendor-independence of Web services also supports organizations to vendor-diversify since Web services do no restrict or impose proprietary communication criteria.

In brief summary, this chapter presents a background of SOA and Web services. We have shown that SOA and Web services are keys to achieving systems standardization, integration and interoperability in any enterprise based on secondary study. The information presented in this chapter would enable us plunge into the main investigation of the feasibility of applying SOA in PPDR services. We have developed a questionnaire which would enable us to further determine the choice of software architecture that best suite PPDR services. In our next paper we would present a service blue print for our problem domain and the final results of our investigation.

VI. Discussions

Regulations and standardization play an important role in applying the results of research to the market and to PPDR end-users. The on-going planning of European external border surveillance system (EUROSUR) [35] and EU´s enhanced powers in the field of internal security by the Treaty of Lisbon sets the pace for further standardization efforts. Finland has one nation-wide TETRA network used by various PPDR organizations. As a consequence, there is full domestic interoperability network-wise. Finland has evidences of developing wireless communications standards and well operating and organized co-operations between authorities at different levels. Here, a prototyping environment with de facto standards could be made.

In order to implement and manage a prototyping environment that can develop and provide standards for interoperability which would in turn enable information to be shared between security providers within and between nations, the prototyping environment should provide for candidate operational scenarios to be synthesized. This for example could be a trans-border incident emulating the data flows between systems and operators, and also so show that information and data exchange retains consistent meaning as well as timeliness when portrayed in different systems. The aim would be to provide a focus for researchers, system designers, information system operators and security front line operators to develop and validate semantics, syntax and meta-data so that such standards can be rolled out by security providers with confidence.

In pursuance of the need to contribute towards resolving the issues of standardization, integration and interoperability between ICT systems that are used in PPDR services, the idea of investigating the feasibility of applying SOA and its standards to this distributed domain is essential. This is even more required as SOA has positioned itself to be the most viable solution for an organization’s enterprise system. Small and medium scale enterprises are gradually tilting towards the adoption of SOA so as to benefit from some of its promises. Web services would no doubt be an interesting technology to provide mobile and internet support for field units and their command and control centers. The national, regional and local administrative structure which describes our problem domain could benefit from SOA adoption as it would present a common integrated abstract layer of administration which would facilitate sharing of common Web services, information exchange between PPDR agencies while making administration efficient and effective. Our study in this regard is to make useful recommendation concerning the probable software architecture that best meets the needs of PPDR services.

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