EW Information Processing: Contributing to Information Superiority through the Exploitation of Shared Information Resources

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Abstract

This paper presents an EW Information Processing (EWIP) strategy that exploits a wide range of information and knowledge resources accessible in a shared information environment to add value to EW sensed data. The value-adding process aims to add qualities to the sensed data that will enhance its potential to be combined with other kinds of C4ISREW data. The shared information environment also makes the value-added EWIP product available for use by information fusion systems. Both the value-adding and the connectivity provides for a greater linking of EW product with other components of the warfighting enterprise than in conventional systems, and is a step toward EW transitioning from its traditional role of supporting platform centric warfare to also contributing to information superiority in network enabled warfare. This knowledge driven EWIP strategy is currently being implemented and has already been demonstrated using knowledge-bases of platform and radar emitter characteristics to add information about platform capabilities to sensed EW data.

1. Introduction

The passive detection of electromagnetic radiation emanating from military and civilian vessels, aircraft and land-based systems (generically termed platforms) is an important source of surveillance information, and is one of a group of activities that are known as Electronic Warfare (EW). EW sensing systems are deployed on most military platforms to support platform centric warfare, such as by providing threat warnings for platform self protection.

As well as aiding platform self protection, EW sensed data can contribute to more general military situation awareness. Situation awareness as defined by Endsley (1995) entails three elements: the perception of entities in the environment, the comprehension of their meaning, and the projection of their status into the near future. A variety of sensing technologies used in EW systems provide a range of qualities in EW observations of environmental phenomena that can enhance situation awareness. These qualities of EW data and their importance to situation awareness are discussed in section two of this paper.

The extent of leverage gained from EW sensing systems for military situation awareness depends in part on the success of the EW Information Processing (EWIP) strategy in providing meaningful interpretations of the sensed data. Conventional EWIP strategies only use embedded Electronic Intelligence (ELINT) libraries to provide interpretations of intercept data. These strategies are discussed in section three.

This paper looks to increase the leverage from the investment in EW sensing systems through an approach that employs a much stronger knowledge driven EWIP strategy that exploits a wide range of information and knowledge resources accessible in a shared information environment. Such a shared information environment is described in section four.

This knowledge-driven EWIP strategy exploits a wide range of information and knowledge resources to generate candidate interpretations of the sensed data, to check the admissibility of the candidates, and seeks to add value to the sensed data. For example, platform and emitter attribute knowledge may be used to generate candidate identities for the detected platforms. Knowledge obtained from a Geographic Information System (GIS) of the physical environment (eg ocean or land) at a particular location may allow an EWIP to distinguish between multiple identity candidates for a radar emitter. Knowledge obtained of platform mobility capabilities may allow the EWIP to eliminate candidates that are incompatible with the detected platform's observed kinematic characteristics. Details of knowledge resources that an EWIP could exploit are presented in section five.

Difficulties in accessing EW stovepiped systems can be seen as contributing to the poor integration of EW data in existing command information systems. Also, integrating other kinds of C4ISREW data with EW sensed data that has only been enhanced with ELINT information and that may have large uncertainty in its geolocation can be very difficult, and this difficulty can also be seen to contribute to the poor integration of EW information in existing command information systems. Section six describes how a knowledge driven EWIP exploiting non-ELINT information resources to add information to sensed EW data may facilitate its combination with other kinds of C4IRSEW data, and how the shared information environment provides equal access to EW data as to other kinds of C4ISREW data. This provides for a greater linking of EW product with other components of the warfighting enterprise, and is a step toward EW transitioning from its traditional role of supporting platform centric warfare to also contributing to information superiority in network enabled warfare [Alberts et al, 1999].

An experimental shared information environment is being developed and has been used to demonstrate a knowledge driven EWIP exploiting a range of information resources. Section seven discusses this work. Section eight summarises the contribution of this paper.

2. **Qualities of EW Data**

A variety of sensing technologies are used in EW systems and can provide data on a wide range of phenomena related to platform activities and events. Appreciation of such data can lead to enhanced understanding of the three elements of situation awareness mentioned in the

introduction. Some of the kinds of sensed EW data and how they may contribute to situation awareness are illustrated below.

Intentional emissions of electromagnetic radiation from a platform as it goes about its business include signals from the use of its radar and communications equipment. For example, the detection of a radar signal is an observation of the platform using its radar for a purpose such as search or targeting, and is evidence of the activity the detected platform is undertaking. Recognition of such an activity not only contributes to perception of an entity in the environment but also contributes to comprehension of its meaning. The detection of the emission of a communications system identifies the presence of an operational unit interacting with other units or systems, but may also indicate force disposition. For example, if the signal can be classified as from an upper echelon communications system and other signals such as from a surface-to-air missile (SAM) system are also detected, the SAM may be performing active defence of a command post or HQ element. Recognition of the command post or HQ element contributes to comprehension of the meaning of an entity in the environment.

Characteristic radiation from a platform's structure or its immediate environment include radiation from hot spots related to a platform's propulsion system or from events such as missile launches. For example, detection of after-burner aircraft emissions is indicative that an aircraft of a particular kind is undertaking a high speed maneuver. Analysis of such emissions can aid perception and understanding of entities in the environment. Detection of ballistic missile launches can also provide status projections into the near future which would be key to appropriate situation awareness.

The interpretation of each of these various kinds of EW data has differing knowledge requirements. Some of these are discussed in section five.

3. **Conventional EWIP Strategies**

Current EW architectures supporting situation awareness employ weak EWIP strategies to add value to intercepted radar signals based on generate-and-test methods. Typically the generate phase is a look-up of embedded ELINT libraries of finite size. Manual library management is used to guarantee that the correct (or best) interpretation is found. The test phase may be little more then a ranking scheme with a threshold. As well as being costly, manual library management is also brittle, which limits the generality of such EWIP strategies.

Conventional EWIP strategies only add ELINT information, such as identifying the type of radar emitter, to the sensed data. As it can be quite difficult to associate such data with other kinds of C4ISREW data, current command information systems have a poor ability to integrate EW data with non-EW data.

These constraints limit the contribution of EW to current military situation awareness. Some investigations have been undertaken to ameliorate such limitations. For example Howe (1999) effectively describes an EWIP in an operational context and which includes information about

platforms and weapons, however it aims to facilitate conventional processing rather than to broaden the EWIP concept. Borden (1998) uses probability based information measures rather than ELINT parameter limit libraries for interpreting EW data to derive a situation assessment. However it is questionable if probability measures of sufficient reliability will be available to support this approach. The formulation of these measures for a particular tactical scenario would be equivalent to the manual library management of conventional EWIP strategies.

4. **Shared Information Environment**

The Shared Information Environment (SHINE) [Nelson et al, 1998] is a concept for sharing C4IRSEW information resources and is being developed within a laboratory demonstrator[1] at DSTO (Salisbury). It is being used to evaluate a knowledge driven EWIP amongst a range of applications aiming to share and exploit information available in C4ISREW systems.

As the purpose of this paper is to present the EWIP strategy, only sufficient details of the SHINE are given to show how it facilitates EWIP. SHINE seeks to implement an environment that defines common services, tools and resources. SHINE uses CORBA technologies. Readers unfamiliar with CORBA can refer to http://www.omg.org to find definitions and tutorials about CORBA and its capabilities, including details of Services, Middleware, Object Request Brokers (ORBs) and the CORBA Interface Definition Language (IDL).

Briefly, a middleware layer in an information architecture greatly simplifies communication between information services and client applications by abstracting away much of the underlying details. SHINE recasts legacy database systems and stovepipe systems into shared Data Services by wrapping them with CORBA IDL interfaces. The SHINE middleware layer currently comprises a Naming Service, an Event Service and an ORB for each machine connected to the SHINE. The Naming Service is used to maintain a dynamic list of services, which binds a unique name for each service to the name of the machine on which it resides. ORBs enable objects such as client applications and information services to communicate with each other through predefined IDL interfaces in a distributed environment. IDL is used to define interfaces by specifying how an application may request data and how it may access the data returned. An interface essentially comprises a set of operators (ie function calls) and data types. An Event Service handles real-time distributed events (such as receiving data from EW sensing systems) and passes them to appropriate processing channels.

Figure 1 shows the flow of EW information in the experimental SHINE. Data from geographically distributed EW sensing systems (and other types of sensing systems) are interfaced through an Event Service to the SHINE. Raw EW events (ie data direct from sensing systems) is available to any SHINE Service that requires it, however for more efficient processing, a EW Data Parser forms Structured EW Events that identify the time, place and source of the intercept. Structured EW Events are available in real time to any SHINE Service

[1] The Experimental C3I Technology Environment (EXC3ITE)

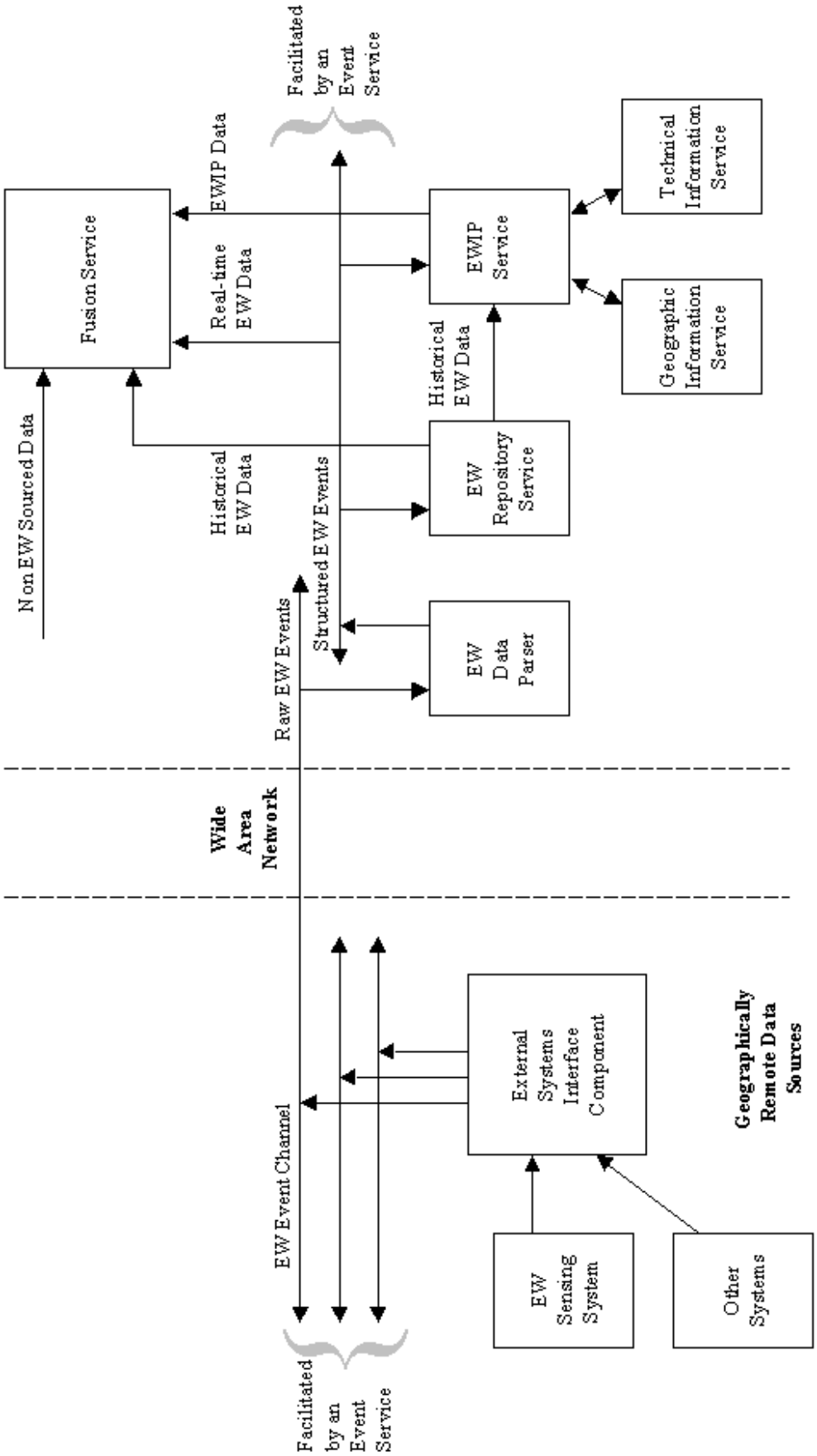

Figure 1: The flow of EW information in the SHINE.

and are also archived in the EW Repository Service for Services that require to interrogate historical data. Real-time or historical data can be passed through the EWIP Service to add value by exploiting Geographic and Technical Information Services. A Fusion Service would be a consumer of such value-added EW data.

The key characteristics of SHINE are that it provides simple and scalable access to a large number of geographically dispersed information resources. It hides implementation details of communications from client applications by exposing information through standard interfaces.

5. An EWIP Utilising Shared Information Resources

Conventional EWIP strategies were criticised in section three for being limited because their ability to generate interpretations of sensed data relied on finite embedded libraries, and because their value-adding strategy only added ELINT information. The approach being presented in this paper is to use as many relevant information sources as possible in a generate-and-test method to provide interpretations of the sensed data. That is, to use knowledge-bases of wide applicability to generate candidate interpretations of the EW data, and then to use domain information to reject inadmissible candidates and assist in tracking detected entities.

The variety of knowledge and information sources that could be exploited by an EWIP includes:

- Knowledge about military platforms, radar emitters and communication systems, may be found in a variety of large technical databases. These include Order of Battle (OOB) databases, Technical Intelligence (TECHINT) databases, Electronic Order of Battle (EOB) databases and ELINT databases. These can be used to refine emitter and platform identity, and to infer platform capabilities.

  For example, measured parameters of an intercepted radar signal may be used to query an ELINT database to obtain candidate emitters that are capable of producing the intercepted signal radar (eg "SPS-55"[2] or "Straight Flush"[3]) and the function of these radars (eg "surface search" or "fire control"). These candidates can be the basis of a query into a EOB database to determine which platform types are capable of carrying the candidate emitters (eg "Adelaide", "SA-6 SAM site") and the role they undertake (eg "coastal patrol", "air defence"). These platform candidates could then be the basis of a query to an OOB database to determine which platforms in the theatre of detection may have emitted the signal (eg "Darwin"). The admissibility of these candidates can be checked firstly by interrogating TECHINT databases to determine that they have appropriate mobility to be able to be at the intercept location. Other admissibility tests are indicated below.

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[2] Janes *Fighting Ships* lists the surface search radar "SPS-55" as being fitted to the Australian "Adelaide" class vessel "Darwin".

[3] Janes *Radar and Electronic Warfare Systems* lists "Straight Flush" as the fire control radar for the "SA-6" SAM system.

As well as being an admissibility test, the above process has matched the sensed data against a range of information sources. Those that match can be included as candidate interpretations of the data. Non-ELINT characteristics, such limits on speed and altitude, which are consistent with all interpretations can be used to add value to the sensed data.

- Knowledge of the physical environment (from a GIS) can be used to help discriminate between multiple interpretations of data, some of which may only be valid in restricted domains such as land-based or ocean environments. For example, a search of a world wide ELINT database is likely to produce a large number of candidates for many signals. Geographic information about the physical environment of the intercept location can be used to reject inadmissible candidates, such as land-based candidates in an ocean environment.

- Knowledge of the geo-political environment (from a GIS) can help discriminate between multiple interpretations of data on the basis of sovereignty. For a particular context, only platforms from countries with a national interest are likely to be participants or observers, and so geo-political information can be the basis of an admissibility check or ranking scheme.

- Knowledge (in the form of templates) which outline missions that typically extend temporally and spatially well beyond the coverage of any single sensor, may be used to enable the association of temporally and spatially distant intercepts from different sensing systems, and to infer platform activity and intent. For example, civilian air traffic follows well defined air routes which can be used to associate temporally and spatially distant intercepts from different sensing systems.

- Knowledge (in the form of templates) which outlines groupings of related activities such as the kind and spatial deployment of high value assets and protective units can be used to identify operational elements and force disposition. For example, if a signal associated with upper echelon communications (eg R-412A[4]) is detected in conjunction with a detection of a search radar from a SAM system (such as SA-6), then the SAM system may be performing active defence of a command post or HQ element.

The effectiveness of this approach greatly depends on the availability of knowledge of the military domain that is as current, consistent and complete as possible.

6. **Linking EW into Information Fusion Systems**

Difficulties in accessing EW stovepiped systems can be seen as contributing to the poor integration of EW data in existing command information systems. Apart from data accessibility, integrating other kinds of C4ISREW data with EW sensed data that has only been enhanced with ELINT information and that may have large uncertainty in its geolocation can be very difficult,

[4] Janes *Military Communications* lists "R-421A" as being a mobile relay station operating in the Rf range 4.438 to 4.750 GHz that provides up to 6 standard telephone channels or data communications with a range of at least 150km.

and this difficulty can also be seen to contribute to the poor integration of EW information in existing command information systems.

The shared information environment makes the EWIP product available for use by information fusion systems in the same way as other C4ISREW data, and this has been illustrated in Figure 1. This connectivity facilitates integration of EW data with other kinds of C4ISREW data and overcomes some of the limitations of stovepiped EW systems.

In addition, a knowledge driven EWIP exploiting a range of non-ELINT information resources (as well as ELINT resources) may be able to add kinematic attributes such as limits on platform mobility to the sensed data. For example, by exploiting knowledge bases the EWIP may be able to decide that the EW sensed platform is used for (say) air transport and propose limits on platform mobility such as minimum and maximum speed and maximum altitude. Since other types of C4ISREW data (such as radar products) often include kinematic attributes such as current platform speed and altitude, a fusion process is able to directly compare related entities in its analysis. That is, the analysis may compare the current speed from a radar datum with the limits on speed from a value-added EW datum.

The sharing of data enhanced with non-ELINT characteristics provides for a greater linking of EW product with other components of the warfighting enterprise, and is a step toward EW transitioning from its traditional role of supporting platform centric warfare to also contributing to information superiority in network enabled warfare.

7. **Implementation**

This paper is describing work in progress. An experimental SHINE has been used to demonstrate an EWIP exploiting ELINT, EOB, OOB and TECHINT technical databases as described in section five. That is, the demonstration system uses platform and radar emitter knowledge contained in these knowledge-bases to add platform capabilities including minimum and maximum speed and maximum altitude to the sensed EW data.

For this demonstration idealised knowledge-bases were used which were populated from corporate sources. Having succeeded with this demonstration future work will seek put CORBA wrappers around legacy database systems. Work is progressing on demonstrating the other forms of knowledge described in section three, and on implementing SHINE services supporting these kinds of knowledge.

8. **Summary**

This paper presents an EW Information Processing (EWIP) strategy that exploits a wide range of information and knowledge resources accessible in a shared information environment to add value to EW sensed data. The value-adding process aims to add qualities to the sensed data that will enhance its potential to be combined with other kinds of C4ISREW data. The shared

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