FUSION STANDARDS STUDY

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INTRODUCTION

Geosciences can only achieve their potential through the fusion of diverse Earth Observation and socio-economic data and information. In a multiple provider environment, fusion is only possible with an information system architecture based upon open standards. This paper reports on the results of a study of "To-Be" fusion environment based on open standards. Consistent with IEEE definitions, three categories of fusion were used in this study: Sensor Fusion, Feature Fusion and Decision Fusion. A main conclusion is that OGC and other standards are well suited to Sensor Fusion and Feature Fusion; whereas standards for Decision Fusion should be developed further based upon on mash-up technologies of the mass market.

1 OGC STUDY OF FUSION STANDARDS

The Open Geospatial Consortium (OGC®) conducted a study of geospatial fusion including: a review of existing standards regarding fusion; a survey of standards and implementations using a Request For Information (RFI); and development of a set of recommendations for future standards and integration of other standards. This scope and need for this study was based on requirements and contributions from several OGC Member organizations, primarily the National Geospatial-intelligence Agency (NGA), along with BAE Systems - C3I Systems and Lockheed Martin.

The fusion standards study goal was to identify fusion standards that provide give analysts an environment where they can use interoperable tools to analyze, process and exploit two or more different types of data or products from the same or multiple sensors and databases from one client. Many of the fusion processes considered in the Study can be achieved in closed architectures with single provider software and hardware solutions. Fusion is not a new topic. The problem addressed by this Study was to move those capabilities into a distributed architecture based upon open standards including standards for interoperability, security, authorization, and rights management.

OGC issued a Request for Information (RFI) to solicit industry input into the Fusion Standards Study [1]. This market survey identified the level of maturity of identified standards and implementations to include any previous testing of these standards and services which may have occurred as part of the OGC interoperability program such as testbeds, interoperability experiments, etc. Responses to the RFI were a major contribution toward focusing the study on topics that can be feasibly deployed in a distributed environment with interoperability based on open standards.

2 DEFINITION AND CATEGORIES FOR FUSION

Based on the RFI Responses on a working definition provided by the sponsors, this definition for Fusion was used in the study:

> "Fusion is the act or process of combining or associating data or information regarding one or more entities considered in an explicit or implicit knowledge framework to improve one's capability (or provide a new capability) for detection, identification, or characterization of that entity".

The Study organized analysis, discussions and recommendations for fusion standards in three categories: sensor fusion, object/feature fusion, and decision fusion. The three categories are consistent with geographic information ranging from sensor measurements through feature operations to decision support.

The Data Fusion Technical Committee (DFTC) of the IEEE Geoscience and Remote Sensing Society has published Special Issues of the IEEE Transactions on Geoscience and Remote Sensing about "data fusion". DFTC has long considered fusion of geographical information and remotely sensed data as requiring fusion architectures that are fully aware of the multiple levels of "fusion" as discussed in [2].

The categories of Fusion in the OGC Study are described in the following paragraphs and shown in Figure 1.

- Sensor Fusion: ranging from sensor measurements of various observable properties to well characterized observations including uncertainties. Fusion processes involve merging of multiple sensor measurements of the same phenomena (i.e., events of feature of interest) into a combined observation; and analysis of the measurement signature.
- Object/Feature Fusion: includes processing of observations into higher order semantic features and feature processing. Object/feature fusion improves understanding of the operational situation and assessment of potential threats and impacts to identify, classify, associate and aggregate entities of interest. Object/feature fusion processes include generalization and conflation of features.
- Decision Fusion: focuses on client environments for analysts and decision makers to visualize, analyze, and edit data into fusion products for an understanding of a situation in context. Decision fusion includes the ability to

fuse derived data and information with processes, policies, and constraints. Collaboration with other analysts is done using social networking services and collaboration tools that are location enabled.

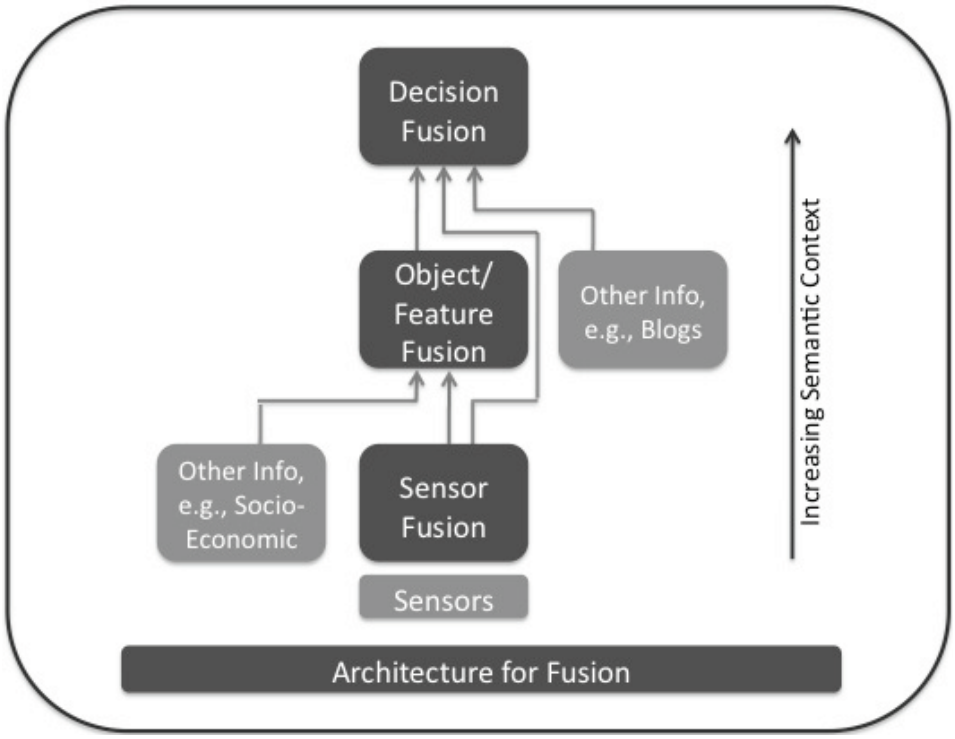

Figure 1 - Categories of Fusion

3 RECOMMENDATIONS

A key result of the Study is a set of recommendations. The recommendations are listed here in bullet form are discussed in detail in the OGC Fusion Standards Study Engineering Report [3]. Some of the recommendations of the study are being implemented in the OGC Web Services, Phase 7 (OWS-7) Testbed [4]. A second phase of the Fusion Standards Study will be conducted focusing on Decision Fusion with consideration of mash-up, social networking and other technologies of the mass market internet.

1.1 Sensor Fusion Recommendations

- Harmonization of the process of precise geolocation
- Online community sanctioned definitions for sensor terms
- Discovery and access of dynamic sensors
- Characterizing and propagating uncertainty of measurements
- Increasing use of geometric and electromagnetic signatures
- Fusion of video from airborne and ground based platforms
- Recognition and characterization of observed objects/features and events

1.2 Object/Feature Fusion Recommendations

- Define a conceptual model of feature lifecycle – beyond conflation.
- Standardize metadata for provenance and uncertainty.
- Develop common data models supporting feature fusion.
- Define a portfolio of feature fusion services.
- Develop schema and encoding to support sharing of Track Features

1.3 Decision Fusion Recommendations

- Develop an information model with decisions as a first class object
- Define interfaces and functionality for decision fusion engine component type
- Uncertainty propagation for a "hard fusion" topic
- "See and Talk" collaboration with common view
- Coordination through social networks
- Political Geography as a step to all information types
- Dynamic routing based on location
- Conduct Fusion Standards Study, Part 2 focused on decision fusion

1.4 Architecture and Infrastructure Recommendations

- Use of Open, Community IT Standards
- Semantics mediation of community vocabularies, taxonomies
- Workflow driven by semantics
- Grid and Cloud implementations for performance and access

4 SUMMARY

The OGC Fusion Standards Study considered the state of open standards that support fusion in a distributed architecture including standards for interoperability, security, authorization, and rights management. The considered fusion in three categories – Sensors, Object/Features, and Decision – along with consideration of cross-cutting architectural topics considered. A main conclusion is that OGC and other standards are well suited to Sensor Fusion and Feature Fusion; whereas standards for Decision Fusion should be developed further based upon on mash-up technologies of the mass market. A second phase of the OGC Fusion Standards Study focused on Decision Fusion has begun with a Request for Information [5].

REFERENCES

[1] "OGC Calls for Industry Input on Geospatial Fusion," Release Date: Thu, 2009-07-16. http://www.opengeospatial.org/pressroom/pressreleases/1061

[2] Gamba, P., and J. Chanussot, *Foreword to the Special Issue on Data Fusion*, IEEE Transactions on Geoscience and Remote Sensing, Volume 46, Issue 5, Date: May 2008, Pages: 1283 - 1288 Digital Object Identifier 10.1109/TGRS.2008.919761

[3] Percivall, G. editor, "The OGC Fusion Standards Study Engineering Report," OGC Document 09-138, published at: http://portal.opengeospatial.org/files/?artifact_id=36177

[4] "OGC Web Services, Phase 7 (OWS-7) Request For Quotation and Call For Participation," RFQ Issuance Date: 28 October 2009, Proposal Due Date: 1 December 2009. http://www.opengeospatial.org/standards/requests/60

[5] "OGC Calls for Industry Input on multi-INT Decision Fusion," Issued on 21 April 2010 and scheduled to close on 11 June 2010. http://www.opengeospatial.org/standards/requests/67