Towards an Ontology for Intelligence Analysis and Collection Management

Roberto Desimone and David Charles

QinetiQ Ltd
Knowledge & Information's Systems Division
St Andrews Road, Malvern, Worcs WR14 3PS, UK
{rdesimone, dcharles}@QinetiQ.com

Abstract. This short paper discusses research within the "Intelligence Support to Commanders" project as part of the UK MoD Applied Research Programme. It presents preliminary results in exploring medium/long-term concepts for the application of knowledge systems technology for intelligence support activities. An initial ontology is briefly described for intelligence analysis and collection management. The research is predominantly aimed at joint operations, but also addresses coalition issues.

1 Introduction

With the ever-increasing availability of sensor data and other intelligence, it is essential that coherent intelligence support is provided to commanders from strategic and operational commands, down to the lower echelons in the tactical component commands. The intelligence analysts that provide this support, whether in the J2 cells or in tactical intelligence cells, need tools that facilitate collaboration with the whole defence intelligence community, including the intelligence collection agencies and coalition partners.

Collection co-ordination and intelligence requirements management (CCIRM) and intelligence analysis (including fusion) are two key activities currently undertaken by intelligence staff at strategic, operational and tactical levels. Greater decision support is needed for these activities beyond limited office automation tools. Effective collection management requires knowledge of the available intelligence products and their currency, determining gaps and planning for new intelligence to be collected to fill these gaps. The results of intelligence analysis helps commanders make command decisions based on reasoned interpretation of the enemy situation, backed up by solid evidence from intelligence sources. Incorporating intelligence from coalition partners and the sharing of intelligence with them in a reliable and secure manner is becoming increasingly important, but is complicated by differences in doctrine that could result in ambiguity, security constraints that prevent connections between information systems, and other cultural differences.

The "Intelligence Support to Commanders" project started in April 2001 as part of the UK Ministry of Defence (MoD) Applied Research Programme (ARP). The research will take place over the next few years with the following objectives:

- Confirming user needs for intelligence support to commanders
- Performing experiments to validate these user requirements by prototype and storyboard development
- Providing validated technical advice to inform UK MoD procurement decisions.

This paper discusses preliminary results from concept development work within this project.

2 Complex user needs for medium and long-term

The project has been conducting a comprehensive review of current processes for intelligence support and eliciting user needs for improving support in the short and medium-term over the next 2-5 years. This paper addresses user needs in the medium to long-term over the next 5-10 years and possibly beyond. It explores user needs that are complex, involving more dynamic processes than currently in force, and a level of collaboration potentially beyond current doctrine and security constraints. Thus, non-technical, as well as technical, barriers have to be explored to convert these complex user needs into validated user requirements.

Figure 1 depicts an intelligence support environment where intelligence analysts and CCIRM officers can access a multitude of intelligence products and tools that assist them in presenting the right information at exactly the right time and in the right format to support commanders' decision-making. Security permitting, analysts would be able to incorporate the rationale for their recommendations within evidential analyses that would dynamically change in response to new intelligence. Explicit representation of this rationale would help minimise misunderstandings with joint and coalition partners. CCIRM officers would be able to prioritise their

requests for intelligence more effectively and work closely with the collection agencies to manage expectations for receipt of specific intelligence material.

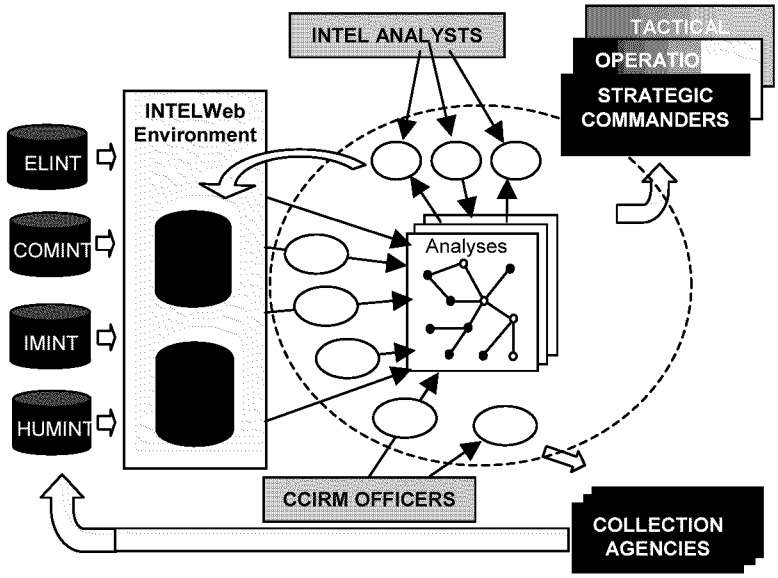

Figure 1. Intelligence support environment

The key to the delivery of these complex user needs is *explicit representation* not only of the intelligence information itself, but also of the processes by which the intelligence has been produced. In effect, an ontology is required for intelligence analysis and collection management. Such an ontology would help provide the basis for semantic interoperability between the plethora of intelligence systems and databases, and encourage an environment where critical information could be shared appropriately with joint and coalition partners. An initial ontology is described later.

2.1 Intelligence analysis concepts and user needs

Commanders normally receive intelligence information in the form of briefings and summaries (INTSUMs), reports (INTREPs) and other intelligence estimates. Battlefield commanders receive more specific documents, entitled intelligence preparation of the battlefield (IPB). These textual reports and oral briefings present critical information, often with recommendations for their most favoured enemy intention. Assumptions for these interpretations are generally recorded, but not in a strong *evidential* sense, pointing exactly to the specific intelligence information that justifies these interpretations. As a result, it is not always easy for the commander to determine whether a particular interpretation has been compromised by new intelligence information, without constant interaction with the intelligence analysts. Conversely, security constraints may prevent the analyst from explaining exactly why a particular command decision might compromise existing intelligence gathering operations. As a result, most of the detailed intelligence analyses, including alternative hypotheses and interpretations, remain in the heads of intelligence officers who rely on individual communication skills to present their brief and keep the commander informed when the situation changes.

The rapidly changing environment and the need for intelligence to flow to exactly where it is needed, both in higher and lower level echelons of command, from where the intelligence analysis has been conducted, means that reliance of face-to-face or voice-to-voice communication is not always going to be achievable. Emerging technologies promise support for the following activities:

- Assisting the analyst in structuring evidence for their interpretations within evidential graphs, accessing generic and past analytical patterns that recur in similar situations.

  Benefits: *Evidential graphs could provide explicit audit trails for linking textual intelligence summaries and reports to validated intelligence, and facilitate sharing of rationale with joint and coalition partners.*

- Recording alternative hypotheses and interpretations, together with subjective (pragmatic) and/or objective (quantifiable) metrics for justifying them and for performing sensitivity analyses on them.

  Benefits: *Permits sharing of alternative hypotheses with commanders including their relative weightings, helping them to determine the level of risk associated with their command decisions.*

- Maintaining dynamic linkages between critical intelligence and interpretations derived from them, and propagating consequences of situation changes, often highlighting alternative hypotheses.

  Benefits: *Commanders can be alerted to consequences of situation changes and alternative hypotheses.*

2.2 Intelligence collection management concepts and user needs

Intelligence officers are being faced with the dilemma of information overload in many areas and yet critical information gaps still occur. Inevitably some of these gaps could be filled by relevant information residing somewhere in the vast repositories, including the heads of intelligence officers and their notebooks. But even when the information is identified, it may not exactly fit the commanders' needs. The information may only partially fulfil the gap, or be too old, inaccurate or unreliable. Thus, the gap still needs to be filled.

Having identified a new intelligence requirement (IR), it is often essential to decompose the request until a number of more specific requests that are pertinent to different collection assets. From these it is possible to determine which collectors should be asked to deliver the necessary information. CCIRM officers then generate a collection requirement (CR), which is disseminated to relevant collection agencies. Negotiation is nearly always required to manage the trade-off between competing IRs/CRs for limited collection assets. Security limitations currently make it difficult for the collection agencies to share their collection plans, even with CCIRM officers. This makes it difficult for CCIRM officers to respond rapidly to dynamic requests from commanders. Ideally, there should be a shared understanding of the IRs, CRs and collection plans between CCIRM officers and the collection agencies. This is going to be difficult enough at national, let alone coalition level; security constraints being the most limiting factor, followed by doctrine and other cultural differences.

Emerging technologies promise support for the following activities:

- Confirming new intelligence/collection requirements (IR/CR) and satisfying others from existing products.

  Benefits: *Maximise the benefits of existing intelligence collected and minimise over-utilisation of limited collection assets.*

- Decomposing complex information requests into more detailed specific requests to avoid duplication with other complex requests.

  Benefits: *Partial responses to requests may be provided more rapidly and several requests partially satisfied by the same information.*

- Managing the trade-off between limited intelligence collection assets, informing scheduling and load balancing tasks by highlighting critical constraints.

  Benefits: *Limited collection assets would be used more effectively to address the highest priority information requests.*

- Assisting incremental IR/CR development by modifying and re-prioritising activities within existing collection missions in-flight to incorporate new objectives.

  Benefits: *Reduces the intelligence collection cycle significantly.*

3 Initial ontology for intelligence analysis and collection management

Underlying all the complex user needs described earlier is the need for information to be shared between a myriad of different systems. Hence, the project team has been exploring the benefits of developing an ontology that provides an explicit representation for intelligence analysis and collection management applications. Such an ontology would provide a means for bridging the information divide between several intelligence systems and databases and moving towards semantic interoperability at a higher abstract level of understanding.

The ontology should comprise taxonomies of terms for describing objects and activities that are being monitored and analysed, in other words, descriptors for the enemy threat, environment and other situation data. It should also comprise process models for the analysis and collection management processes, clearly identifying the roles and ownership of particular activities. Each activity should include the following:

- Description – within the context of an accepted verb classification
- Resources – needed to perform the activity
- Constraints – quantitative, qualitative and temporal
- Products – effects of the activities
- Duration – time to complete the activity.

The products of the intelligence support processes, such as the intelligence estimates, reports, briefings; collection plans, information and collection requirements are all part of the ontology. In addition, the evidential graphs, the structure of the intelligence databases and the systems from which information should be accessed, also comprise the ontology. Effectively, the ontology provides a theory of the domain, with terms for describing products within the domain, activities, players, organisation and authority (policy).

For example, an evidential graph might point to evidence of the presence of enemy that could offer them control of movement within an area of interest (AOI) if they held key terrain. The latter needs to be confirmed. In addition, the commander requires information about enemy strength, composition and disposition, and also which routes should be cut to prevent the key terrain being occupied. Other factors could enhance or prejudice these interpretations, but could also compromise the intelligence collection operations. Expectation of bad weather (low cloud and fog) might require all-weather sensors to be tasked in addition to other, more prevalent, sensors. Knowledge of enemy unit composition would help determine whether signals intelligence (SIGINT) could confirm their location.

3.1 Literature review

During the past few years, there has been a flurry of academic papers reporting attempts at applying ontologies, especially for search and retrieval of information repositories (Uschold & Gruninger, 1996; McGuiness, 1998; Guarino *et al*, 1999; Jasper & Uschold, 1999). Although the term ontology is still relatively new, ontologies have been used effectively under different names in many domains. Astronomers, archaeologists, palaeontologists, and biologists have been refining taxonomies to share research results within their research communities for decades. The international standards community for process applications has been active in disseminating a variety of process formats, IDEF0 being an example.

Even within the military community, standards have been established at the national and international level (NATO STANAGs) for many types of military information formats: NATO AdatP3, the UK Defence Command Army Data Model (DCADM), to name just two. Often these standards are at the detailed data level rather than at more abstract information and knowledge-level, which explains why there are so many of them, and yet interoperability is still a major problem.

Review of the ontology literature suggests that agreeing common standards at higher levels of abstraction is much easier to achieve than at the data-level. There is less need to enforce common data formats that must be adopted by all players, as long as information can be mapped between them at higher abstraction levels. There is still a requirement for common languages to be agreed at some abstraction level. But this can be carefully selected to minimise cost for legacy systems compliance, since data in legacy systems need not be modified. Instead, effort is placed on providing mappings of terms to the common languages.

Although no papers were found on intelligence analysis and collection management ontologies, there is related work on smart workflow technology for intelligence collection management (Berry, 2001a) and on document collection templates for web management systems (Ko *et al*, 2000). Other papers have described research into various prototype intelligence support tools (Gorrell, 1991; Tomlin, 1995; Gonsalves & Rinkus 1998; Jones *et al*, 1998), and lessons learned from collection management operations during Operation Desert Storm (Franz, 1995). These papers provide starting points for an initial process language described next.

3.2 First steps towards a process language

Figure 2 expands on the previous figure, highlighting support processes for intelligence analysis and collection management. A detailed study of the these processes has been conducted within the project, relating them to Joint Essential Tasks (JETs) from the UK Permanent Joint Headquarters, and presented within a storyboard (Storyboard, 2001). The processes are hierarchical with activities being undertaken at different echelons for strategic, operational and tactical purposes. These processes help to determine terms for describing activities, players, products and information flows for each activity.

Table 1 provides a verb classification of key activities, derived from a verb classification for intelligence collection management (Berry, 2001b), which has been refined to include terms for intelligence analysis tasks. Associated with each verb are other verbs that describe related activities, very much like a thesaurus. Such a classification provides a foundation for a hierarchical set of terms for describing how these activities fit together. The next steps involve defining a corresponding noun classification that identifies key players, products and information flows. This is in progress and will be reported in future papers.

We believe that these verb and noun classifications will provide a basis for building a process language. Together with a corresponding taxonomy of terms (nouns and verbs) for describing situation information (e.g. enemy threat, environment, and other situation data) they will form major parts of the overall ontology. Other elements of the ontology would include representation of information flow and delegation of authority. The

workflow community has been developing tools that are relevant, and have been explored recently for collection management (Berry, 2001a). Commercial workflow tools are still limited, since they tend support well-defined processes, rather than dynamic ones, but do provide a starting point for exploring transferring delegation of authority.

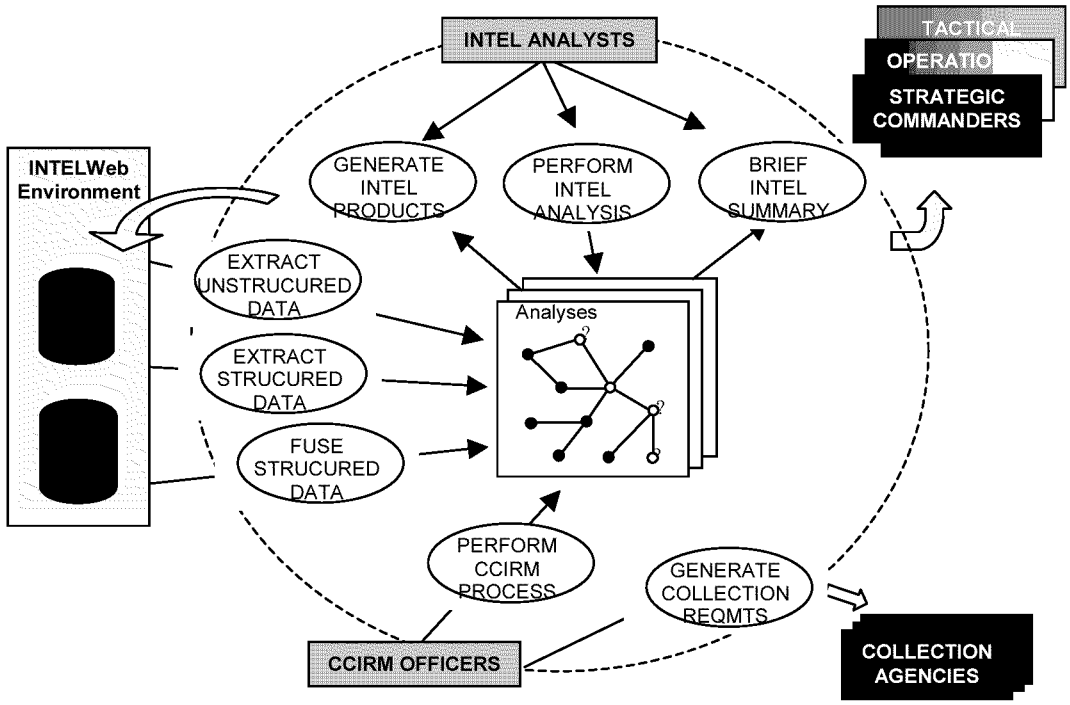

Figure 2: Intelligence support processes

ANALYSE – predict, determine, monitor, diagnose, measure
ASSESS – estimate, expect, consider, ascertain, determine, evaluate
ASSIGN – apportion, delegate
COMMUNICATE – request, acknowledge, reject
DECIDE – complete, finalise, approve, terminate, choose
DEVELOP – build, construct, create, compose, generate, prepare
EXTRACT – retrieve, search, mine
FUSE – collate, correlate, aggregate and reduce
IDENTIFY – classify, group, match, select, compare, resemble, detect
ISSUE – circulate, transmit, publish, deliver, release
MODIFY – combine, join, link, refine, integrate, evolve, augment
OBTAIN – receive, acquire, establish
ORGANISE – co-ordinate, regularise, formalise, de-conflict, phase, sequence, plan
PERFORM – execute, undertake
PRIORITISE – order, rank
PROVIDE – supply, furnish, equip, offer, give, input
REVIEW – learn, appraise, summarise, critique
SUPPORT – sustain, aid, assist, approve

Table 1: Preliminary verb classification for intelligence analysis and collection management

3.3 Next steps

The next steps involve extending the verb classifications, integrating them with relevant noun classifications and building up the process language for intelligence analysis and collection management. The emerging process language will be applied to prototypical, but, initially, small analysis and collection tasks that match the user needs identified earlier, and tested for expressiveness and effectiveness. In addition to a process language, the ontology requires a domain language for describing terms within the intelligence reports and estimates. Eventually, experimental plans will be defined that validate the complex user needs outlined earlier, so that the relevant military requirements can be informed.

4 Summary and conclusion

This short paper describes concept development work within the "Intelligence Support to Commanders" project. Complex user needs are outlined in support of intelligence analysis and collection management tasks. A review of ontology research is briefly described, and an initial ontology for intelligence support tasks is proposed. The first steps towards a process language for describing intelligence analysis and collection management tasks is presented, together with next steps. Eventually, this research will lead to experimental plans that aim to validate the complex user needs, so that relevant military user requirements can be informed.

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