12th International Command and Control Research and Technology Symposium
"Adapting C2 to the 21st Century"

USER DEFINED OPERATIONAL PICTURES FOR TAILORED SITUATION AWARENESS

Topic: C2 Technologies and Systems or Cognitive and Social Issues

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Abstract

This paper describes an effort underway to develop operational concepts and technical implementations for user defined operational pictures (UDOP). The purpose of the UDOP capability is to create, visualize, and share decision-focused views of the operational environment for decision-makers to support accurate situation awareness and timely decision-making in a distributed net-centric C2 environment. Net-centric C2 architectures will make available a considerable amount of information that can be injected into an operational picture for situation awareness and decision support; the UDOP capability enables transformation of that universe of data into a decision-focused narrative of the battlespace. Unlike a traditional common operational picture (COP), a UDOP allows the user to select what information should be included in or excluded from the data set defining the operational picture at the source. The core elements of a UDOP capability are data access mechanisms to build a UDOP from the outputs of systems of record using net-centric means; visualization and presentation tools that provide effective situation awareness; business logic for creating added-value information products derived from raw data inputs, and collaboration tools to enable shared situation awareness. This paper provides an overview of a proposed UDOP operational concept, as well as a description of a reference architecture and prototype implementation.

1. Introduction

Emerging network-centric warfare (NCW) technologies will provide operators in military command centers with access to unprecedented amounts of real-time battlefield information, and they offer the potential to enable transformational C2 capabilities that improve mission effectiveness through shared situation awareness and self-synchronization. Effective, intuitive, agile decision support and visualization capabilities will be a key driver of the shared awareness that improves mission effectiveness. It will be insufficient just to get information to people; it must be synthesized, organized, and presented in a way that can improve decision-making and operational effectiveness at all echelons of C2, from theater commanders to national leadership.

Supporting such shared awareness in a distributed C2 setting relies on creating a suitable common operational picture (COP) of the battlespace. A COP facilitates collaborative planning and assists all command echelons in achieving consistent situation awareness. In this context, the term "picture" refers not so much to a graphical representation, but rather the data used to define the operational situation. As such, the creation and dissemination of the COP is as much an information management (IM) challenge as it is a visualization challenge. Today, a massive amount of "sausage making" is required to build such a picture. Large, cumbersome information products and data must be pushed, melded, and exploited to produce useful operational pictures. Much of this melding process is manual, in that it requires a considerable amount of human intervention to decipher data and information, extract the requisite information, build the desired representation, and disseminate it to the proper users. This process results in a considerable amount of information flowing through C2 information channels to support a desired product, when only portions of that product are actually needed to support a particular decision process.

This inefficiency and lack of agility has motivated the development of the concept of the user defined operational picture (UDOP), in which the information content is *tailored* to meet the needs of an individual or community of interest (rather than a bulk broadcast of all information that must be teased apart to extract the relevant pieces and create an effective narrative to support C2 decision processes). Making an operational picture *user defined* can entail many things:

- The user identifies the specific content to be included in and excluded from the picture. This distillation can include bounding content by spatial region, temporal window, affiliation, and other such criteria. The user may want to focus on any particular areas of interest or responsibility in the world, and assemble a picture of an evolving situation using data feeds from relevant regional and national assets
- The user specifies how the selected content should be formatted based on personal preference (2D, 3D, tabular views, unit aggregations, labels, and annotations). Multiple visualizations may be combined in a user-defined layout that can be re-used at the next login.
- The user develops and incorporates added-value products based on his domain knowledge to augment the machine-to-machine (M2M) data provided by systems of record.
- The user tailors a given set of contents to address the needs of a particular C2 echelon. For example, theater commanders may be interested in seeing and understanding specific airspace configurations, air tasking orders, sensor characteristics, and target numbers; however, national leadership may be interested in broader questions of likelihood of mission success, population at risk, and world political response.

The purpose of the UDOP capability is to create, visualize, and share decision-focused views of the operational environment for decision-makers to support accurate situation awareness and timely decision-making in a distributed net-centric C2 environment. Net-centric C2 architectures will make available a considerable amount of information that can be injected into an operational picture; the purpose of the UDOP capability is to enable transformation of that universe of data into a decision-focused narrative of the battlespace. This paper describes an effort underway to develop operational concepts and technical implementations for a UDOP capability. We first describe the proposed operational concept for UDOP, followed by descriptions of a reference technical architecture and initial implementation.

2. UDOP Concept Description

2.1 Operational Context

The purpose of a UDOP capability is to create, visualize, and share decision-focused views of the operational environment to support accurate situation awareness and timely decision-making in a distributed net-centric C2 environment. Net-centric C2 architectures will make available a considerable amount of information that can be injected into an operational picture; the purpose of the UDOP capability is to enable transformation of that universe of data into a decision-focused narrative of the battlespace. This narrative will support many of the core functions of C2, which include (Alberts & Hayes, 2006):

- Establishing and understanding command intent
- Determining roles, responsibilities, and relationships
- Establishing rules and constraints
- Monitoring and assessing the situation and progress

- Provisioning resources

To support these C2 functions, a UDOP capability will enable its users to do the following:

- Focus on any particular areas of interest in the world, and assemble a picture of an evolving situation using data feeds from relevant regional and national assets
- Create mission pictures at multiple levels of abstraction, from detailed theater-level C2 perspectives to decision-focused pictures for national civilian leadership
- Transform vast amounts of raw data into a meaningful story that can be understood at a glance, and animated backwards and forwards in time
- Provide explicit representation of information quality and pedigree of data obtained from net-centric sources, so that consumers of the picture understand its scope and limitations
- Transcend individual situation awareness (SA) by supporting shared SA of distributed decision-makers through collaborative pictures

Figure 1 illustrates a notional hierarchy of how UDOP products would be used to support shared situation awareness across multiple C2 echelons, ranging from individual force providers and collection platforms up to national leadership.

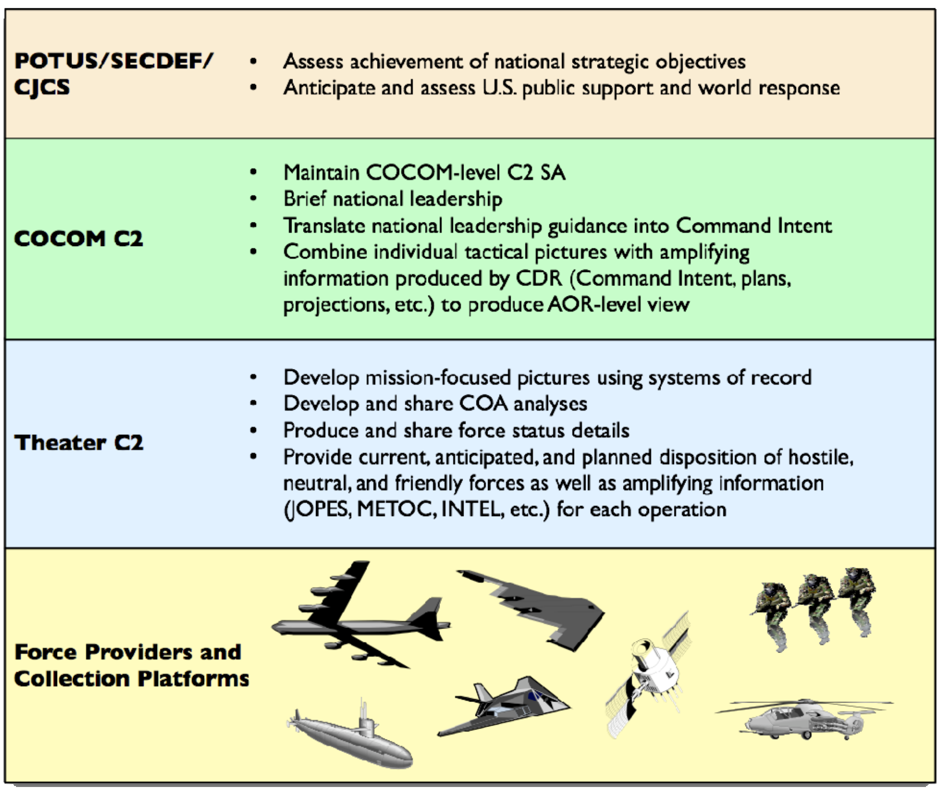

Figure 1: UDOP Context and Perspectives

The specific situation awareness needs of the stakeholders in this diagram vary as we move from top to bottom in Figure 1. At the top of the diagram is national leadership, shown here as consisting of the President (POTUS), Secretary of Defense (SECDEF), and the Chairman of the

Joint Chiefs of Staff (CJCS). They are concerned with assessing achievement of national strategic objectives, understanding world response to potential U.S. activities, and coordination of military activities with other agencies and the governments of other nations. Commanders of individual combatant commands (COCOMs) are responsible for maintaining global situation awareness of the status of the forces under their command, and also for translating directives from national leadership into Command Intent that is disseminated throughout their chain of command. Each COCOM CDR's picture consists of products made available from individual theater-level views. Inputs to the systems of record enabling these views come ultimately from force providers and collection platforms.

2.2 Components of a UDOP

Figure 2 illustrates the notional components of a UDOP, described as a hierarchy of constituent elements.

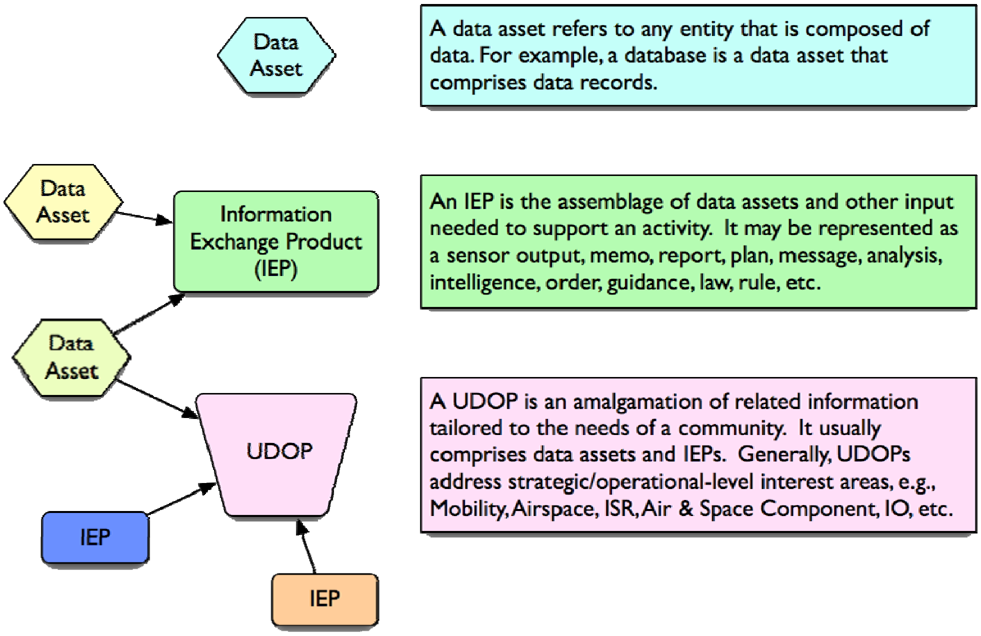

Figure 2: Components of a UDOP. Based on Vittori & Cook (2006).

The atomic element is the **data asset**, which is a data entity required by a user. A data asset might be an aircraft takeoff time, target database, image, etc. The data asset is a key element of an **information exchange product** (IEP), which applies context to data assets and is organized around a particular activity. The most common IEP is a message. For example, the airspace control order (ACO) contains hundreds of data assets that support airspace management. A UDOP is a tailored information product that serves a strategic or operational-level interest such as air mobility, space, air defense, etc. A COI may form for an interest area such as airspace management, and an airspace UDOP (tailored to the particular operational theater) could support this COI. Members of the COI such as AWACS would feed IEPs and data assets into the UDOP, and in turn subscribe to it to see the aggregate picture. The UDOP thus becomes a packaging concept to address operational needs. An analogy to a newspaper would be:

- The COP is the entire newspaper
- The UDOP might be an assemblage of articles based on a reader's interest
- An IEP would be a single article
- A data asset might be the results from a particular baseball game

In this analogy, the entire newspaper is a large common bin of information, but each user or user community pulls out only what is relevant to their activity. Importantly, each individual element is consistent with the big picture.

2.3 Building a UDOP

In addition to specifying exactly what a UDOP is, it is also necessary to define how to build one in the first place from individual data assets. It is assumed that the UDOP capability resides in a net-centric enterprise where individual data assets, IEPs, and existing UDOP products are accessible through standards-based networking protocols. Figure 3 illustrates the notional pipeline for building a UDOP from individual data products. Net-centric *UDOP services* make it possible to build, display, and share the composite information products in a UDOP. On the left are the requirements that motivate UDOP content, as well as the data products that are available for injection into a UDOP. Data will be exposed primarily through two net-centric means:

- **Request/reply**, in which a client asks for a specific body of data using query parameters, and receives a well-structured response in reply
- **Event-driven** (also known as publish/subscribe), in which a client indicates interest in a particular category of data, and then is pushed that data as it becomes available on the network (or receives a notification that it is available, and can then retrieve it through request/reply means)

Request/reply mechanisms are often preferable for one-time or infrequent retrievals of large amounts of data. Typically the interaction is synchronous, and the service invoker waits for a reply. In the event-driven approach, one system expresses interest in events generated by another. Events are published to "subscribers" without any expectation of a response. This approach can be more effective for more frequent, timely transfers of smaller amounts of data (e.g., near-real time tracks, alerts, and so on).

As shown, the first step is to select the data to add to a UDOP. The user may select this data by applying filters against streaming data sources, or specific query parameters for database retrieval.

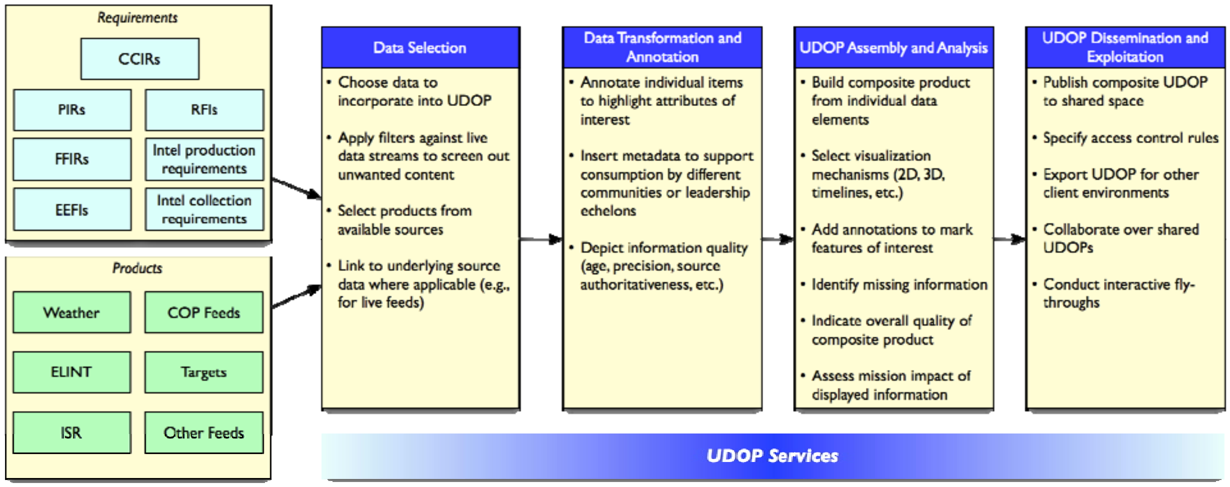

Figure 3: UDOP Pipeline

After selecting the data (which links back to its authoritative source), the next step is to perform any desirable transformation and annotation steps. For example, the user may annotate individual items of interest, or add comments that make judgments about the displayed data. The UDOP is then assembled and displayed using whatever visualization mechanisms are most appropriate – 2D or 3D maps, tabular views, timelines, and so on. Additional metadata may be added to identify missing information, call out features of interest, or to indicate an assessment of the quality or accuracy of the picture, as well as the likely mission impact. Finally, the user makes the composite UDOP product available in a shared space that is discoverable by other users. Any access control rules that restrict who can see what content may be applied, and multiple users at distributed locations may collaborate over a UDOP to build shared SA in real time.

2.4 Enabling a UDOP Capability

Several core pieces of functionality are needed to enable the UDOP capability described in the preceding sections:

- **Data access** mechanisms for building a UDOP from the outputs of systems of record using net-centric means
- **Visualization and presentation** mechanisms to provide the requisite historical, current, and anticipatory situation awareness
- Domain-specific **business logic** to create derived, added-value information products from the raw data inputs and displayed data and to extract insight based on the content therein
- **Sharing and collaboration** tools to enable shared situation awareness and collaborative decision-making based on the decision-focused view created through the UDOP. In the 21st net-centric C2 enterprise no user will be operating alone; how to use UDOP capabilities for collaborative analysis and planning must also be understood.

Each of these elements is discussed below.

2.4.1 Data Access

As discussed earlier in section 2.3, data access mechanisms allow the UDOP capability to retrieve the data to be visualized and exploited. These mechanisms will employ net-centric, loosely coupled standards-based means to do so. They may employ request/reply and event-driven means as previously explained. Parallel, ongoing data exposure efforts within DoD will define the specific protocols and data schemas that must be supported.

2.4.2 Visualization and Presentation

Once the necessary data products are retrieved into the UDOP environment, it must be visualized to support varying levels of situation awareness. Geospatially oriented data will naturally be presented using a combination of 2D and 3D map displays. Mission schedules may be shown in timeline views, and it may also be desirable to present tabular data as well as unstructured textual information. The UDOP capability should allow the user to create and display a tailored information environment that stitches together multiple modalities of data (geospatial, temporal, tabular, textual, etc.). Once the picture is built the user may want to annotate features of interest, which should then be captured as part of the UDOP, either as annotations to the data assets or to the UDOP itself. The former would be used in situations such as tagging an asset with information, where the latter would be used to draw interest to an area on a map.

Complete situation awareness relies not just on understanding the current circumstances, but also on how that situation evolved and how it is likely to progress into the future. Thus, the visualization tools should provide “TiVo” style functionality to provide user-controlled animation between past, present, and anticipated future. Animation can be a very effective tool for allowing observers to understand the evolution of a situation. It has long been used as a mechanism for expressing time-dependent information. Animated views should be combined with timeline views that allow the observer to place the current scene in the context of a longer-term timespan such as a mission timeline.

Any UDOP presentation should reflect the *quality* of the data used to build it, so that decision-makers are cognizant of the limitations in their knowledge of some operational situation. The crucial hypothesis of NCW is that robust networking and information sharing will improve shared situation awareness and mission effectiveness. The premise of this hypothesis is that improved networking, particularly in C4ISR systems, will add value (Perry *et al*, 2004). This value added will clearly depend on the quality of information used in net-centric operations, and thus, in a UDOP capability.

The NCW Conceptual Framework (Signori *et al*, 2002) defines eight attributes that can be used to describe information quality. The attributes are shown below in Table 1. These attributes are divided into two categories, *objective* and *fitness-for-use*. Objective measures can be used regardless of the particular context or scenario, while fitness-for-use measures require a particular context or scenario to be defined before they can be used. Thus objective measures are context-free, while fitness-for-use measures are context-dependent.

Table 1: Objective and Fitness Measures of Information Quality (From Perry *et al*, 2004)

Category	Measure	Definition
Objective	Correctness	The extent to which information is consistent with ground truth
	Consistency	The extent to which information is in agreement with related or prior information
	Currency	The age of the information
	Precision	The level of measurement detail in each item of information
Fitness for use	Completeness	The extent to which information relevant to ground truth is collected ("relevant to ground truth" depends on the scenario)
	Accuracy	The appropriateness of the precision of information to a particular use
	Relevance	The proportion of information collected that is related to the task at hand
	Timeliness	The extent to which the currency of information is suitable to its use

Information quality metrics such as those shown in the table can be combined with guidance for explicit depiction of uncertainty and information quality (e.g., Endsley *et al*, 2003). Depicting information quality requires that the data delivered through the services provide the necessary metrics. The responsibility for describing information quality and pedigree rests with the data providers upstream of a UDOP framework. However, once such measures are available, a UDOP should represent them properly.

Finally, any presentation of a certain set of information should be tunable to the needs of the C2 echelon it is intended to support. As discussed earlier, decision-makers at different levels may have different interests in the components of any given UDOP, and may want to see things at different levels of abstraction. The UDOP capability will provide tools to perform this tuning, design in accordance with a specified set of business rules. These rules will specify notional templates for what categories of information should be used for different categorizations of views (theater C2, COCOM C2, etc.). Aggregation rules can be defined to combine individual members of a given mission capability package (MCP) into a single icon on the screen. While theater/COCOM level displays may use conventional MIL-STD-2525b symbology to depict units, they may be simplified to more intuitive representations for briefing civilian leadership. The following categories of content manipulation are envisioned:

- **Distillation**: Reduce or filter full data sets in an operational picture to focus on specific items of interest. Items not of principal interest may be hidden or de-emphasized in their appearance (icon size, color intensity, etc.).
- **Annotation**: Augment machine-based data with human-derived content (notes, explanations, visual features such as lines and arrows, etc.) that facilitates understanding and interpretation of the situation.
- **Transformation**: A specialized form of annotation, this is modification of entity names, descriptions, and/or visual representations to make them more suitable for consumption by the target audience. Examples include changing symbology to facilitate understanding by civilian audiences, or changing textual tags to replace complex machine-generated ID codes with something more human-readable.
- **Aggregation**: Combine multiple entities in the picture into a single composite entity, which may use different or derived symbology. A common example would be to show several

similar entities such as aircraft or ground units with symbols that denote groups of those entities.

2.4.3 Business Logic

Closely related to the presentation function is business logic for deriving new information products from the retrieved data, over and above the visual transformations discussed earlier. For example, one straightforward function is extrapolation in space/time, to support the TiVo capability. To support planning processes, UDOP tools used by subject matter experts can provide "what if" analysis capabilities to explore and visualize alternative COA options.

As discussed earlier, a UDOP is a composite information product composed of (potentially) individual data assets, IEPs, and even other UDOPs. Because of this set nature of UDOPs, the following operations on UDOP *A* and UDOP, IEP, or DA *B* may be desirable:

- Union ($A \cup B$): Create the set of all items that are either in *A* or *B* or both
- Intersection ($A \cap B$): Create the set of all items that are in both *A* and *B*
- Subtraction ($A \setminus B$): Remove all elements from *A* that are not in *B*
- Existence ($B \in A$): Test for the presence of *B* within *A*

As UDOPs change, it may be necessary to derive a new UDOP from an existing one. This new UDOP will be free to diverge from the basis UDOP, and show different, but related information. For example, a UDOP that is transposed to a different geographic area based or a UDOP that contains more detailed information of interest to a specific operator, but not of general interest to the larger community that uses that UDOP. A new UDOP may be created from an existing UDOP through two methods:

- Derivation (*derive(A)*): Create a new UDOP, *B*, that is a inherits its items and structure from *A*. As new items are added, modified, and removed from *A*, they are similarly affected in *B*. However, changes to *B* are not propagated back to *A* nor to *A*'s further descendents. If *B* has an item *i*, that has been modified, and *i* changes in *A*, those changes are no longer propagated to *B*.
- Clone (*clone(A)*): Create a new UDOP, *B*, that is a snapshot of *A* at the time of the copy. No future changes from *A* will be reflected in B. They are completely distinct after the clone takes place.

The logic for such set operations may be resident within services available on the network, or built into individual clients tailored to a particular mission domain.

2.4.4 UDOP Sharing and Collaboration

Once a UDOP has been built, annotated, filtered, and tuned, a mechanism is needed to publish that decision-focused product into the network so that others can consume it. UDOP *services* will be used to publish the composite product where it can be discovered and exploited (and thus become an input to downstream SA and C2). These services will be distinct from those used to retrieve the underlying data from systems of record. An architectural concept for such services is presented later in section 3; the focus here is on understanding what those services will enable from a capability perspective. The collaborative functions of the UDOP capability will allow one user to create shared awareness with other distributed users:

- Sharing a UDOP as a specification of information content (i.e., a "recipe")
- Sharing a UDOP as de-referenced data for the benefit of those users who do not have access to the enabling UDOP services
- Sharing a UDOP as a literal picture (i.e., pixels) for disadvantaged users who cannot access the full range of UDOP functionality
- Annotating a UDOP to provide metadata on its contents, highlight areas of interest, and provide explanatory details on what the UDOP means
- Annotating individual elements of a UDOP to amplify their nature and relevance for C2 purposes
- Enabling collaborative UDOP walkthrough, so that one user can guide another on interpreting the space/time narrative within the UDOP

3. Architecture Approach

Figure 4 illustrates a UDOP reference architecture, patterned after the layered, loosely coupled approach advocated by the ESC Strategic Technical Plan (STP) (ESC, 2005). The STP provides a common technical vision to guide programs implementing a variety of C4ISR systems that are working towards achieving the promises of net-centric capabilities. The STP defines six key goals (and metrics to track them) for achieving a net-centric C2 enterprise. Most relevant for this discussion is the first goal, which is to migrate nodes and programs to a common layered architecture consisting of five layers: Applications, Information Infrastructure, Networks, Sensors, and Information Assurance. The UDOP capability resides in the information infrastructure and application layer, as shown.

The bottom of the diagram shows the various systems of record providing data that will drive a UDOP. These sources are encapsulated by information access services that provide access via request/reply and event-driven means, using a variety of potential transport mechanisms and interaction design patterns (ESB, SOAP, REST, etc.). In the green layer reside services for managing UDOP products per the preceding section, as well as the visualization clients used to exploit them. This architecture does not prescribe whether thick, thin, 2D, or 3D clients are to be used. Rather, the architecture should be flexible enough that a range of client platforms can be used, each designed with loosely coupled interfaces to interact with the UDOP services and the underlying data services. Finally, information assurance mechanisms provide access control for system interaction as well as services for authenticating the correctness of information in a UDOP.

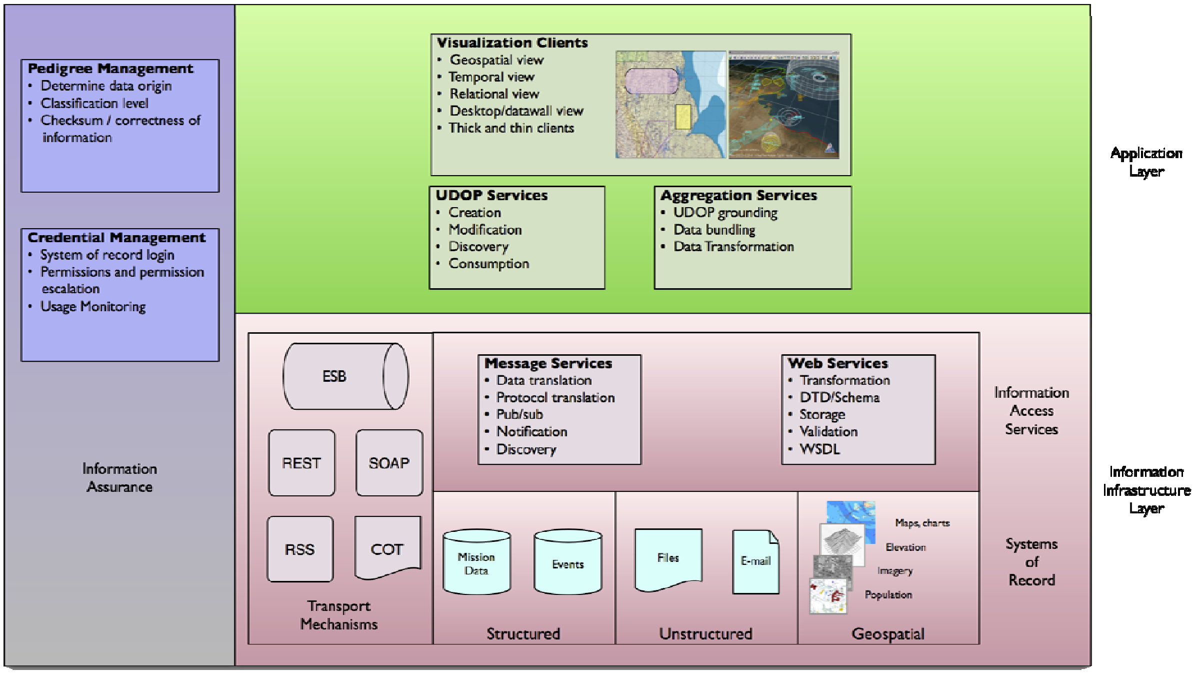

Figure 4: Loosely Coupled Architecture for UDOP

4. Prototype Implementation

Figure 5 illustrates a reference implementation of the UDOP concept, developed in accordance with the architecture concept described above. A **thick client user interface** provides a highly interactive 3D visualization experience based the Satellite Toolkit from Analytical Graphics Inc, while a **web-based user interface** provides more basic functionality through a web browser. Its map visualization is based on Google Maps technology. Each interface provides components for browsing available information products. The thick client interface focuses on interaction with underlying data sources and UDOP composition/publishing, while the thin client interface at present focuses on subscribing to available composite UDOP products.

Two sets of **UDOP Network Client** libraries enable interaction between these user interfaces and server-side resources, both of which enable access and consumption of UDOP products. The .NET/Java client used by the thick client enables production and consumption of UDOP products, while the Javascript library developed in this prototype for the web client at present enables only consumption behavior.

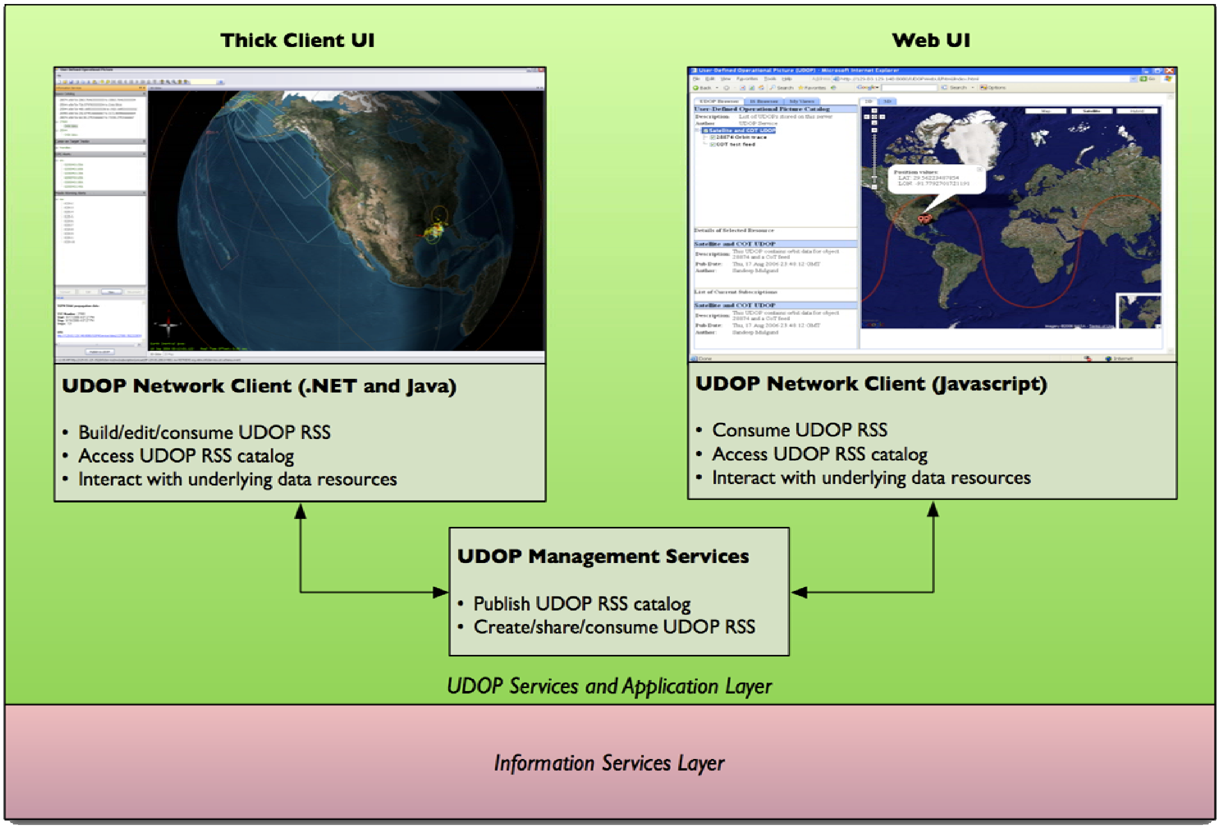

Figure 5: Prototype Implementation Architecture

The UDOP Management Services provide the interface for creating and accessing UDOP products. In the prototype implementation, UDOPs are exposed as "really simple syndication" (RSS) feeds (Hammersley, 2005). RSS is an XML format used to publish frequently updated digital content, and it is in wide use in the commercial world for publishing headlines from news sites or web logs. A typical RSS feed contains header information such as the source and time of update of the feed, and a series of individual items, each of which has a network link to the source data as well as brief descriptive information.

The UDOP management services use RSS in two ways: first, as a catalog of available UDOPs, each of which has a unique uniform resource identifier (URI) address on the network, and secondly, as the data model for representing an individual UDOP's contents. Each item (data asset or IEP) in a UDOP has a unique URI also, which points to the underlying data in the information services layer (simplified in the diagram above). UDOP-specific extensions to RSS encode the nature of the data being accessed; i.e., whether it is a request-reply web service invocation, a streaming data feed, etc. The UDOP network client uses this information to determine how to interact with the data source itself.

Figure 6 and Figure 7 illustrate this hierarchy, which is a concrete implementation of the general concept shown earlier in Figure 2. Figure 6 shows the RSS-based UDOP catalog, which advertises all UDOP products stored on the hypothetical server. Each `<item>…</item>` region in the RSS document represents a single UDOP, with address and descriptive information provided.

```
<rss>
  <channel>
    <title>User Defined Operational Pictures Catalog</title>
    <link>http://mitre.org/udop</link>
    <description>List of UDOPs stored on this server</description>
    <item>
      <title>Satellite and track UDOP</title>
      <link>http://mitre.org/udop/udop_1162480572834/</link>
      <description>New udop with satellite and CoT data</description>
      <pubDate>Thu, 02 Nov 2006 15:16:12 GMT</pubDate>
      <dc:creator>Sandeep Mulgund</dc:creator>
    </item>
    <item>
      <title>Air Picture UDOP</title>
      <link>http://mitre.org/udop/demoudopoct20_1161361956290/</link>
      <description>Air picture UDOP</description>
      <pubDate>Fri, 20 Oct 2006 16:32:36 GMT</pubDate>
      <dc:creator>SSM</dc:creator>
    </item>
    <item>
      <title>Ground Picture UDOP</title>
      <link>http://mitre.org/udop/demoudopoct21_114365134290/</link>
      <description>This UDOP describes the ground picture in the
         theater of operations</description>
      <pubDate>Fri, 20 Oct 2006 16:32:36 GMT</pubDate>
      <dc:creator>SSM</dc:creator>
    </item>
  </channel>
</rss>
```

Individual UDOP

Individual UDOP

Individual UDOP

Figure 6: UDOP Catalog RSS

Each `<link>…<link>` field in Figure 6 points to another RSS document that describes the referenced UDOP. Figure 7 shows an example of a UDOP instance document, for the first item listed in Figure 6. The top of this document provides metadata about the UDOP itself – its title, publication date, and authorship. Each `<item>…</item>` region in this document points to actual data assets contained within the UDOP. The example shown contains two items, distinguished by the `<udop:resourceType>` field; the first is a subscription to a streaming data feed, while the second is a link to a data document with a specified network address.

```
<rss>
  <channel>
    <title>Satellite and track UDOP</title>
    <link>hhttp://mitre.org/udop/udop_1162480572834/</link>
    <description>New udop with satellite and CoT data</description>
    <pubDate>Thu, 02 Nov 2006 15:16:12 GMT</pubDate>
    <dc:creator>Sandeep Mulgund</dc:creator>
    <dc:publisher>MITRE Corporation</dc:publisher>
    <dc:source>http://mitre.org/udop</dc:source>
    <item>
      <title>cotfeed</title>
      <link>http://mitre.org/infoService/bft/subscription/unicast/</link>
      <description>cotfeed</description>
      <pubDate>Thu, 02 Nov 2006 15:16:13 GMT</pubDate>
      <dc:creator>Sandeep Mulgund</dc:creator>
      <dc:publisher>MITRE Corporation</dc:publisher>
      <dc:date>2006-11-02T15:16:13Z</dc:date>
      <udop:resourceType>subscription/unicast</udop:resourceType>
      <udop:resourceLink>http://mitre.org/infoService/bft/subscription/unicast/
                       </udop:resourceLink>
      <udop:resourceFormat>cot</udop:resourceFormat>
      <udop:parameter udop:name="type" udop:type="xs:string">a-.*</udop:parameter>
    </item>
    <item>
      <title>28874 orbit for 907.6776833333333 to 2347.6776833333333</title>
      <link>http://mitre.org/SGP4Service/data2/28874_2066345691</link>
      <description>28874 orbit for 907.6776833333333 to 2347.6776833333333
                 </description>
      <pubDate>Thu, 02 Nov 2006 15:16:13 GMT</pubDate>
      <dc:creator>Sandeep Mulgund</dc:creator>
      <dc:publisher>MITRE Corporation</dc:publisher>
      <dc:date>2006-11-02T15:16:13Z</dc:date>
      <udop:pollIntervalMillisec>0</udop:pollIntervalMillisec>
      <udop:resourceType>data</udop:resourceType>
      <udop:resourceLink>http://mitre.org/SGP4Service/
                       data2/28874_2066345691</udop:resourceLink>
      <udop:resourceFormat>sgp4set</udop:resourceFormat>
    </item>
  </channel>
</rss>
```

URI-referenced Subscription Item

URI-referenced Data Item

Figure 7: UDOP Instance RSS

The UDOP network client uses the `<resourceType>` element to determine how to invoke communications with the underlying data service, whose location is specified via the `<link>` element.

The thick client user interface allows the user to create connections to available data feeds from the information services infrastructure. Each connection has different particulars on filtering options (to scope the content of the returned data), update rates, and connection type (event-driven vs. request/reply). Some of these are visible in Figure 7. The UDOP network client abstracts these complexities to provide the client application with a uniform interface to the data. A user can then constructively build a tailored picture of the environment. Once complete, it can be published to the network, where it is exposed as an RSS feed by the UDOP management services. The thin client can see this RSS feed, and use it to select and display available UDOP products. It reconstructs the same view developed originally in the thick client environment.

5. Summary

This paper has described an effort underway to develop operational concepts and technical implementations for user defined operational pictures. The purpose of the UDOP capability is to create, visualize, and share decision-focused views of the operational environment for decision-makers to support accurate situation awareness and timely decision-making in a distributed net-centric C2 environment. Net-centric C2 architectures will make available a considerable amount of information that can be injected into an operational picture; the UDOP capability enables transformation of that universe of data into a decision-focused narrative of the battlespace. The core elements of a UDOP capability are data access mechanisms to build a UDOP from the outputs of systems of record using net-centric means; visualization and presentation tools that provide effective situation awareness; business logic for creating added-value information products derived from raw data inputs, and sharing and collaboration tools to enable shared situation awareness.

Current work focuses on developing a fleshed out UDOP implementation that enables all of the functionality described in section 2, using the architecture concept described in section 3. While the prototype UDOP authoring environment was based on a thick client interface, in future revisions it will employ a thin client interface, with the ability to export UDOP products into increasingly ubiquitous visualization tools such as Google Earth. Efforts are also under way to validate the operational concept and workflow with users, and to assess the concept's utility in real-world use.

6. Acknowledgments

The authors thank Mr. Terry Rorabaugh, Mr. Michael Prausa, and Ms. Maria Casipe of the MITRE Corporation for their support in the development of the UDOP software prototype described in this paper.

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