Exploring Two Enterprise Semantic Integration Systems

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Abstract

An Enterprise Semantic Integration System (ESIS) provides cross-domain and cross-department insights by normalizing and merging structured, semi-structured, and unstructured data sources from both internal and external source, into a knowledge model that can then be visualized in an integrated portal. The interface of an ESIS shows data, metadata, and semantic connections. Search and analysis tool and integration points to other enterprise systems can be made available to the knowledge worker in the ESIS. In this paper, we first present an overview of the complex task of data aggregation, cleansing, and import into a knowledge model. We go on to explore two major types of ESIS: a market or competitive intelligence system, with illustrative examples Corporate Radar and Business Event Advisor, and a knowledge management system, the Knowledge Discovery Capability. Each of these case studies provides interesting insights into the challenges involved in the design and deployment of an ESIS.

1. Introduction

Semantic integration involves a challenging array of data manipulation tasks. The motivation for the effort is sense making in the context of heterogeneous data sources [1]. To get a bird’s eye view that synthesizes various sources is a strategic goal that can be only met with the assistance of semantic integration [2]. When this is done successfully, knowledge workers can access a cross-silo model in a visual interface to review established insight or synthesize new insight. Ideally, this translates into actionable intelligence – insight immediately useful in garnering business intelligence, decision making and/or constructing a work product.

To achieve this integration, a knowledge model is formulated, and then populated from existing data sources. This is challenging for a number of reasons: First of all, the data being integrating will typically differ in format, data quality, security access, retrieval methods, numerical units, language, and more. When data sources are pre-conditioned and merged, they must be de-conflicted, validated, and tagged to accurately represent their relationships inside a knowledge model. Enterprise knowledge architects face the additional challenge of handling and codifying both external and internal data sources so that they coexist and can be accessed in a common framework. Internal silos have their own security access model, specialized vocabulary and idiosyncratic access and retrieval. The same is true of important heterogeneous external data.

While the need for this kind of integration has been widely recognized, there has thus far been too little work done establishing common frameworks and application classes to support this kind of integration. In this paper, we first describe and define key requirements for Enterprise Semantic Integration Systems (ESIS), and describe the general steps in their deployment. We then present two case studies, corporate radars, and the Knowledge Discovery Capability. Each case provides interesting insights into the advantages and challenges involved in the design and deployment of an ESIS.

2. Enabling the Enterprise Semantic Integration System (ESIS)

Figure 1. ESIS Up To the Creation of the Enterprise Ontology

The first stage in enabling an ESIS is to construct
and load the knowledge model that represents the first pass at the enterprise ontology. This involves several discrete steps as shown in Figure 1.

As shown in Figure 1, the ESIS may wish to access external data sources. If this is the case, the external data sources are marshalled and brought across the enterprise firewall (or, alternatively, mediator systems are built to read external data and shape it for subsequent processing using data wrappers [3, 4].

Similarly, internal enterprise data sources may be marshalled or handled with mediators. Data (both textual and numeric) are then cleansed and normalized in the step labelled ‘Pre-Conditioning’. Text analytics tools may be employed to extract named entities from semi-structured document data, and controlled vocabularies gleaned. At this stage, automated relationship extractor tools may then be run to deduce associations between named entities. These pre-processing steps aim to reduce the manual effort necessary in constructing the initial controlled vocabulary, relationships between named entities, and knowledge model by the Knowledge Architect (KA). A related approach to increase the semantic useability of documents is to add logical links between text documents and relevant structured data [5].

3. Mandatory, Recommended, and Optional Features of the ESIS

Now that the knowledge model exists, and is loaded with initial data, what features do we expect in the user interface? We need facilities to access and retrieve the normalized, heterogeneous data. However, a great many other features are possible and perhaps highly desirable depending on the business domain. Let us review some of these possible features.

3.1. Internal Knowledge Model Inconsistencies and Conflict Resolution

It is often the case that the processing of numerous data sources will come across a situation where two or more incompatible assertions are being made regarding a given Named Entity. How do we know which assertion to load into the knowledge base? This is where Conflict Resolution features come in handy. The set of incompatible assertions are forwarded to an arbiter for manual action, for example in an administrative section of the knowledge vendor’s user interface. Or, there may be semi-automated cleanup by comparing the set of problematic assertions to a core set of axiomatic assertions. A related effort, as described by Noy [6] is the reconciliation of previously built ontologies into a unified knowledge model. They may use, for example, “the same linguistic term to describe different concepts” [6, 7] and thus require cleanup before import. It is beneficial to store the discarded assertions, including metadata such as source, date, and author, for audit and rollback. One can imagine this facility to be very useful when attempting to reconcile multiple semantic models inside the same enterprise [1, 2].

3.2. Uncertainty and Lineage

One feature that is certainly useful is the representation of the uncertainty of an assumption; in other words, the confidence one has in making the assertion. In addition, the system when it automatically fetches associations, can assign less confidence to an implied association than a direct one. This is useful in applications (for example, crimonology) where observations are stated as "the car may have been red, but it was dark." The confidence can either be built after fetching raw data from the underlying data stores, or built directly into the data model as demonstrated by the TRIO system [8].

Another appreciated feature is a lineage engine – the explication of relationships displayed on demand in language accessible to the user – the closer to natural language, the better. The easier it is for the user to read and understand the system’s explication for an assertion, the better.

3.3 Workspaces and Collaboration

Another handy feature is the ability to store common queries in the personal workspace for re-use (“shoeboxing”). Various members can share personal updates and arrive at consensus updates. Collaboration mechanisms can be synchronous (for example, instant messaging facilities) or asynchronous (for examples, wikis, e-mails, bulletin boards). The question then becomes, how to arrive at consensus and where do we position authority? This is discussed in the next section.
3.4. Scoped Knowledge Models

Dividing the knowledge model into “onion layers” has advantages. Consider the Core Knowledge Model (CKM) assertions that are axiomatic in nature. These “givens” form the backbone of the user’s view in the ESIS UI. The user also sees here a Domain Knowledge Model (DKM) – enterprise-level assertions that the user may want to change. Changes are reflected in the personal workspace and are labeled as Personal Knowledge Model (PKM). Scoped knowledge models are very useful when the user is banded into a workgroup (that often crosses intra-organizational boundaries [9] and is solving a joint task. For example, a team of intelligence analyst may be given a set of facts and they work individually on the fact set, communicating interim progress in a collaboration workspace (CW). Thus, changes made to each PKM should be reflected in the CW at the moment of PKM “publication.” Conflicting PKM’s can be resolved, as discussed in Section 3.1., by consensus mechanisms or by third-party arbitration, such as a knowledge “librarian”. PKMs can take the form of entirely new assertions (new named entities, new relationships between existing named entities) or the dispute of an existing assertion in the DKM (named entity or relationship). The CKM should only be revised rarely by its nature. The work product of a collaborative semantic exploration in this case would be an intelligence report summing up interesting relationships discovered, and potentially making recommendations on the basis of the discoveries. These work products can in turn be routed to the higher level arbitrator for potential further update to the EKM.

3.5. Convenient Extensions: Geospatial and Timeline

Many business problems can benefit from integration of the ESIS to common extension platforms. One of these is a geospatial representation. We will see more of this in our discussion of KDC in Section 6. The ESIS, in its preconditioning step, can extract latitudes and longitudes via, e.g. MetaCarta and feed them into a geospatial visualizer such as Google Earth or Microsoft Virtual Earth. One example of a powerful semantic geospatial setting is the visualization of large-scale environmental models [10].

Another convenient ESIS extension is timeline visualization. A slider bar in the interface provides the user with a way to go forward and back in time to replay sequences of events of interest. Appendix 1 contains Table 1 that presents a sample list of essential, recommended, and optional features of an ESIS.

4. How the ESIS Is Used

Turning to the question of ESIS use - one or more knowledge workers will interface with the visual representation of the knowledge model to perform inquiries, or gain additional insight (knowledge synthesis). These steps may have a collaborative workgroup component. The basic components are shown in Figure 2.

The steps shown in Figure 1 occupy the top left of Figure 2. These steps lead to the creation of the initial knowledge model which is used by the ESIS to display the welcome page UI to the knowledge worker (labeled KW in the figure). Clearly, some of the functions in Figure 2 such as Inquiry are mandatory in an ESIS and some are optional, such as Workgroup Alert mechanisms when a new contribution or synthesis of interest occurs. In the center bottom of Figure 2 we have the scoped
knowledge models discussed previously in Section 3.4. It is critical to insulate pre-vetted material and to establish vetting mechanisms before the putative new material percolates upward into the group view.

4.1. Organization of the Rest of the Paper

In the remainder of this paper we will discuss two ESIS case studies: i) Enterprise Corporate Radars, including Business Event Advisor and Technology Investment Radar, and ii) Knowledge Discovery Capability. This will help illustrate how broad this class of applications is in terms of end-user functionality and purpose as well as the complexity in data handling and representation.

5. Two ESIS Case studies

5.1. Enterprise Corporate Radars

A better-informed decision-maker is obviously better positioned to make good decisions. For example, a decision-maker running a business will make better decisions if he/she is more informed about what is going on in and around the business. Furthermore, information about what is happening outside the enterprise plays an important role in informing good decisions. Accessing this external data, should be where the Web is used to inform decision-makers. After all, the Web has dramatically increased the amount of information about the business environment that can be accessed on demand. The Web, for example, has information about the activities of players upstream in the extended supply chain and downstream in the distribution network. It also has information about what is going on with customers, competitors, regulators, complementary products, relevant technologies, and so forth. These information resources, however, come in disparate forms, are often unstructured, and are often inconsistent in their coverage. Addressing this problem requires systems that can automatically mine the Web to detect business-relevant events; to normalize the descriptions of these events (which will include both structured and unstructured source material) into a standardized representation that are independent of the original source (which includes the event types, participants, and so forth); and to map those standardized, normalized event descriptions to a model of the business dynamics in which the decision-maker’s organization operates to generate actionable insights. This mapping serves to resolve – or at least surface – inconsistencies and to make the business-relevant relationships between events explicit.

These systems – which we call enterprise corporate radars – can be built on the platform defined in [11] which consists of three components (see Figure 3) – models, reasoners, and web-sensors.

Models provide semantic representations of events and entities that are relevant to decision-makers and their organization (i.e. the business dynamics). These models, for example, can include representations of entities like the manufacturers, the products they make, their suppliers, their customers, etc., and can include representations of events like deployments, mergers and acquisitions, price changes, etc. Models are used by the reasoner to guide the detection of relevant events from the Web and to interpret their implications.

The reasoner generates actionable insights from detected external events by applying the implications associated with the corresponding event representations in the business dynamics models. The reasoner also determines the appropriate web sensors to invoke (and hence what events to detect from the Web) based on what events are encoded in the models.

Web-sensors detect relevant unstructured signals on the Web and produce from them structured event descriptions that are consumed by the reasoner to generate actionable insights. The implementation of the sensors depend on the corporate radar being built, but they all require some form of natural language processing as most information on the Web are in the form of unstructured text.

We have used this platform to build corporate radars like the Business Event Advisor [12,13] and the Technology Investment Radar [11] described below.

5.1.1. Business Event Advisor
Many corporate executives would like a more systematic way of monitoring the external environment in which their company operates. They seek a way to spot the external business/economic events that might constitute threats to – and opportunities for – their business. For example, there would be important business value for executives who could more consistently notice signs that a competitor might introduce a new product to directly compete with one of their products, or that a supplier was at risk of failing to deliver. Everything from a competitor’s online job-recruiting advertisements to announcements of deals made, contracts won, real estate purchased, changes in the price of raw materials, and so forth are examples of the types of information that – if systematically tracked and interpreted in terms of the business dynamics that govern the executive’s business – can be used to provide these early warning signals. This in turn can help executives respond quickly.

The Business Event Advisor is designed to address these needs by detecting, organizing, and interpreting a broad range of external business events in order to help business decision-makers spot external threats and opportunities affecting their business. The Business Event Advisor achieves this capability using a model of the business dynamics in which a business operates. The specific representations encoded depend on the company and industry that the model (and hence the system) is customized for. Obviously the richer the model, the better the system can perform, but even with a simple model the system can still provide valuable insight through targeted text processing and simple inferences. For example, a simple model encoding the products a company makes, its competitors, and their suppliers can enable the system to infer that a new-product introduction by a competitor's supplier may change the demand for products made by the company. It can infer this possibility even if it does not recognize the new product being reported – it just needs to recognize the supplier and the product introduction event.

The Business Event Advisor uses this model to continuously scan many relevant sources of news and information on the Web to generate an executive dashboard like the one detailed in Figure 4. This dashboard makes it possible to see systematically what is happening in the external business environment by reporting the types of events detected, the entities involved in these events, the estimated importance of each event, and whether an event was directly detected from a news source or predicted from one that was.

Once the system has produced the normalized event descriptions, it then uses those descriptions to populate a graphical interface which facilitates the access and retrieval of various facets of the user’s competitive situation. The system also allows the user to drill down on any event to see the raw signals from which the event was detected and the implications that could be inferred from it. The design thus provides lineage information relating implications back to explicitly-detected events. Figure 5 details this feature for a product introduction event that the system has detected. This event was detected from a story about Denso introducing new hybrid vehicle components and suggests to corporate executives the possible threats (e.g. competitors can change features to their products) and opportunities (e.g. the executive’s company can expand its product line) that might impact their company.

5.1.2. Technology Investment Radar

Decision-makers often recognize – early on – the potential for a technology to have an important impact on their business, but have difficulty determining when this potential will be realized. For example, many executives in the mobile phone industry recognize WiMax as a technology that may have a very significant impact on their industry, but they are less certain about whether (and when) that impact will be realized. Some technologies that look promising in the lab never make it to market.
Figure 5. A drilled down view of an event detected by the Business Event Advisor.

Some that go to market become niche products which never deliver on the impact they promised originally, and some that do deliver on their promise do so on a different time-line than one might have imagined when the technology first began to emerge. In order to manage their company effectively, executives need to continuously track technologies to determine when various levels of investment are worthwhile – e.g. when to invest in building up in-house expertise on the technology; when to start designing and offering products based on the technology; etc.

The Technology Investment Radar is designed to address these needs by helping decision-makers track the maturation of technologies that relate to their business and understand when these technologies are mature enough to justify investing in them. The Technology Investment Radar achieves this capability by using a model of the business dynamics surrounding the technology being tracked (like the Business Event Advisor) and a model of the technology maturation lifecycle. The lifecycle model consists of the following six stages that a technology can advance through as it matures: 1 Pre-market stage: Research is still being conducted on the technology. 2. Potential market stage: Companies are beginning to conduct trials and demos of the technology. 3. Emerging market stage: A company has sold or deployed the technology. 4. Growing market stage: Many companies have sold or deployed the technology. 5. Mature market stage: The market has solidified with a few major players remaining. 6. Declining market stage: Companies are beginning to leave the market.

Associated with each stage are a set of gates (i.e. metrics) that must be met in order for a technology to enter into that stage. These gates encode how the entities (e.g. manufacturers, suppliers, etc.) and events (e.g. sales, deployments, etc.) from the business dynamics model determine a technology’s placement in the maturation lifecycle. For example, some user’s company may require that there be at least five sales (or deployments) of the technology in order for that technology to be considered as being in the emerging stage. This is an example of a gate. Using a set of standardized stages and gates offers a normalized view of the unstructured and disparate information detected by the system.

Figure 6. The executive dashboard produced by the Technology Investment Radar.

Like the Business Event Advisor, the Technology Investment Radar uses its models to continuously scan a variety of sources – e.g. RSS feeds, blogs, public forums, standards sites, etc. – to produce a dashboard. Its dashboard is detailed in Figure 6 which shows where each technology, that is being tracked, has gotten to in the maturation lifecycle.

The system also allows the user to drill down into any stage to examine the gates for that stage, and how close the gates are to being satisfied. This design, similar to that of the Business Event Advisor, facilitates the access and retrieval of various facets of the information collected. Figure 7 shows the gates for the emerging market stage and which of these gates are satisfied for WiMax.
The user can further drill down on any gate to view the events that have been detected which support the gate.

The Technology Investment Radar was evaluated through a pilot with Accenture’s Wireless Community of Practice (CoP) – an organization within Accenture that focuses on wireless technology consulting. Nine analysts from the Wireless CoP used the Technology Investment Radar over a 6 week period to track the maturity of various wireless technologies like WiMax, WiFi, etc. At the end of this period, we conducted an exit survey designed to help us assess the utility of the tool from the end user’s perspective (e.g. will the analysts continue to use the system after the pilot, how satisfied are the analysts with the tool, and so forth).

The survey was completely anonymous. It was hosted on a third party survey hosting site where the identities of the respondents were not known to us. Hence, the respondents were not under any pressure to respond favorably.

The survey consisted of 25 questions, but given the limitation in space, we will not present responses from all these questions. Instead, we give an overview of highlights from the survey.

- When asked to indicate their overall satisfaction with the system – the possible answer choices are very satisfied, somewhat satisfied, neutral, somewhat dissatisfied, and very dissatisfied – 6 of the analysts said very satisfied, 2 said somewhat satisfied, and 1 said neutral. No analysts gave a somewhat dissatisfied or very dissatisfied response.

- When asked to indicate if they will continue to use the system after the pilot study – the possible answer choices are yes and no – 8 of the analysts said yes and 1 said no.

- When asked to indicate how using the Technology Investment Radar to track technology maturation compared to their current method – the possible answer choices are much better, somewhat better, about the same, somewhat worse, and much worse – 2 of the analysts said much better, 6 said somewhat better, and 1 said somewhat worse. No analysts gave a much worse or about the same response.

These responses show that the majority of the analysts found the Technology Investment Radar to be useful and will continue to use the system after the pilot, demonstrating the practical value of the tool.

5.2. Knowledge Discovery Capability

The Knowledge Discovery Capability (KDC) is a synthesis of a set of commercial off the shelf (COTS) applications and custom integration code that extracts, transforms, indexes, integrates and manages information and knowledge derived from a wide variety of sources; structured/unstructured, and internal/external to the organization. This content is organised around a knowledge model which incorporates the lexicons and ontologies of interest.

KDC organizes vast collections of data so that any given concept can be a focal point, while related data remains visible providing context to the focal concept. Multiple views (classifications) are supported in the end-user session depending on role, activity and privileges. The system displays large amounts of data and their interconnections simultaneously. KDC is able to surface inferred relationships by hopping across multiple sources facilitating knowledge workers in uncovering hidden relationships.

The knowledge model provides a framework to capture annotations and to share them within a team, or with the wider organization. Associations between researchers and concepts can be used to identify social networks and subject matter experts, so that knowledge workers can better leverage the organization’s tacit knowledge.

KDC uses workflow orchestration and routing. System maintenance uses workflow orchestration to sequence the events in the fetching, pre-processing and cleanup, and subsequent load of data into the knowledge model – which is effectively a set of ontologies and taxonomic classifiers. Routing is used to notify the right personnel when discrete events occur. For example, end-user alerting based on content changes, or communication of system
generated flags where data load yields conflicting assertions. Routing can take place via synchronous or asynchronous messaging, using existing enterprise communication mechanisms.

Maintenance is accomplished via a GUI client. A user with administrative privileges uses a GUI tool to modify the knowledge model or the business rules associated with filtering and end-user GUI display. In addition, end-users with sufficient permission can modify their local view of the knowledge model. Depending on business need, local changes can be propagated to the workgroup level for vetting and, if approved, subsequent publication to the group. Visualization of the ontology model is via an administrative GUI console. In this console, the administrator can view, edit, or delete ontology entries.

Since the KDC solution uses standard relational databases, we serialize RDF triples as notated in XML syntax to standard database table storage. There are special structural triples to describe the ontologies including system-information version numbers for administrative use kept in our system. Each ontology can have its own sequence of version numbers, effective dates, and termination dates – i.e. timeboxing each ontology.

Some visual examples will be useful to see its operation. We discuss a KDC pharmacology research data that culled from structured (citation) and unstructured (full article text) sources. As Figure 8 shows, named entities and their relationships are presented in the patented user interface.

On the left is a project explorer and below that, a Search Results window. The power of the patented interface rests in the user’s ability to double-click on an entity, focus that in the center pane, and quickly redraw the connections. Thus, previously unknown commonalities may be discovered during this activity. To load this demonstration, unstructured documents were parsed and named entities were placed into the appropriate category (HumanCase, reportSource, ContractedFrom, and so on). By right-clicking, Figure 8 shows a pop-up box. The user may elect to View Document Source – integrating to an enterprise document management system.

As mentioned in Section 3.5., certain business domains are good candidates for geospatial integration. A medical epidemiology demo such as this one qualifies. The ‘flow’ of cases can be visualized on the US/Mexico border; in this case using Microsoft Virtual Earth as shown in Figure 9. Similar work has been done implementing KDC instances with another geospatial vendor, Google Earth.

KDC also allows the user to contribute new named entities and classify them. By viewing document source, the user is able to highlight a phrase, select the link type, confidence level, related entity, and overall category and then submit the entry. In any contribution mechanism, the effort (opportunity cost) must be low enough that the user’s input has sufficient marginal utility [14].

KDC is not meant to bring the knowledge worker to a hard and fast decision point. Rather, the user can "surf" relationships, discovering previously unknown connections. This is especially valuable in large knowledge spaces. The system has discovered...
novel linkages in pilot tests in the intelligence community but to date no user surveys of the style in Section 5.1.2 have been performed.

6. Conclusion

We have illustrated the steps that go into the initial load and display of an enterprise knowledge model. We have also talked about essential, preferred, and optional features that might go into an ESIS depending on the problem at hand. As we have seen, the idea of collaboration is a powerful one that helps individual workers communicate as they inquire from and contribute to the knowledge base. In our discussion of the two case studies, Enterprise Radars and Knowledge Discovery Capability, we have an example of a Business Intelligence and a Knowledge Management approach that span a wide variety of high-level enterprise strategic needs. Strategically, the costs of the initial build and ongoing maintenance must be weighed against the value to the enterprise. Integration points to existing enterprise applications and low-cost COTS components undoubtedly add to the value. Increased business intelligence, especially the variety that is not gleanable with conventional database or data warehouse technology, is another good argument for an ESIS being a value differentiator.

7. References

### Appendix 1.

#### Table 1. A Sample of ESIS Required, Recommended and Optional Features

<table>
<thead>
<tr>
<th>ESIS Feature Grid</th>
<th>Required</th>
<th>Preferred</th>
<th>Optional</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normalized</td>
<td></td>
<td></td>
<td></td>
<td>Beyond the scope of a relational database system, the ESIS presents a wide spectrum of input data sources.</td>
</tr>
<tr>
<td>Presentation of</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heterogeneous Data Sources</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Access and Retrieval</td>
<td></td>
<td></td>
<td></td>
<td>Often a tricky requirement to fulfill, the ESIS must provide UI handles for the user to quickly and easily zoom around potentially vast stores of normalized information.</td>
</tr>
<tr>
<td>Mechanisms in the User Interface</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maintenance and administration</td>
<td></td>
<td></td>
<td></td>
<td>Usually provided by an administrative console, the ESIS can be configured as to: source(s) of input data, pre-processing (handling) of same, presentation of same in UI.</td>
</tr>
<tr>
<td>Pre-conditioning</td>
<td></td>
<td></td>
<td></td>
<td>Both textual and numeric data require normalization and cleanup before a knowledge model load.</td>
</tr>
<tr>
<td>Support for both structured and unstructured data</td>
<td></td>
<td></td>
<td></td>
<td>Organizations have unstructured documents and structured (database, spreadsheet) data to consider.</td>
</tr>
<tr>
<td>Conflict Detection and Resolution</td>
<td></td>
<td></td>
<td></td>
<td>When data is loaded into the knowledge model, conflicts should be flagged and referred to either an automated or a manual cleanup process. All conflict-related activities should be logged.</td>
</tr>
<tr>
<td>Workgroup Support: Collaboration and Alerts</td>
<td></td>
<td></td>
<td></td>
<td>Without this component, individual knowledge workers must communicate insights “offline” to their peers. Alerts let group members know when new contributions or syntheses of interest have been made.</td>
</tr>
<tr>
<td>Shoeboxing</td>
<td></td>
<td></td>
<td></td>
<td>The ability to save certain queries and/or certain data source subsets locally to assist in future work in the personal workspace.</td>
</tr>
<tr>
<td>Contribution</td>
<td></td>
<td></td>
<td></td>
<td>The user’s ability to contribute to the knowledge model in the UI (add/edit/delete connections; add/edit/delete data components or metadata properties).</td>
</tr>
<tr>
<td>GeoSpatial</td>
<td></td>
<td></td>
<td></td>
<td>Often desirable is an integration point from ESIS to enterprise components such as geo-spatial visualization, using e.g. MetaCarta tagged documents.</td>
</tr>
<tr>
<td>Timeline</td>
<td></td>
<td></td>
<td></td>
<td>To track events as they unfolded in a certain time window, usually accomplished by a slider control in the UI.</td>
</tr>
<tr>
<td>Workflow Component</td>
<td></td>
<td></td>
<td></td>
<td>Business Logic to establish waypoints, triggers, and alerts to accomplish subtasks en route to the accomplishment of the larger task.</td>
</tr>
<tr>
<td>Lineage</td>
<td></td>
<td></td>
<td></td>
<td>ESIS “explanation” for how a particular connection was established between data items – an explanatory rationale. The more like natural language, the better.</td>
</tr>
<tr>
<td>Uncertainty Modeling</td>
<td></td>
<td></td>
<td></td>
<td>The ability to represent and/or toggle confidence levels when viewing connections.</td>
</tr>
<tr>
<td>Contribution Merge and Deconfliction</td>
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<td></td>
<td></td>
<td>Ability of system to process and merge multiple sources of contribution and refer conflicts for manual or automated resolution.</td>
</tr>
<tr>
<td>Vetting</td>
<td></td>
<td></td>
<td></td>
<td>An administrative role to accept/edit/deny user’s contribution to the knowledge model (usually coupled with a workflow component that alerted the vetter that a contribution had been made).</td>
</tr>
</tbody>
</table>