Net-Centric Information Framework

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Abstract

The Net-Centric Information Framework (NCIF) is a Specialized Framework (SF) from the Network Centric Operations Industry Consortium (NCOIC®) that defines the concepts and principles governing the use of information in a net-centric environment. In addition, the NCIF provides guidance for net-centric information-based patterns. This allows these patterns to be consistent with constructs as defined by the overarching NCOIC Interoperability Framework (NIF®).

Because of the broad applicably and complexity of information as a whole, NCIF is a starting point for development of additional domain, mission, and system-specific information specifications that may be developed as part of any large-scale information systems development activity. The domain-specific examples provided in this document demonstrate the use of this specific framework in the generic advancement of thinking about information systems and development of program-specific documentation, not as a definitive framework for the example domains highlighted.

Version History

Version Number	Description	Author
V0.1-2010-04-20	First Draft	Kevin Newman
V0.2-2010-11-01	Second Draft, incorporating comments from LTA, TS, JS	Al Jones
V0.3.00-2011-03-29	Third Draft	Al Jones/Zia Khan
V03.12-2011-05-31	IPT Review Draft	Al Jones, Leslie Anderson, Rex Brooks
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V04.05-2011-09-02	Formal Review Draft	Al Jones
V1.0-2011-11-30	Incorporated all changes	A.S. Jones, et al

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1 Introduction

The Net-Centric Information Framework (NCIF) is a Network Centric Operations Industry Consortium (NCOIC®) Specialized Framework (SF) as shown in Figure 1-1. It defines concepts and principles governing the use of information in a net-centric environment. The NCIF provides guidance for net-centric information-based pattern developers to conform to constructs defined and used by the NCOIC Interoperability Framework (NIF®).[1]

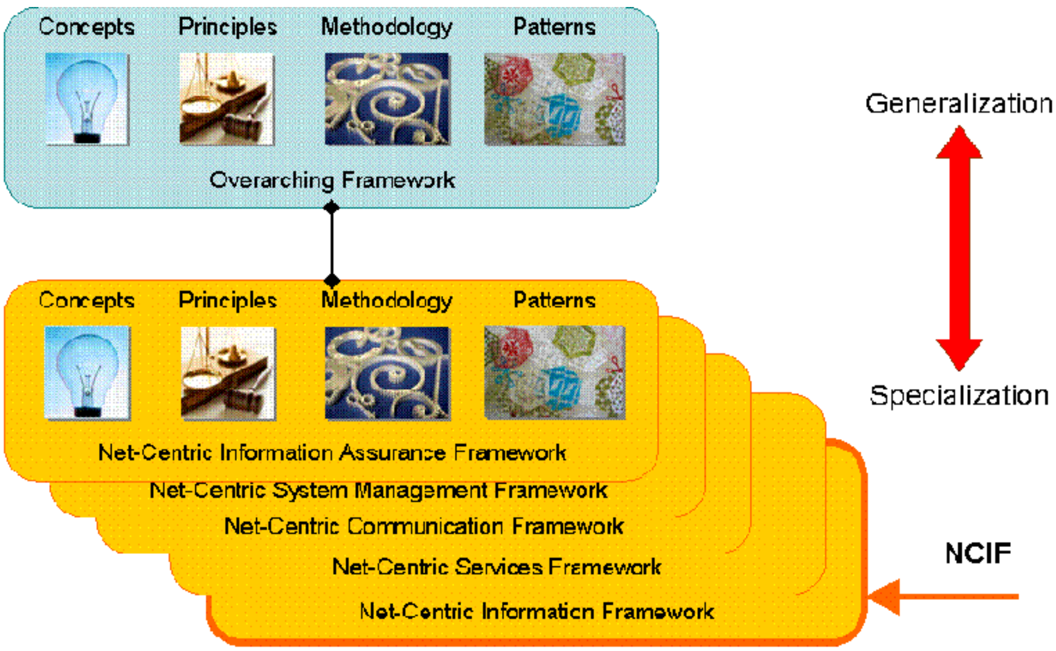

Figure 1-1. Framework Hierarchy – NCIF Emphasis (Source: NCOIC Interoperability Framework)

To foster understanding of net-centric information, the NCIF takes a view markedly different from a mathematical formulation of information. Formalisms such as Shannon's[2] deal with aspects of information in a different way for successful information systems development. For the net-centric environment, semantics of the information and its context(s) is critical for the effective use of information. For the NCIF, the semantic content of information (the explicit representation of meaning) is represented in the color gradient shown in Figure 1-2 and described in sections that follow.

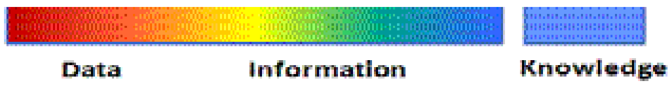

Figure 1-2. Semantic Relevancy Gradient (Source: NCOIC)

[1] NCOIC-NIFv2.1NSD-RM-20091125
[2] *The Mathematical Theory of Communication* (1949, Urbana: University of Illinois Press).

To treat the primary concepts and substance of information, when moving to the right on this gradient, mechanisms must be used that do not remove, but enhance, vital contextual information. Any information system can make use of this framework by defining the model it encompasses and the queries it supports. These queries lead to exposition of the contents of the model in such a way to provide views or viewpoints of the model showing aspects that enhance meaning. The assessment of information level on this gradient may vary with time as information modeling evolves over the system life cycle. The assessment also depends on the capabilities of the user.

The NCIF follows the NIF framework outline: Section 2 presents concepts; Section 3 contains principles; Section 4 describes patterns consistent with these principles; Section 5 discusses process and models for an information architect to develop Information Systems and in particular to apply the principles contained in Section 3 to information patterns.

1.1 Scope

The scope of this framework covers information characteristics, structure, and capabilities of an information communication system. Information from both web services and non-web service-based systems is included. The scope of this document focuses on Internet Protocol (IP)-based information communication systems with emphasis on service orientation, but interface to non-IP systems is mentioned. Although the scope includes machine-to-machine (M2M) and human-to-machine (H2M) interfaces, emphasis in this document is on M2M, particularly at the break in the gradient between information and knowledge as shown in Figure 1-2.

1.2 Relationship to Other Frameworks

The NIF Framework of Frameworks (FoF) defines structure of network centric frameworks and relationships between them. This structure is shown in Figure 1-3.

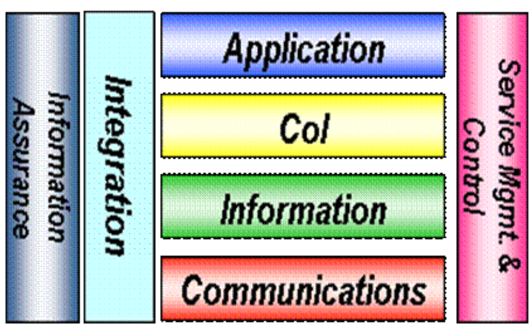

Figure 1-3. NCOIC Capability Model
(Source: NCOIC Interoperability Framework)

Information assurance/information, systems management, and service integration are closely related to information topics, but these are contained in the other frameworks shown in Figure 1-3 in the manner shown and are not addressed herein.

1.3 Users

Users of this framework include system architects, information system designers, and information system procurers.

1.4 Expected Benefits

Expected benefits of this framework include the following:

- Assists users to assess completeness of a net-centric information system specification.
- Outlines a process to convert information to knowledge suitable for decision making.
- Facilitates training for information and service architects.
- Provides an example of a model for implementation of a net-centric information system.
- Provides guidance to net-centric pattern developers.

2 Concepts

Concepts capture explicitly the necessary knowledge about the framework. Concepts are described using definitions, attributes, sructures, relations, and constraints.[3,4]

2.1 Core Concept (Definition)

Before describing net-centric information concepts that are described by attributes, structures, relations, and constraints, definitions of information and related terms as used in this document are contained in the following sections. A development effort using this document should tailor these definitions to provide stakeholders a common basis for understanding scope and intent of their information system. This is because at the far right extent of the information gradient shown in Figure 1-2, the definition of terms is domain dependent. Also, tailoring these definitions should be viewed from an aspect of interoperability with current and future systems. Tailoring is intended to allow these definitions to be useful in a particular context.

2.1.1 Context

Context describes the interrelated conditions in which something exists or occurs. A context is itself simultaneously both a collection of information and a piece of information. Context constrains the interpretation of terms. In a net-centric environment or even a technology-mediated interaction there may not be sufficient contextual information to interpret information in a way consistent with the meaning or interpretation of the sender or their intent.

2.1.2 Semantics

Semantics is the study of meaning. It typically focuses on the relation between signifiers, such as words, phrases, signs and symbols, and what they stand for, their denotata.[5] Semantics contrasts with syntax, the study of the combinatorics of units of a language (without reference to their meaning), and pragmatics, the study of the relationships between the symbols of a language, their meaning, and the users of the language.

In more colloquial usage, and as used in this framework, semantics refers to the interpretation or meaning of terms, words, and their arrangements (that conform to common usage). Interpretations of the same term are context dependent. For instance, the term “tank” would be interpreted differently in a military context than in an aquarium context. Even in a military context, there is not a unique interpretation of this term. For an Army, tank may be a vehicle. For an Air Force, it may be an object that contains fuel. So context is a crucial component of interpretation. Hence, context contains semantics of any overall interaction where information is communicated.

In a net-centric environment, where much H2H interaction is mediated by technology, the lack of sufficient context can severely impede correct interpretation or lead to outright errors of interpretation. For M2M interactions, the lack of explicit context or semantics in a machine

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[3] Excerpted from NIF version 2.
[4] The reader should be reminded that the scope of this document is constrained to net-centric information systems.
[5] Actual object (s) referred to by a linguistic expression (from Memidex).

usable representation constrains the possibilities of interactions, specifically dynamic interactions For example, “tablet” in the context of medicine differs from “tablet” in the context of a hand-held device.

Semantic metadata provides information on how to interpret data or information in a way consistent with the provider's intent. Such semantic metadata may include ontologies or contextual information, e.g., who, what, where, and when.[6] In some circumstances, semantic metadata may also constitute provenance metadata.

2.1.3 Net-Centric

A comparison between several definitions of net-centric, or net-centricity, is contained in the appendix. Each definition may be used in appropriate domains. Within the NCIF, net-centric is defined as “a system perspective that views system components as extensible, interoperable network nodes.” Nodes in net-centric systems act as information publishers and consumers; as publishers, net-centric nodes are responsible for providing relevant, explicit, authenticated, trusted, and verified information to consumers in a timely and seamless fashion, and as consumers, net-centric nodes are responsible for discovering, determining relevance, and adding value. Enabled by current and emergent networks and network technologies, net-centricity describes the approach to designing new systems that interoperate with existing networks, and the benefits of interoperating with existing applications and services.

2.1.4 Data

Data is a “representation of facts, concepts, or instructions in a formal manner suitable for communication, interpretation, or processing by humans or automatic means. This representation is for characters or analog quantities to which meaning is or may be assigned.”[7] Data also may be thought of as individual facts with little or no meaning if taken out of context. The purpose of a process that collects, stores, and retrieves data is to translate it into meaningful information.

Data representation over the semantic gradient begins with binary character representations, numerical representations, then proceeds to more complex representations such as alphanumeric characters, then to extended character sets, then further to other language representations such as Chinese characters. Various other representations including vectors, matrices, metadata further described in this document, and graphics may be added in any order.[8]

2.1.5 Information

The term “information” is used in two contexts in this document. First, in the document title, information is used at a level of the domain description, “information tchnology”, i.e., information is used at the same level as communications or security. In the second context, Figure 1-1 depicts the primary constituents addressed by this information framework document, data, information, and knowledge, as segments on that gradient. The context in which Information is used is generally stated, but one must be careful when reading this document to ascertain the context in which Information is used.

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[6] DoD 8320.02 Guidance for Implementing Net-Centric Data Sharing, April 2006.
[7] Joint Publication 1-02 of 12 April 2001 as amended through 09 Nov 2006.
[8] The NCOIC Lexicon is in the process of adopting a high level definition.

In the latter context, information is data combined with semantics. The semantics may include a relation to a larger environment in which the data can be used. The context in which the data is applied is enlarged to include an application context. For instance, a thermometer may indicate a current temperature, and this value may be called a piece of data or data point. But when this data point is used to determine when to turn on a heating system, it is the point at which it is used as information.

This section contains pointers to semantics that relate data and information:

1. Any communication or representation of knowledge such as facts, data, or opinion in any medium or form, including textual, numerical, graphic, cartographic, narrative, or audiovisual forms.[9]
2. Facts, data, or instructions in any medium or form.
3. The meaning that a human assigns to data by means of the known conventions used in their representation.[10]

Information is a set of data in context that has meaning or relevance to an "actor." That actor may be a human or machine that supports business processes and business objectives. Knowledge is a collection of information that is effective in supporting decisions including executing operational processes, making strategic decisions, or collaborating for innovation and growth. Information is transient and depends on context and the consumer's interpretation. It may be communicative, with meaning given from the provider.

2.1.6 Knowledge

Semantics has to address a wide range of layers of information, like the skin of an onion, that represent a gradient of meaning as it moves from unstructured to unambiguous. Different points on this gradient define the coherence of the information, and loosely define a transition from data to information.

In this view knowledge is also placed on this gradient. However, there may be a significant transition between information and knowledge. There are three primary conditions that must all be satisfied concurrently to say that information has been upgraded to knowledge:

1. Knowledge is a form of information transmitted from a provider to a consumer with sufficient semantic content for understanding.
2. Sufficient semantic content means allows the consumer to understand and take ownership of the knowledge in the sense that the consumer is then a "knower" of the knowledge.
3. The knowledge is actionable by the knower.[11]

This definition of knowledge and the definition of Information as measurable against some model and query set will be used to show in the following sections describing patterns and processes, an approach to the measurement of the amount of net-centricity of information for projects, domains, and programs. There can be a discontinuity between information and knowledge when the information is transmitted to different consumers. A set of information may

[9] DoD Directive 8000.1
[10] DoD Dictionary http://www.dtic.mil/doctrine/jel/doddict/
[11] Information Sharing Value Chain DoD Information Sharing Strategy May 2007.

have semantic content and meaning unique to the provider. When this information is sent to a consumer who has a different context and capability, it may have more, less, or the same meaning to that consumer. In general, providing additional semantics constrains a consumer's possible interpretations and thereby increases the likelihood of understanding the provider's information. The process of converting data into information increases the meaning of that original data. Once information has been provided to a consumer, the consumer can continue to add semantics to that information so that meaning increases. However, if a consumer is limited by environment, adding semantics to the information may not be possible. For example, with a M2M transmission, if the provider has significantly more processing or communications capability, there may be a discontinuity in meaning.

Other examples are the following:

1. In a disaster situation where neighboring countries have an outstanding capability to handle the aftermath of an earthquake or tsunami, but have this capability documented in a different language, transmission of instructions to the victim country may have no value.
2. In the same situation where the language is the same but experience and understanding differs, instructions may be met with disbelief or questions of why?
3. In a machine to machine situation where the provider gives a consumer information, and that consumer has a much lower capability for processing, storage, display or transmission bandwidth, the capability or "knowledge" gained may be less useful.[12]

2.2 The Semantic Gradient (Structure)

To foster an understanding of this information framework, the NCIF takes a view different from that of a mathematical formulation of information (for example Shannon and Information Theory). While formalism can deal objectively with information,[13] context is critical for successful information systems development and is most useful in natural language. The semantic content of information (the explicit representation of meaning) forms a gradient and is a key metric in the evaluation of the relevance, hence value, of information, shown in Figure 2-1.

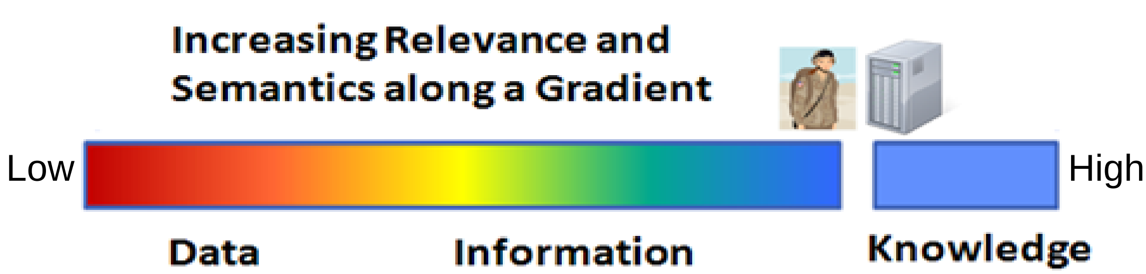

Figure 2-1. Enhanced Semantic Relevancy Gradient (Source: NCOIC)

[12] In this instance, it is sometimes referred to as "operational knowledge."
[13] Introduction to Logic and to the Methodology of Deductive Sciences, A. Tarski, Oxford University Press 1946.

Mathematical formalism and representation can abstract away context from information. In so doing operational useful aspects are lost and “information” becomes merely symbolic. To treat the primary concepts and substance of information, mechanisms must be used that do not remove vital contextual information. Any information system can make use of this framework by defining the model it encompasses and the queries it supports. One would expect this to evolve of the life cycle of the system and so expect an assessment of an information level to be a point in time calculation.

The Semantic Relevancy Gradient is a key for a set of patterns that are described in the NIF. The NCOIC Patterns are architecture fragments. These fragments may be instantiated into reusable building blocks, most often service oriented architecture (SOA) services, as defined in the Net-Centric Services Framework (NCSF). The patterns related to this NCIF will describe details of the architecture along the semantic gradient.

For example, at the low end of the gradient, it may be important to understand data representations that can maximize the utility to the user across many domains. At the high end, a knowledge-related pattern, which is by necessity domain dependent, can take advantage of the modeling presented in Section 5. That pattern can take advantage of this framework for M2M systems in particular, as this document does not delve into relationship between human-to-machine interfaces, a body of knowledge unto itself.

Within this document, it is important to emphasize the precepts of the NCOIC, namely interoperability and net-centricity. For knowledge, meaning results from applying a semantic process to information using a second, independent set of information representing results of previous learning processes. To achieve interoperability means that the semantic information sent to another user will provide the same or similar result to/from the semantic process assuming that the second user has the same prior learning process. Net-centricity has similar difficulties; the problems of “anywhere, any time” are soluble, but the differences in the environment, namely the previous learning process environment, may form a different result.

There are no discrete levels within information. There is a gradient of meaning as information moves from unstructured to unambiguous. Also, orientation of the information consumer is not universal; it is affected by the situation (see concept of information relativity) and one's experience. For example, the interpretation of a pet owner to a dog bark is quite different than a mailman trying to deliver mail. To the pet owner, the information ("bark") might mean "someone is at the door." To the mailman, the same information might mean "be careful - possible threat." It is important to have a model that captures this information consumer domain orientation.

Having such a model implies having a domain. Since one can only claim to have orientation in respect to something, the model must be domain driven. In simpler terms, as one works with something repetitively, one gains a better understanding of that thing.

2.3 Sharing (Relationship)

One of the keys of net-centricity is sharing of information across multiple domains. Semantics provides the tools that assist with the sharing of information.[14] One way this may be accomplished is through use of a message format built on a taxonomical structure comprising

[14] http://en.wikipedia.org/wiki/Information_sharing

four groups of terms under the headings of who, what, when and where.[15] A Universal Core Semantic Layer that provides an ontology for information sharing is known as UCore-SL[16], a set of terms that may facilitate the sharing of information. UCore-SL evolved from the original UCore[17] pareto. The use of such a set can encourage formation of a distributed set of consumers and providers who can collectively add value in a net-centric social networking pattern.

As an example of how this might work, consider the following notional scenario:

> Jane is a user who carries a smart phone with a camera. She is currently walking around Paris and occasionally snaps a picture. As Jane walks she gets the idea that just like the yellow pages, she could offer a service to anyone who wanted pictures of Paris that happen to be on her route. By following the guidance contained in this framework, the NCIF, and tools such as UCore, she is able to easily share information with the rest of the systems users. Jane creates a service on the network that contains information on her geo tagged route, time of day, and the quality of her camera. Not only does Jane offer information needed to find pictures she has already taken, she also offers information about the capability of taking more or different pictures.
>
> Jack, another user on this system, is looking to find pictures of the Eiffel tower's ticket window. Systems and services on behalf of these two users can make the connection between the need and the capability. Jane gets an automated message as she approaches the tower that a picture is requested of the ticket window. If she is agreeable, the image is taken (with a tag or two from Jane or her camera). Jack seeing the result takes a moment to add a few tags of his own regarding why he wanted it, and to give a vote up on the services that enabled this picture. If Jane did not take it, perhaps another service from someone else satisfied his request, or failing that, perhaps he provides information to the network about the missed opportunity.

This example shows how consumers and providers can share information based on their needs and capabilities via a system enabled by net-centric information framework concepts.

2.4 Relativity (Attribute)

This information framework explicitly recognizes that information is relative. Since it must be relative to something, one can only determine the relevance of information after creating a model by which to gauge its value to the system.

- The information environment is the model, queries users ask of this model, and the user's context for asking those queries.
- The model represents a collection of data, information, knowledge and semantics that comprise the information environment
- The information environment evolves over time with both its use and its users (human and machine) understanding of its use.

[15] Universal Core Semantic Layer, Barry Smith, Lowell Vizenor, and James Schoening, National Center for Ontological Research, University of Buffalo.
[16] http://semanticommunity.info/Universal_Core_Semantic_Layer
[17] http://cio-nii.defense.gov/initiatives/ucore.shtml

2.5 Pragmatism (Constraint)

Pragmatism is necessary because technology does not currently exist to support the full implication of the Open World principle[18] (e.g., self-adaptive or evolutionary behaviors that advocate considering all possible alternatives when beginning an effort) or the technology exists, but does not provide sufficient cost/benefit to be implemented in a particular context. However, too often at the outset of system development unnecessary constraints or assumptions (often implicit) are used. Another way of expressing this is *do not constrain the scope of your requirements unnecessarily before the design phase when requirements have been fully analyzed.*

> "Pragmatism constrains net-centric development because of the natural inertia in human institutions and conceptual paradigms. Experience of the author and certain colleagues is that the ultimate outcome in a development is very different if one starts from a narrow, internally focused perspective and then try to expand out/adapt to accommodate the evolving net-centric versus starting from a global, net-centric ecosystem perspective and then deciding how best to structure one's own little corner of the world to best leverage and accommodate the global user.
>
> Although the end result is ultimately constrained by pragmatism and a solid business case, the aperture of what is considered in arriving at that business case is so much wider – and the solutions are more innovative and operationally useful, not just for the immediate need at hand. There are times when a narrowly focused approach is best, but more often, this approach leads to significant rework, if not outright "creative destruction" later on. Having people think of requirements dynamically (i.e., how are they likely to change in the future), rather than as static entities can have major impacts on the chosen design/architecture."[19]

2.6 Net-Centric Information Framework Ontology (Definition/Relationship)

Can one build an information framework without a specified ontology? Certainly! Any such framework will have an implicit ontology. An explicit ontology is contained here because it is useful in information system development.[20]

2.6.1 A Domain Ontology

A domain ontology (or domain-specific ontology) models a specific domain, or part of the world. It represents the particular concepts, relations and their interpretations as they apply to that domain. For example the word "card" can have many different meanings in different domains. For instance, an ontology about the domain of poker would model "card" as a "playing card" – an element of a game. While an ontology about the domain of computer hardware would model "card" as a "punched card," "expansion card," or "video card" (in fact such an ontology would only add the term "card" as a synonym and should also indicate that it is a colloquialism). For the NCIF, the domain is net-centric information systems. An ontology for this domain (there

[18] Net-Centric Principles, to be published by NCOIC.
[19] Ibid
[20] Jerome Sonnenberg, Harris Corporation, 2011.

may be more than one) can be thought of as a blueprint for understanding of the NCIF within the context of NIF.

There are many definitions for ontology. The NCIF takes a middle-of-the-road approach. For NCOIC's purposes, what "exists" is that which can be represented. When the knowledge of a domain is represented in a declarative formalism, the set of objects that can be represented is called the universe of discourse. *This set of objects, and the describable relationships among them, are reflected in the representational vocabulary with which a knowledge-based program, such as Cyc, represents knowledge.* Thus, the ontology of a program can be described by defining a set of representational terms. In such an ontology, definitions associate the names of entities in the universe of discourse (e.g., classes, relations, functions, or other objects) with human-readable text describing what the names mean, and formal axioms that constrain the interpretation and well-formed use of these terms.[21] For NCIF's purposes, this represents the strictest viewpoint taken, but it is not the only one. This constrains the extent to which NCIF holds this direction of the spectrum between expressivity and computability.

2.6.2 Semantic Spectrum

For NCIF's purposes, the foregoing description represents a very strict point in a possible spectrum. This is the furthest extent the NCIF takes in this direction between expressivity and computability. The NCIF intent is to be minimally expressive to only what is needed to allow the net-centric use of information to be inferenceable. This is the extent to which it can be pragmatically used to answer the kinds of queries about information contained in information systems that NCOIC members and their clients require.

Figure 2-2 charts the Semantic Spectrum between the ontology's expressivity or explicitness and the tightness of the coupling or computability of the ontology.

[21] Toward Principles for the Design of Ontologies Used for Knowledge Sharing Revision: August 23, 1993, Thomas R. Gruber Stanford Knowledge Systems Laboratory.

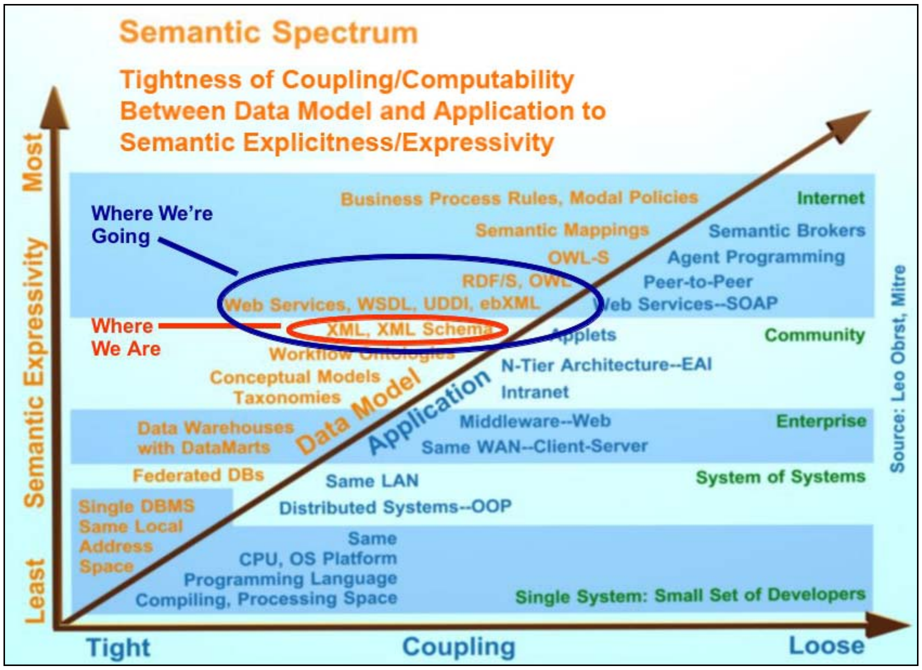

Figure 2-2. Semantic Spectrum (Source: Leo Obrst, MITRE[22])

A foundation ontology or upper ontology is a model of concepts common across a range of domain ontologies. It employs a core set of concepts, relations among the concepts and descriptions in natural language. Foundation ontologies available for use include Basic Formal Ontology,[23] OpenCyc/ResearchCyc,[24] DOLCE,[25] Command and Control (C2) Core Ontolgy,[26]and SUMO.[27] Foundation ontologies are not used in operational systems. They provide a basis for developing interoperable and logically consistent domain ontologies at design time. WordNet,[28] while considered an upper ontology by some, is not strictly an ontology. However, it has been employed as a linguistic tool for learning domain ontologies.[29] C2 Core Ontology, which is intended to be a mid-level ontology representing the meaning of the C2 Core vocabulary (on par with UCore), and so C2 Core Ontology is like UCore-SL. The NCOIC may adopt a suitable foundation ontology in the future for laying a basis for Working Groups and Integrated Product Teams to define or develop domain ontologies for their areas of interest. Such areas of interest can be technology domains or customer domains.

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[22] Obrst, Leo, 2006. The Ontology Spectrum and the Range of Semantic Models. Two-part presentation given to Ontology community on January 12 and 19, 2006. (http://ontolog.cim3.net.file/resource/presentation/Leo Obrst_20060112/OntologySpectrumSemanticModels-LeoObrst_20060112.ppt. See Slide 5.
[23] http://www.ifomis.org/bfo/
[24] http://www.cyc.com/
[25] http://www.loa-cnr.it/DOLCE.html
[26] http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA503082.
[27] http://www.ontologyportal.org/
[28] From Wikipedia: **WordNet** is a lexical database for the English language. It groups English words into sets of synonyms called *synsets*, provides short, general definitions, and records the various semantic relations between these synonym sets.
[29] Wikipedia

2.6.3 Ontology Languages and Tools

To properly manage a net-centric environment, the information model needs to be extended with an ontology-based abstraction that provides the explicit semantic representation of concepts and their relationships within that net-centric environment. The Web Ontology Language (OWL) is used to do this. The most appropriate representation language would be Common Logic. Nonetheless, OWL is the starting point for this description.

Because OWL can capture a computable description of net-centric environments, it is similar to programming languages that capture content and structure in a standard form that can then be used by other programs such as policy-based management applications. OWL allows inferencing engines to process the content of information instead of just presenting information to humans (e.g., policies). OWL can facilitate greater machine interpretability of resource attributes than that supported by extensible markup language (XML) or resource description framework (RDF) alone, by providing additional relations along with a formal semantics. It should be noted that OWL is written in XML.

There are a number of tools that can be used to develop ontologies. For example, the Protégé-OWL editor is a freely available[30] tool that supports the OWL. OWL is a standard ontology language developed by the World Wide Web Consortium (W3C) to promote the Semantic Web vision. An OWL ontology may include descriptions of classes, properties and their instances. Given such an ontology, the OWL formal semantics allow logical inferences to be made. Conditions that are not literally present in the ontology, but are inferred by the semantics, result in logic that can be used to automate system management, e.g., policy based management.

Ontologies require a set of instances, i.e., a knowledge base. OWL uses RDF to represent individuals, in triple stores, and OWL 2 has a new construct called “Nameindividual”. Ontologies can also use relational databases, and so in some cases, a row in an RDB can represent an instance.[31] Another benefit is wider understanding of information that clear semantics bring. In addition, as SPARQL, an OWL-based query language (which resembles SQL) can be configured to scan over existing relational databases as well as RDF TripleStores[32] to find more complete answers to complex queries that cannot be done in SQL except as a series of multiple query operations (if the appropriate tables exist). This can, in some cases, represent a significant increase in performance, and depending on the applications and systems in which it is adapted to operate, it can also provide improved productivity. As with all such implementation decisions, there may be tradeoffs between performance, cost, time to implement, etc, to consider.

[30] Protégé was developed by Stanford Center for Biomedical Informatics Research http://protege.stanford.edu
[31] Per Leo Obrst, October 2011.
[32] From Wickipedia: A triplestore is a purpose-built database for the storage and retrieval of Resource Description Framework (RDF) metadata.

2.6.4 NCIF Ontology

Figure 2-3 contains NCOIC terms and their relationships in SysML. Note that this chart is similar to NCSF's Figure 2. Table 2-1 describes these terms and their relationships in a tabular format. The terms contained in Table 2-1 are defined in the appendix.

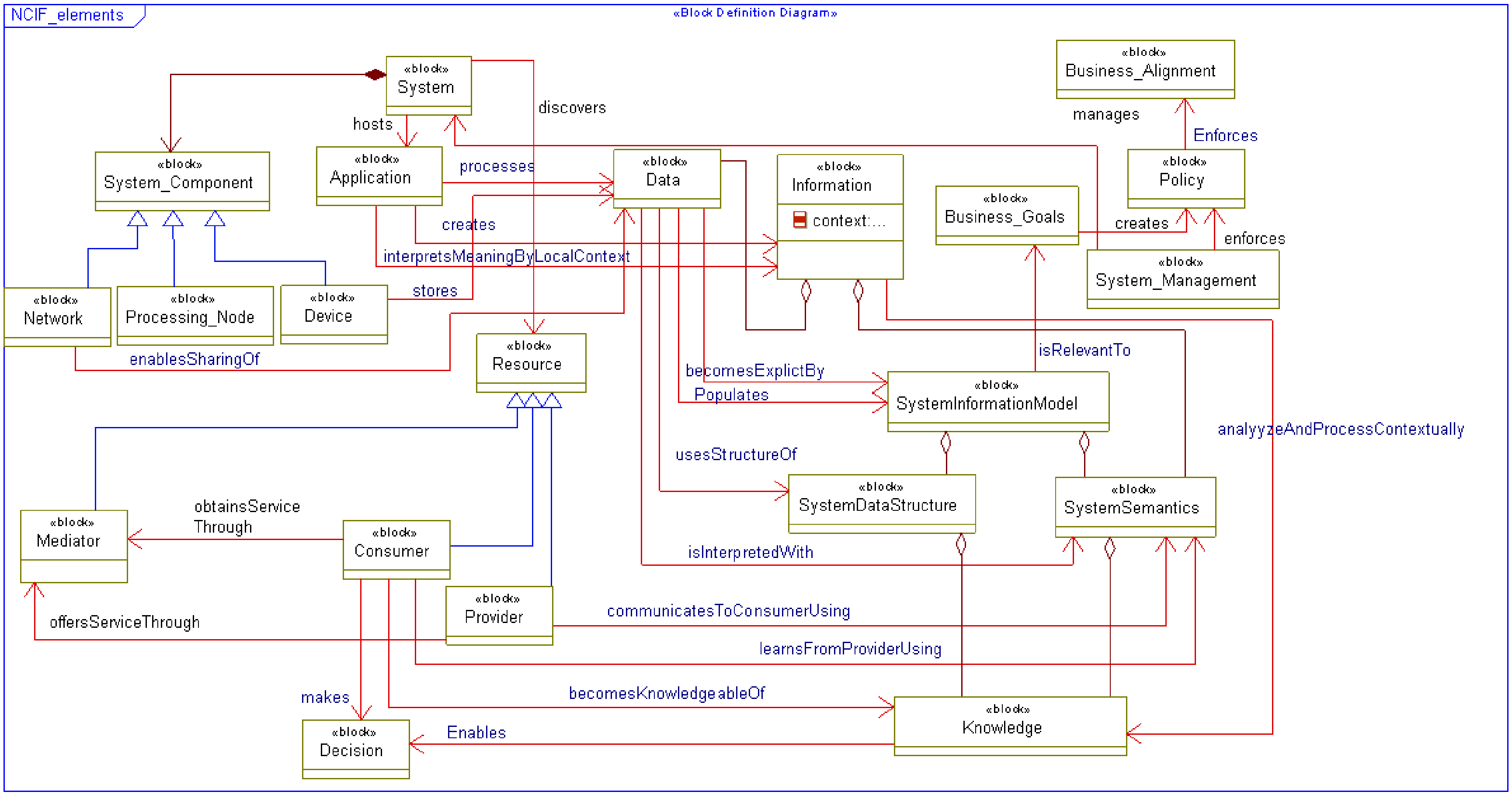


Figure 2-3. NCIF Terms and Relationship Between Terms (Source: NCOIC)

Table 2-1. Relationships Between Terms

Term Relationships (NCIF Term)	System	System Component	Application	Network	Processing Node	Device	Data	Information	Information Context	Business Goals	Business Alignment	Policy	System Management	Resource	System Information Model	System Data Structure	System Semantics	Mediator	Consumer	Provider	Decision	Knowledge	Context
System		2	1										5	3									
System Component	6			7	7	7																	
Application	9						12		5														
Network		8					13																
Processing Node		8																					
Device		8					39																
Data			15	14		16		20							19	18	17						
Information							38										38						
Information Context			26																				
Business Goals												10			22								
Business Alignment												10											
Policy										23	23		10										
System Management	4											23											
Resource	30																						
System Information Model							35			21						38	38						
System Data Structure							36								20								
System Semantics							42	20							20				43	44			
Mediator																			33	32			
Consumer																	41	34			24		
Provider																	40	31					
Decision																			29			28	
Knowledge																					25		27
Context																						26	

1	Hosts		23	enforces
2	isMadeUpOf		24	makes
3	discovers		25	enables
4	manages		26	affects
5	isControlledBy		27	isAffectedBy
6	isChildOf		28	isEnabledBy
7	isContainedIn		29	isMadeBy
8	isTypeOf		30	isDisoveredBy
9	isHostedBy		31	offersServiceThrough
10	creates		32	isServicedBy
11	interpretsMeaningByLocalContext		33	offersServiceTo
12	processes		34	receivesServiceThrough
13	enablesSharingOf		35	isPopulatedBy, showsIn
14	isSharedOn		36	providesStructureFor
15	isProcessedBy		37	providesMeaningFor
16	isStoredBy		38	contains
17	isInterpretedWith		39	stores
18	usesStructureOf		40	communicatesToConsumerUsing
19	populates, becomesExplicitBy		41	learnsFromProviderUsing
20	isPartOf		42	interprets
21	isRelevantTo		43	providesInterpretationTo
22	determine		44	areCommunicatedToConsumerBy

2.6.5 Initial Radio Ontology – Example

A primary reason to create a domain ontology is to capture operational knowledge. It is key, however to separate domain knowledge from operational knowledge, and couch both in terms that allow the system to respond to a command intent. Figure 2-4 is an example of an ontology that creates a representation of radio parameters that affect the capabilities of the network. This enables automation of rule development and the translation of high level policy statements into actionable parameter settings for specific business/mission scenarios.

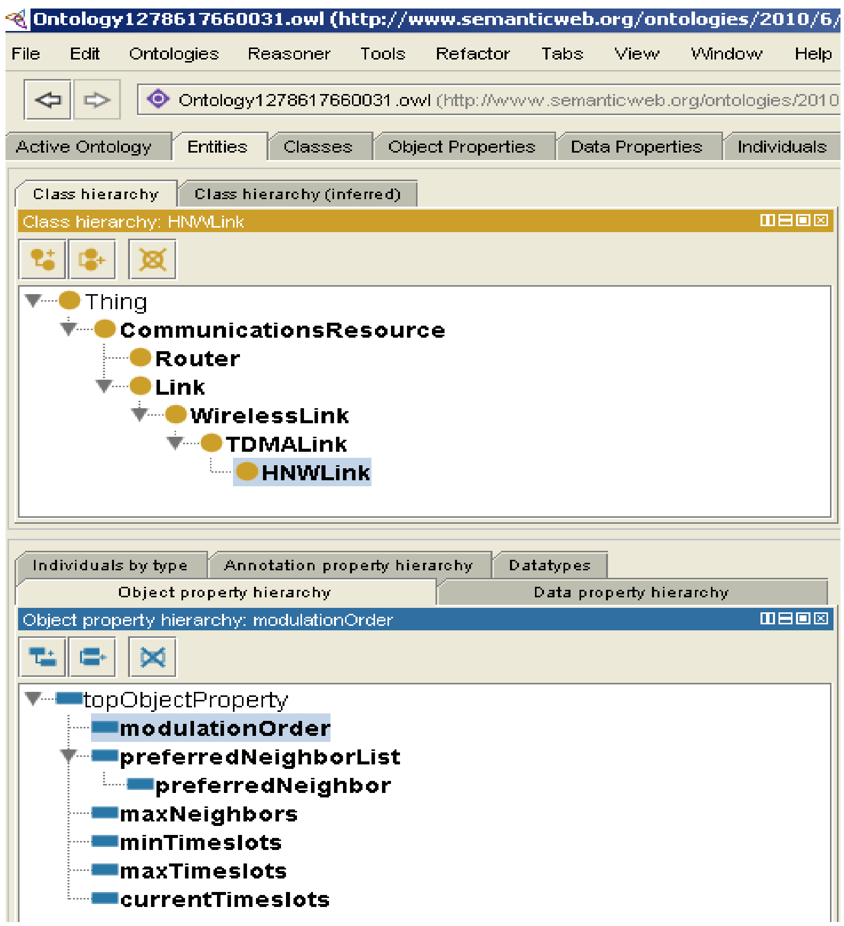


Figure 2-4. Initial Radio Ontology

Ontology development is by nature an iterative process, thus it is easy to plan for expansion. For example, a simple router representation can be defined in an ontology and later expanded to capture its more complex features. The radio ontology is expanded in the NCOIC DIL Communication management technical Pattern.

The NCIF ontology described in the preceding section is being considered to be produced as a separate .owl document. The basis of this ontology is the NIF principles further described in the following sections. These, in turn are combined with the NCSF principles to define a coherent domain ontology that may be extended over time.

3 Principles

Net-Centric Information Principles are overall requirements, goals, tenets, or best practices that should be applied to foster net-centricity. Net-Centric Information Principles serve to guide development of information specifications, information patterns, and information architectures that are net-centric and conform to NIF architectural principles.[33]

The intent of this NCIF section is to provide goals and tenets for net-centric information systems development. It describes data, information, and knowledge. These data, information, and knowledge principles are related. It is an unresolved question whether one accepts that data, Information, and knowledge are part of a sequential order, as products of one another, or as overlapping synonyms. Beyond the interrelation between data, information, and knowledge there are valuable attributes contained in the definition of each. By not addressing these unresolved fundamental philosophical questions, data, information and knowledge can be understood in this document through their relationships with each other. The principles of this document rest on the meaning of data, information, and knowledge, based on net-centric domains, definitions and relationships between each other as mentioned in the concepts section.

To form a foundation for definition of Net-Centric Information Principles as well as the principles contained in other NCOIC SFs such as the NCSF, NCOIC has developed two sets of higher level principles from which a subset of Net-Centric Information Principles may be derived. These sets include the net-centric principles and principles contained in the NIF. These are described in detail in Appendix A.4.

This section narrows the principles' characteristics that directly relate to making information net-centric. The primary outcome of applying these principles is optimized, relevant information targeted at the consumer's contextual needs.

3.1 Relevance

Description	Relevance is one of the key Net-Centric Information Principles. Given its most general definition/interpretation, relevance could be expanded to include all of the other net-centric principles. If the information is not useful for the intended consumer, it only hampers the recipient. Two of the associated principles in relevance deal with explicitness of the information and the ubiquity of the information.
Rationale	Avoiding human information overload is the key to net-centricity. Decision making is facilitated by having only pertinent, timely information, in other words, only relevant information upon which to make a decision. The existence and use of the NCIF information environment (model queries, and user context) enables providers to evaluate the relevancy of a request for information. As a particular user request is made, its place along the semantic gradient can be evaluated by measuring how the request relates to others using the model, queries and user context. The information relevancy paradox occurs when there is too much information and/or one has not sufficiently filtered less relevant information (as

[33] Excerpted from NIF version 2.

	defined by its place on the gradient and how it relates to the model, queries, and user context).[34] Making sense of higher relevant information is then impaired, and therefore untimely. If one has too much information, one effectively has less information – a real paradox. Ability to provide relevant information is the key benefit to rigorous application of a net-centric information framework. Human information overload is not a recently discovered problem. A newspaper journal reported the following: “Our very facility and enterprise in news-gathering have overwhelmed our newspapers, and it may be remarked that editorial discrimination has not kept pace with the facilities. We are overpowered with a mass of undigested intelligence, collected for the mast part without regard to value. The force of the newspaper is expended in extending these facilities, with little regard to discriminating selection. The burden is already too heavy for the newspaper, and wearisome to the public.” This was written in 1879 and is referring to the fact that the newspapers cannot keep up with the information flow from, of course, the telegraph![35]
Implication	An example of the implication of not being relevant is the 9/11 incident in New York City. To get closest to the scene of this calamity and thereby have the latest and best information, it was decided that the command post should be set up on the ground floor of one of the towers. Unfortunately, nobody thought to check with a Civil Engineer to understand the risk of building collapse. Indeed, much information was gained relative to those trapped souls on the floors above the floor where the airliners hit, but it came for naught when the building fell down on the command post, adding to the loss of life in that tragedy. That one piece of relevant information would have saved the lives of over 100 police officers.

3.2 Explicitness

Description	Information must be explicit in conveying its content and context in a concise, effective manner to eliminate or reduce the possibility of misinterpretation. This is a core principle of effective information transfer.
Rationale	Making information or its assumptions explicit aids the consumer in determining the relevance of that information. This allows the user to filter unwanted (less relevant) information.
Implication	Not providing explicit information or withholding assumptions about the context of information usefulness leads to information overload and becomes a major driver in the information relevancy paradox mentioned earlier.

[34] Some people say that relevance can only be determined afterward, i.e., after a decision has been made. This makes it difficult to filter the less relevant information.
[35] http://www.gutenberg.org/cache/epub/3110/pg3110.html

3.3 Accuracy

Description	Accuracy of information refers to the ability of a consumer to validate the degree of adherence to the core definition of a piece of data. This is a core principle of effective information transfer.
Rationale	Accurate information is required to allow the consumer to filter unwanted (less relevant) information
Implication	In many instances there is a tradeoff between the most accurate information versus most timely information. There may be an overhead sensor that can pinpoint an airliner, for example, to a 1-foot accuracy, information about which may take many seconds to reach an airport control tower. However, the timeliness of such data may not be as critical as the less accurate but immediate information gathered visually (and immediately) by operators looking out on the tarmac and warning two airliners about to collide to maneuver to avoid a collision. In this case, visual information may only provide a rough idea about the relative locations of the airliners.

3.4 Timeliness

Description	An important principle in a net-centric environment is delivery of information to a consumer at any location in a timely manner as mentioned in the net-centric definition. The full breadth of geo and temporal constructs needed to effectively deliver this capability are simply contained in the "when" and "where" of the UCore taxonomy referred to above. However, since in any operational domain the spatial and temporal concepts have to meet a complex reality. For example, the Army and Marines have an understood concept of latest time information/intelligence is of value (LTIOV) that captures the notion of time as critical to the importance of an information definition. Army FM 1-02 Operational Terms and Graphics: latest time information is of value – The time by which an intelligence organization or staff must deliver information to the requester in order to provide decision makers with timely intelligence. This must include the time anticipated for processing and disseminating that information, as well as for making the decision. (FM 2-01.3) Marine Corps: latest time intelligence is of value The time by which information must be delivered to the requestor in order to provide decision makers with timely intelligence. This is a core principle of effective information transfer.
Rationale	Without a sense of time (in both production and use) information may devolve into being only data. Also, without a sense of time, this information may result in negation of the relevancy principle. Many current enterprise approaches to data, information, and knowledge do not explicitly deal with time and may be incomplete when being considered as part of a net-centric implementation.

	Another example of spatial and temporal net-centricity is the stock market. Markets today are worldwide, and somewhat loosely or tightly coupled dependent upon the security. The Hong Kong Exchange and the New York Stock Exchange are affected differently by timing and world location. It is important that a trader understand when and where to execute an order to achieve a specific objective. Precise timing may also be a factor for certain high volume traders. Inherent (either explicitly or implicitly) in the idea of consumers querying a database is that almost all queries contain some time horizon of usefulness. After this horizon has passed, the query results are of no interest and no longer contain any relevant information to the consumer. The environment model and queries by which information net-centricity is measured must be "well defined." NCIF guidance is that the role of time should be explicitly declared when measuring and evaluating information. For example when measuring the information net-centricity or usefulness of a target implementation, such as a mission planner, the implementers should declare and manage the time scale and time horizon of the systems information
Implication	The implication of timeliness is simply that information must be pertinent to the decision to be made and to the desired outcome.

3.5 Location Transparency

Description	In any situation where a decision must be made, information should be provided to the decision maker in his/her location.
Rationale	Information contained in a database, information store, or knowledge repository unavailable to an actor who needs to use it is irrelevant.
Implication	It is imperative to provide decision makers information at their current location globally. This is often referred to as information mobility.[36]

3.6 Separation of Function and Data

Description	Historically, context and meaning have been embedded in the computing application code that supported the creation, reading, updating and deletion (CRUD) of an information system's data. Whatever life cycle capabilities existed were either included in the code or initiated by manual review followed by manual or batch updates of the data. Relationship to data in other information systems was identified through point-to-point interfaces that replicated the data – usually by batch processing – to whatever information system required it. Net-centric information architectures manage data context and meaning outside their authoring systems. Definition and context are abstracted and stored independent of the instances of data they describe. Commonly referred to as metadata, context attributes include definition, structure, relationships between data attributes and information objects, models and their relationships to each

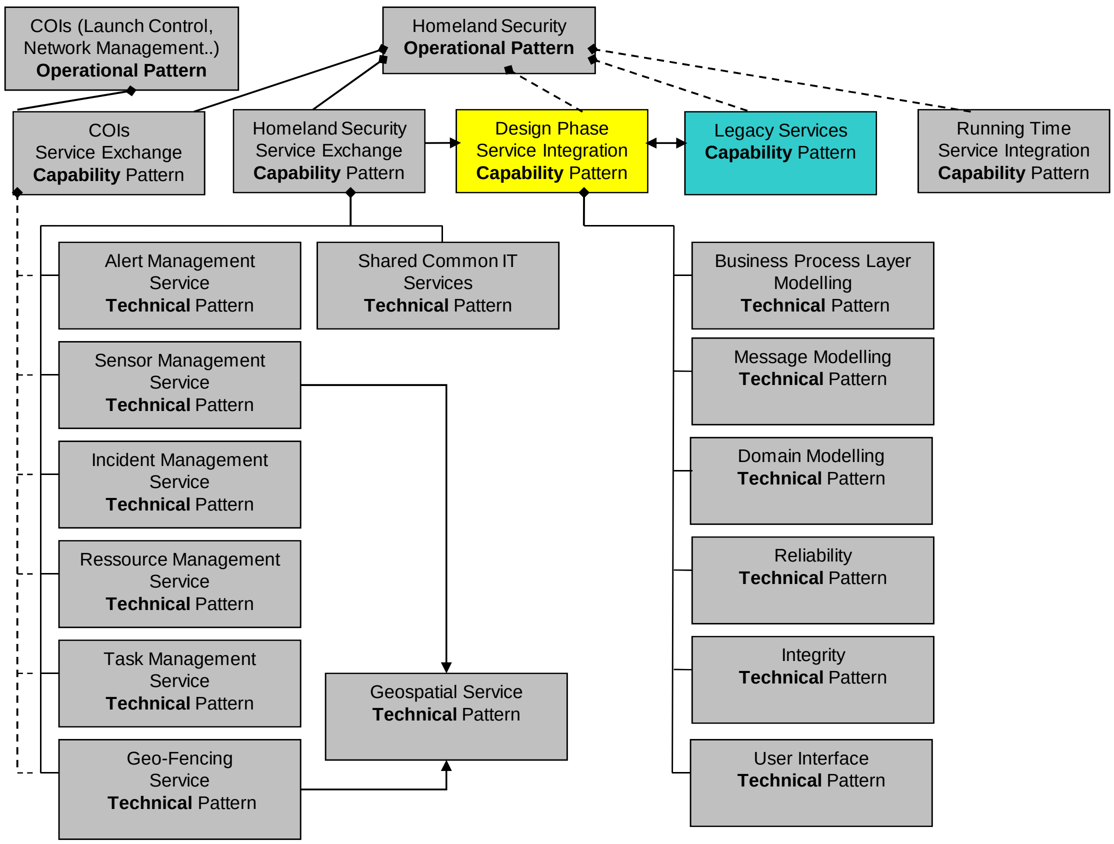
[36] Department of Defense Information Sharing Strategy, May 4, 2007
[37] DoD Enterprise Architecture Data Reference Model, DoD Enterprise Architecture Congruence Community of Practice, August 20, 2005.

	other, protection requirements, location, quality rules and measures. A collection of metadata can describe one information system or a system of systems, the scope of which can vary from a business process to an entire enterprise[37].
Rationale	Separation provides a method to discover and use information/data and use them independent of their sources and, thus, across sources.
Implication	Separation requires configuration management for both function and data, increasing the number of objects to be managed. However, it decouples changes to function from data, providing simplification in many instances. It also enables extensibility.

4 Patterns

Patterns are often described as architecture "fragments."[38] The patterns are intended to work within the NCIF to elaborate upon specific sets of functions. A net-centric pattern expresses the intent of the framework in a concrete, rules-based fashion. NCOIC has three pattern types: operational, capability, and technical. Each of these can describe a set of requirements as the systems engineering process proceeds from needs to implementation.

Figure 4-1 shows a typical pattern structure developed by an NCOIC integrated product team (IPT). Two of the existing patterns are shown in pastel colors: items in work at NCOIC are gray.



Legend:
- The lines with arrows represent light relationships.
- The lines with a square identify strong hierarchical dependencies.
- Dotted lines relate to future patterns.

Figure 4-1. Homeland Security Pattern Hierarchy

The user of a technical pattern should be able to instantiate it in hardware, software, or/and human actions. NCOIC has within its organizational structure an IPT entitled "Building Blocks." The function of this team is to certify software instantiations as being net-centric and

[38] NIF: A.1.7.3, page 85.

interoperable. As such, the building block should be an instantiation of one or more technical patterns.

A pattern contains a specific context of the problem to be solved. Unlike concepts and principles, a pattern has an explicit description of the problem domain and the user of the pattern. There may be instances where a pattern crosses the boundary between this NCIF and another framework, for example the NCSF or the Net-Centric System Management Framework (NCSMF). For example, there may be a pattern describing a service for converting information to knowledge.

4.1 Pattern Content

Patterns related to the NCIF should focus on interoperability and net-centric aspects of information. Standards for data and information by their very nature provide a path for interoperability in these two areas. Information standards should be selected with consideration of net-centricity in mind.

The net-centric aspects of getting the right information to a consumer any time, anywhere dictate that not all consumers have access to a fiber optic cable, but may have a 16 Kilobit/sec data channel or less. So it is important to select an information standard that does not overburden the information exchange with “overhead information.”

Knowledge lies at a different point on the semantic gradient. Interoperability of knowledge depends to a degree on the difference in the existing knowledge level of the consumer and that of the provider. So to a certain degree, these two existing knowledge states need to be equalized for effective knowledge interoperability.

The NCOIC Pattern format is shown in Figure 4-2. Any pattern related to the NCIF should follow the recommended NIF pattern development format to the extent applicable.

1. Introduction and Problem Description
    - 1.1. Context
    - 1.2. Problem Statement
    - 1.3. Expected Benefits
2. Recommended Solution
    - 2.1. Actors
    - 2.2. Interfaces
    - 2.3. Pre-Conditions
    - 2.4. Structure
    - 2.5. Behavior
    - 2.6. Post-Conditions
    - 2.7. Standards
3. Additional Information (non-prescriptive)
    - 3.1. Lessons Learned
    - 3.2. Constraints & Opportunities
    - 3.3. Known Uses
    - 3.4. Potential Capability
    - 3.5. Related Patterns
    - 3.6. Reference
4. Verification

Figure 4-2. NCOIC Pattern Format

For Information related patterns, a process for pattern development is contained in Section 5. These information related patterns should be in consonance with the concepts and principles of Section 2 and Section 3 respectively. The patterns should describe concisely some operational, capability, or technical facet of an information system. Also, patterns should have a granularity that allows a short description. The document should be less than 20 pages. The technical patterns will be used as a basis for building blocks, primarily SOA services.

4.2 Pattern Map

An example of a top-level information pattern map is shown in Figure 4-3. This structure may be used as a basis to instantiate a physical structure for a member/customer system. Note that this is a notional system showing a potential structure. There could be more than one operational pattern if, for example, an aircraft had sufficiently different operational characteristics when used as a passenger carrier than a freighter. In that case, there could be a different structure, or not. Some of the technical patterns could be combined, and could certainly be decomposed into patterns with finer granularity.

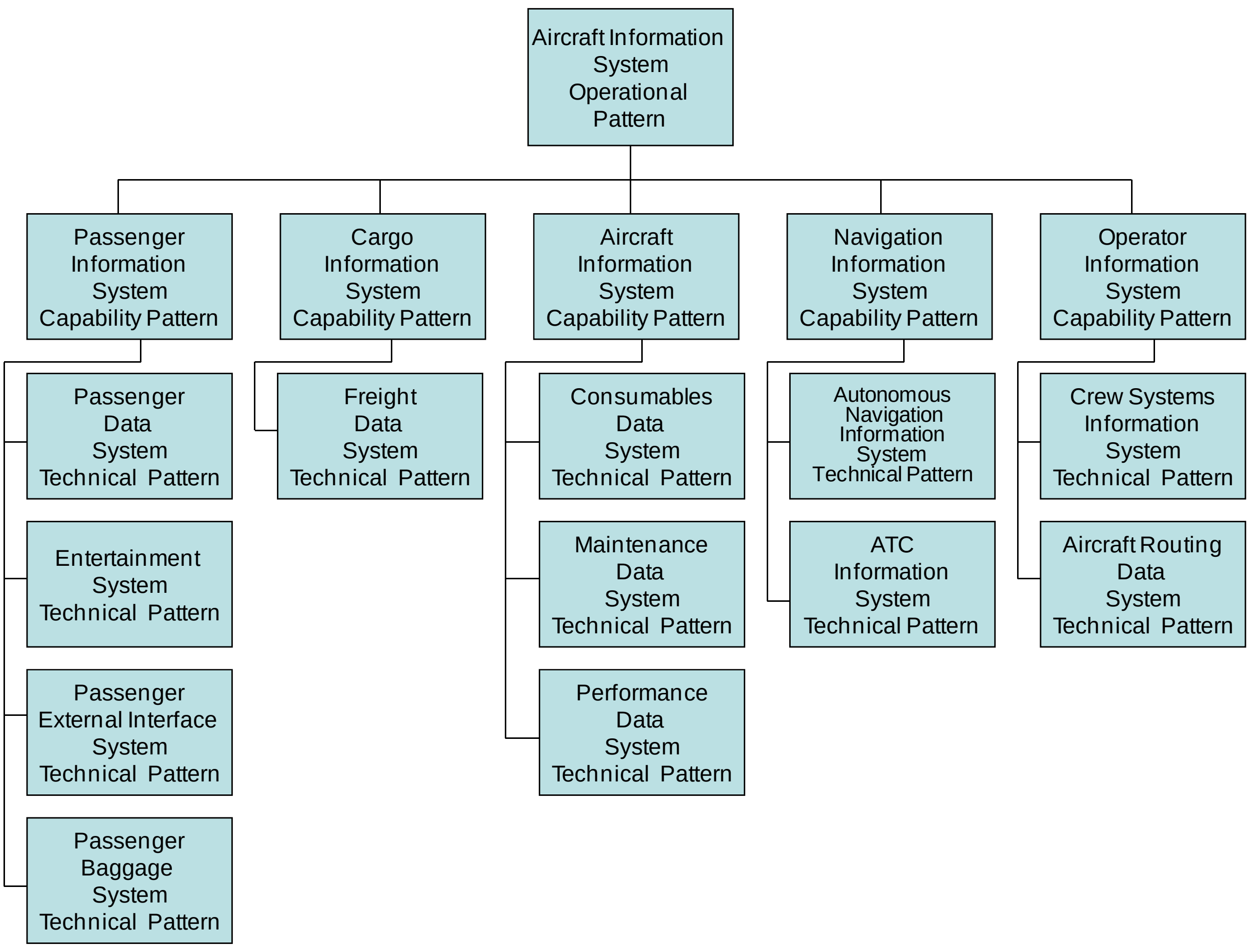


Figure 4-3. Notional Aircraft Pattern

Before developing a pattern for a particular domain, it is recommended that the pattern author give consideration to a structure such as this to determine the scope of the patterns to be determined. It may be that some already exist or their material is contained in existing documents. It also may be the case that a particular function is already in existence and will not change irrespective of net centric and interoperability concerns, so that information pattern development for that item would never be instantiated in a building block and would be a waste of resources to document it.

4.3 Examples of Information Related Patterns

Released NCOIC patterns related to this framework include those shown in Table 4-1.

Table 4-1. NCOIC Patterns Related to Framework

Pattern	Relevancy
Legacy Systems Capability Pattern	Outlines the possible approaches to creating interfaces to leverage legacy capabilities. Described in the Legacy Systems Capability Pattern are instances of interfacing legacy and net-centric systems where this framework could serve as a check list.
Design Phase Service Integration Capability Pattern	Further defines some of the concepts surrounding design-time structures required to ensure proper integration of services. The Net-Centric Services Interface Capability pattern could be employed to guide the creation of the various interfaces described in this framework.
All Hazards Alert and Warning (AHAW) Capability Pattern	Captures functional interfaces that are required for implementing a Hazards, Alerts, and Warning capability. This framework provides high level concepts on how to create information interfaces.
Disconnected, Intermittent and Limited (DIL) Communications Technical Pattern	The major static interface is between the communications mesh element (CME) and the policy manager (PM). This framework outlines strategies to interchange information across the CME-PM interface.
Information Dissemination Shared Database Capability Pattern	The Information Dissemination Shared Database (IDSD) Pattern provides a solution for exchange and dissemination processed information of different types from different sources to multiple information systems using computing and communications services through and from different organizations. The IDSD Pattern embodies a network service that enables efficient data sharing among multiple stakeholders. This service Provides a single data subscription capability and uses a meta model to indicate where data are available to a data consumer. The shared data can be videos, pictures, raw data and processed data.

A NCOIC Pattern Database is being constructed so that all NCOIC patterns released or in development can be easily found on the NCOIC KAVI website. A current trial copy has been posted on KAVI. Members are encouraged to review it and provide their comments to the NIC Functional Team.

5 Process

This section recommends activities an information or data architect should perform when using the Information Framework. One of the architect's goals should include influencing the structure of the network system being designed so that the information contained therein can be interchanged with other systems simply and rapidly. Implementing patterns when available simplifies this interchange. A second goal should be to employ the Net-Centric Information Principles outlined in Section 3 of this document appropriately, in patterns, or other documents.

For development of information patterns and domain specific information frameworks, the following model driven tasks include:

- Development of a semantic model, congruent to the domain under consideration.
- Instantiation of such a model, outlined below to serve as the primary basis to portray the context and environment of the information system under development.
- Development of a base set of model queries, answers to which are often described as or contained in views.[39] The answers to these queries form the bases for establishing system information.

Although this framework may be used as a reference document for the architect in a information system development process, it is an NCOIC document. It is recommended that the architect using this framework tailor this framework for functional instantiation in the architect's system. This framework provides guidance at a higher level so that it can be useful across a variety of domains. However, a medical domain would have to be tailored differently from an air traffic control system domain, let alone a weapons system. Also, each organization in either government or industry has its rules and regulations governing production and control of its documents. These rules dictate configuration management of a framework tailored from this NCOIC framework that may not be in consonance with NCOIC processes. In connection with development of an Instantiated Framework, a governance process should be in place to enforce the policies for its use. When tailored, the models contained in this document are optimized at the process start, but should be updated throughout the life cycle.

5.1 Information Systems Development

Top-level process activities for an information architect include gathering information requirements, collecting and generating capability assessments, distilling those requirements and assessment into functional requirements, allocating those functional requirements to hardware, software, or human actions, detail design, production, integration, verification, and validation. Figure 5-1 shows a process flow and the feedback that is contained therein. Note that this process is a top-level engineering process that is not restricted to information systems.

The process can be a spiral process, that is, when a first cycle of documentation is completed, there may be elements that can be refined or replaced in a second or future cycle. In modern systems engineering, it is important to understand capabilities of existing systems performing related functions to those of a postulated future system. A capabilities assessment may initially be a product of an operational analysis. This assessment defines and documents operator's needs

[39] For example, DoDAF views or viewpoints.

to remedy perceived deficiencies. The capabilities assessment is further refined into a requirements document for new systems.

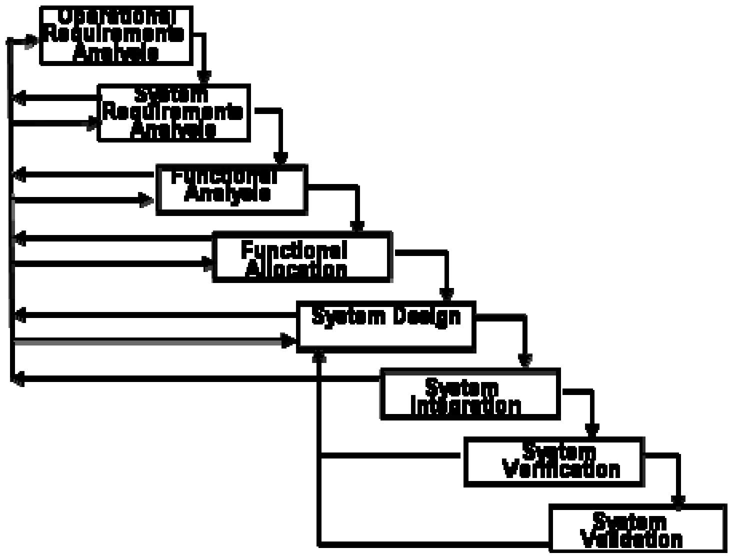


Figure 5-1. System Development Process

Recent industry attention has focused on product responsibility over a product's life cycle. Behavior of organizations in a product chain is interdependent on actions of other stakeholders including contractors, suppliers, operators, and customers.[40] Only through cooperation and close interaction between different parties involved is it possible to form an efficient chain of responsibility over the life cycle.

Drawing on previous efforts, systems assessment documents should be developed to express customer needs. Interpretations of stakeholder desires, integration into and monitoring business processes, and communication with stakeholders are central to such documentation. Application of this framework to several cases illustrates the capability assessment function.

Case 1. Emergency Management

The NCOIC NEER IPT has a number of documents that describe scenarios that portray the capabilities needed in emergency situations. Such a document is the All Hazards Alerts and Warning (AHAW) Capability Pattern, as well as a number of other documentation under development in NCOIC in Emergency Management. Information plays a prominent part in Emergency Management. An emergency services pattern is under development by this IPT that is information intensive.

Case 2. Air Traffic Management

The NCOIC Aviation IPT is involved in developing products for this area. The Flight Data Object Dissemination Pattern is one such pattern. Other operational analysis documents are also under development. The flight data object has aircraft data contained therein continually updated to provide information such as

[40] Design Phase System Integration Capability Pattern, NCOIC 2009.

position, velocity, altitude, aircraft status, and other information to the stakeholders. Information from multiple aircraft is assembled into knowledge to enable pilots, air traffic controllers, aircraft operators, airfields and logistics suppliers to make appropriate decisions.

Case 3. Border Protection

Currently under investigation within the NEER IPT are several border protection activities. These have two objectives: Simplification of legal border passage and prohibition of illegal border passage.

5.2 Modeling Tools

In developing documents that describe a complex system, it is helpful to have a model and set of queries against that model that can be referred to throughout the process. Figure 5-2 is a top-level description of a commonly used model describing the hierarchy of data, information, and knowledge. This diagram is closely related to the gradient discussed in Section 1 of this document.

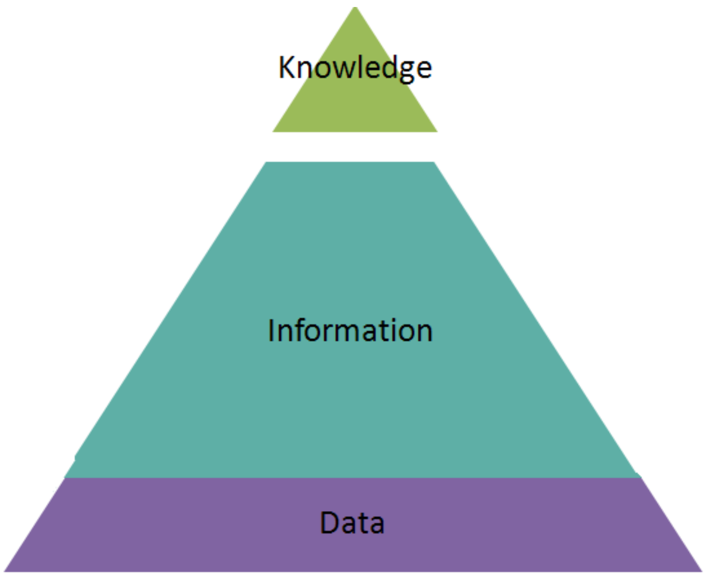


Figure 5-2. Information System Model

5.2.1 Information Models

The pyramid of Figure 5-2 may be further decomposed as described as shown in Figure 5-3 to provide lower level components of data, information, and knowledge. In pattern development, this model or a similar decomposition is useful to (1) select the boundaries of an architecture fragment (pattern) to construct and (2) understand the adjacent elements to the selected subject. It is also useful in instantiation of a specific framework. Figure 5-3 is specifically provided so that the designer could tailor it to his program. For example, one might not need both the message-oriented middleware (MOM) and object request broker (ORB) components in the same system. An even more extensive tailoring could be to move selected knowledge components into the top of the Information layer, or in another system move fusion into the knowledge layer.

Information systems exist for the purpose of capturing and using information required by business, whether data to drive a numerical controlled machine in a factory, execute everyday business functions, or capture creative collaboration for future product innovations. Note that the components in Figure 5-3 are defined in the appendix, along with selected standards.

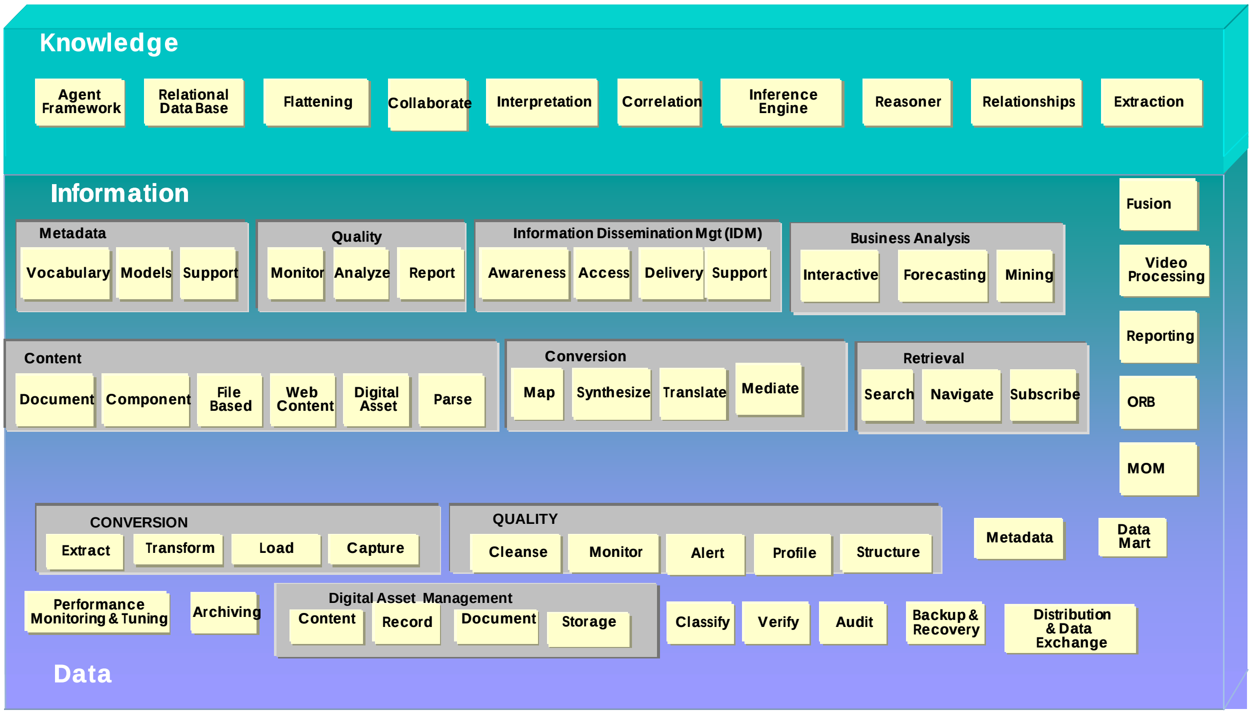


Figure 5-3 Information System Model Decomposition Strawman (Source NCOIC)

An information model describes the technologies, products, methods and rules for managing data, information and knowledge in an enterprise. Though enterprise strategies and priorities for implementing information management disciplines may vary over time, in general this model must support life cycle management of data and information assets to meet business needs. This quickly becomes a complex problem when the scope is increased from one system using one technology to bridging today's ever-evolving heterogeneous and redundant data and information, coming from internal and external sources using many technologies.

The challenge for information services is to bridge evolving, disparate sources to meet real-time on-demand requirements from the business while managing the life cycle of the data and information as well as the technologies that support them. The instantiated information architecture of each segment must provide capabilities for managing data, information and knowledge within and across information sources to meet business needs through a system's life cycle. An information architecture specific project should be addressed by first constructing a model similar to that shown in Figure 5-3, but containing elements that are germane to the domain being modeled and eliminating those elements that are not. There are many shades of gray across the boundary of the data layer and information layer.

The model of Figure 5-3 should be tailored to suit the purposes of the user of this model. For instance, if the user is not using MOM, the user could delete (or deprecate for further consideration) this component at the onset of the process. General descriptions of the components of this model are contained in the appendix under "Information Model Terms." In Figure 5-2, the transition between data and information in this model is depicted by use of separate colors for data and information, when in reality the transition is not discreet. In fact, there may be components in the lower portion of the gradated information/data box that may be applied in the upper, or information portion as well. For example metadata may be applied to raw data as well as data that is processed and fused. Fusion may applied to data having low semantic content as well as to information, particularly in its conversion to knowledge, as well as to knowledge already established. Also, auditing may be applied at any step in information processing.

This information model encompasses technical architecture elements used to manage data/information/knowledge over its life cycle. Such an architecture supports managed, structured data optimized by design for information technology, i.e., processing, storage and user devices, not for human consumption. These aspects deal with data at a technology level, or in preparation for technology implementation, e.g., physical schema (data models), managed storage (databases), conversion between physical stores (extract-transform-load); assessment of stored data values and relationships including data quality analysis content and quality monitoring, format and structure, data query and retrieval based on physical structure, quality of values and format as stored and archived.

Some of these technologies, currently at a highly evolved state, have existed for decades. For example, databases, data modeling, and data query; other technologies have evolved with the need to migrate data between changing technologies and integrate data across information systems. This maturation has been vital in providing managing data quality, e.g., data conversion, data analysis, and data monitoring.

Information model components also support acquisition, processing, storage, and distribution of information as well as active collaboration. They provide a foundation for client-server interaction and information sharing between nodes to support applications. Software components supporting knowledge management and software agents as well as server technologies related to web services and application integration are distributed across the information portion of this model layer as well as in the knowledge layer. For example, fusion provides support to knowledge development by combining similar higher level information to form a basis for understanding.

Functions that use data mining, data fusion, and data search engines are contained in knowledge management components in the model of Figure 5-3. Agents gather data and metadata from disparate sources in disparate formats, generate new information, or transform information into a new format contained in a relational database for processing. This database allows collaboration and interpretation by agents who employ inference engines and reasoners to develop relationships. Finally, other agents extract the resultant for distribution to consumers having needs for, or redirect consumers that issue search requests with knowledge management services for decision-making purposes.

5.2.2 Information Transfer and Knowledge Processing

Information transfer outside of one's enterprise is often more complex than transfer within that enterprise. If enterprise can be defined as a domain in which all actors have the same context, then it is easy to see how moving information out of that context might be easier or more difficult for the consumer to understand, depending on the consumer's capability.

Basic reasons for transferring information outside of an enterprise include both situational awareness[41] and taking action. For situational awareness, the consumer needs to invoke processing of incoming information that brings the consumer's context at least up to that of the provider so that the transferred information meaning will be equivalent between consumer and provider. This equivalence may be as simple as altering metadata from the provider's native language to that of the consumer, or altering the visual display of information for equivalence. The processing could be complex because of differences in processing capabilities between provider and consumer. This could require domain dependent alterations to processing. In some instances, this may be impossible.

To make information actionable may require other processing techniques depending on the mission of the system, the domain, the possible set of actions, and the environment. These may be mature such as use of rational databases. There may be a need for complex and specialized such as reasoners and extraction. Some of these components are shown in the model of Figure 5-3. Typical specialized components may include the following:

- Agent
- Correlation
- Relational Database
- Inference Engine
- Flattening
- Reasoner
- Collaboration
- Relationship
- Interpretation
- Extraction

Figure 5-4 is a hypothetical example of a flow for converting raw data from a provider, to a consumer who uses this information, transformed into knowledge, to make decisions. It is domain dependent to an extent, but could be applied in at least two of the cases shown in Section 5.1. This process has two objectives discussed above: (1) bringing the consumer's context to at least the provider's level through use of subject matter expertise and processing in the block labeled Data Center and (2) improving the consumer's ability to make decisions through processing actionable information in the block labeled Action Center.

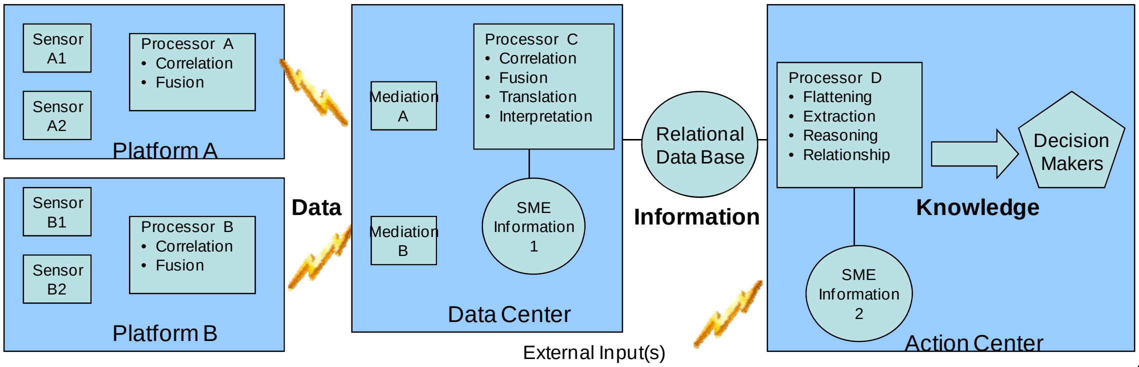


Figure 5-4. Data to Knowledge Conversion

41 "The perception of elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future." Endsley's definition (1995b).

Processing to adapt the context of the consumer is often separate from the processes of manipulating information in the knowledge components described above. Processibility of information is a key constraint in producing knowledge within or without an enterprise to an information state that is useful using the kinds of components described above. The three blocks in this diagram could be separate enterprises or contained within a single enterprise.

An enterprise boundary in this example is not shown because it could be anywhere to the right of the platforms, depending on the physical location and ownership of the service. In a coalition environment set up for disaster relief, an intermediate data center could perform translation from German to French to English, for example, then pass that information to an information database in a higher level operations center for decision processing into actionable knowledge.

In the recent nuclear disaster, Platform A could be a ground observer on a nearby mountain with a visual sensor and a nuclear sensor, whereas Platform B could be an airborne observer with IR and spectrographic sensors. The data center could be the local operations center. The action center could be the Tokyo Electric Power control center that took specific actions. Clearly, the processing would be domain dependent; however, if the sensors were located in an air traffic control system, the same functional flow could be applied with a different set of components.

5.2.3 Viewpoints/Views

Figure 5-3 is an example of a model that may be used to describe the elements of an information system. The first step in the process of completing an information architecture for a specific project is to develop a domain specific model having elements that are germane to the domain being modeled and eliminating those elements that are not. Secondly, the queries, or viewpoints, that serve to enhance the meaning of the information should be selected. For example, one could use specific DoDAF views to show actors in an information system. Model refinement is an iterative process that continues after the model is formulated. This process can continue over the program life cycle as additional systems understanding is achieved.

The viewpoints, sometimes referred to as views, that serve to enhance the meaning of information should suggest the queries and visa versa. Queries made against a model as developed above are suggested through graphical or tabular presentations. There are several architecture frameworks suggested in the NIF that may be used. Often the particular customer for a system will have a favorite that expresses the system context for that customer. These architecture frameworks include The Open Group Architecture Framework (TOGAF) Ministry of Defence Architecture Framework (MoDAF), the NATO Architecture Framework (NAF), and the Department of Defense Architecture Framework (DoDAF). Each of these has a slightly different context, but there are also many similarities that make the queries obvious and provide systems understanding that also provides the relationship between objects at a lower level.

The products of requirements analysis include the following viewpoints using the DoDAF for an information system.[42] As mentioned above, these viewpoints may have a different context using another architecture framework.

[42] Note, these definitions are taken from DoDAF 1.5

#	Title	Description
OV-1	High Level Operational Concept	Primary Actors, roles, environment and general context. (included for reference)
OV-2	Operational Node Connectivity	Description of Operational nodes, connectivity, and information exchange need lines between nodes
OV-3	Operational Information Exchange Matrix	Information exchanged between nodes and the relevant attributes of that exchange
OV-7	Logical Data Model	Documentation of system data requirements and structural business process rules of the Operational View

A functional analysis produces items described in these viewpoints. Note that these viewpoints are recommendations for an information system a security system will have others.

#	Title	Description
SV-1	Systems Interface Description	Identification of systems nodes, systems, system items, services, and service items and their interconnections, within and between nodes
SV-2	Systems Communications Description	Systems nodes, systems, system items, services, and service items and their related communications laydowns
SV-3	Systems-Systems Matrix Services-Systems Matrix Services-Services Matrix	Relationships among systems and services in a given architecture; can be designed to show relationships of interest, e.g., system-type interfaces, planned vs. existing interfaces, etc. See earlier description of Ontologies
SV-4a	Systems Functionality Description	Functions performed by systems and system data flows among system functions

5.2.4 Data Characterization/Information Handling Tools[43]

The following tools as well as the model previously described are artifacts recommended to be generated in the information system design process.

5.2.4.1 Data Dictionary

One of the first steps in an information engineering process is to both model and expose enterprise data. The first tool in data modeling is a data dictionary that identifies in what system a data element is available and what system or subsystem needs a data element. Structure should be put in place to make available this data dictionary plus the model(s) and viewpoints.

In addition to use of a data dictionary a process whereby a developer can search the data dictionary to determine in what system or service a data element(s) reside should be established. Alternatively a user should be able to specify a need for a data element or elements. This is often referred to as an enhanced data dictionary discovery process. Established providers should also be able to contribute to the data dictionary. Over a systems life cycle, the dictionary should be open to its enterprise for input, with appropriate authorization.

5.2.4.2 Data Source Description

A description of data sources is important for understanding of how to translate data into meaningful information useful across the enterprise and further outside of the enterprise if appropriate. Factors such as precision, accuracy and frequency should be determined at the outset as well as any projections for improvement (or degradation). Standards for displaying data and characterization of this data are important to recognize. Applying these standards is a significant step in making progress up the semantic gradient.

[43] Note: Governance should be established for the tools used in this process.

5.2.4.3 Metadata

Translating data into information as mentioned earlier begins to add content and domain considerations. Standards for meaning, i.e., metadata, must be selected with care so that any degradation introduced is well understood. For example when inertial and radio navigation data are used to form a state vector, the associated processing masks statistics of the original two data sets, inertial and radio.

Although metadata is shown in the "Data" area of Figure 5-3, it in fact is endemic throughout the model. As mentioned elsewhere, metadata refers to context attributes including things such as definition, structure, relationships between data attributes and information objects, models and their relationships to each other, protection requirements, location, quality rules and measures. At the heart of net-centric operations is the ability to share information on a network. UCore is an example of an information exchange specification and implementation profile for information Sharing.

5.2.4.4 Information Curation Plan

It is recommended that an information curation plan (ICP) be developed early in the development of the information system. This plan which describes a life cycle process is helpful in systems development since it provides a checklist for a system developer, in particular in pattern development. For many information types, the source and consumer are obvious, however this isn't true for all data types. Traceabilty is an important characteristic that should be maintained for all information systems.

The meta-information stored in the ICP should be accessible during the entire lifetime of a system. It would be written first during design but be updated during the lifetime of the system, especially when changes are made to the system. It should be accessible outside of the development documentation, because it is more often used and subject to more changes than the development documentation. Very often, information has a much longer lifetime than the system it was originally used in, so the ICP must be decoupled from the system itself. Detailed descriptions of the ICP contents are found in the appendix.

Information systems, especially knowledge heavy systems, have had many difficulties in their introduction, when users found that the necessary information (knowledge) was not available or not coded in a way that the system could use it. It is important to code information in a reusable way, especially for knowledge-intensive systems, in order to ensure that users continue to be able to exploit the information.

Legal obligations as well as other needs make it necessary to have a clear process of storing information for a defined period and protecting the access until destruction of this information. Other typical problems in the handling of information include the following:

- Necessity to track changes made to information, and reason for the changes.
- Information protection from not only unauthorized access but also destruction.
- Secondary usage of information as, e.g., in data warehouses.
- Responsibility for the update of information that changes only occasionally.

5.3 Information Pattern Development Process

The first step in the pattern development process is to determine the scope of the pattern. Section 4.2 describes a top-down process for the breakdown of a system information pattern into lower level patterns. Knowledge of the domain under consideration can be used to validate the pattern breakdown and should also be captured within the information model for the system.

Often the so called “bottom up” solution wherein some inventive individual comes up with an idea on which a pattern may be built, usually due a combination of background and experience in a particular domain. Both approaches contribute to the definition of a system's information patterns, so that the individual's domain experience can be incorporate into the information model to make the knowledge explicit and re-usable. One way of doing this is for the top-down architect to work with the bottom-up individual to test the "workability" of the proposed information solution. Section 4.2 describes the top-down process.

When selecting a pattern to develop, and eventually the service or similar building block that is instantiated, it is important to solidify the scope not only because patterns are often a documentation of an existing capability, but they must take care not to duplicate the function of an already mature system that is well proven and inexpensive.

Granularity is also important, particularly in technical patterns. An overly complicated technical pattern is difficult to read and does not result in a building block or service that is easily instantiated. Brevity is the key here. Validation and verification are also major considerations. Quite often it is found that the requirement is not clearly written until the author understands the approach to verification.

NCOIC recognizes that each of its members may have detailed processes that members of their engineering departments must follow. It is hoped that the following paragraphs can serve to supplement these internal documents in a way to provide suggestions for net-centric information systems development without conflicting with internal policies and procedures.

5.3.1 Operations Analysis

In the operational analysis of a net-centric system, the first step is typically to identify the actors in the system, which can be facilitated by the use of operational views or equivalent. Policy is an important input into this analysis since it governs the operation and therefore it is important to define it. Typical issues include the identification of the planned and potential users of the information Policy should be described in the context section of the pattern and, in certain cases, in the problem statement section of the pattern.

If the pattern is related or dependent upon an existing or proposed pattern developed by one of the NCOIC IPTs, one can generally obtain a use case that will provide information that would be helpful in developing a operational requirement document which will contain the appropriate viewpoints.

5.3.2 Requirements Analysis

As mentioned earlier in this document, net-centric information systems should always document information systems requirements at the top level. Key considerations are as follows:

- What are the sources of data and information?
- Do they need development?

- What are the nodes through which the information passes?
- Are there constraints which impede quality of the information transmitted or its ubiquity?

The system/service views mentioned above would answer some of these queries when documented to the appropriate granularity. Those queries may also be addressed in the problem statement and context sections of the pattern and also will define the precondition section.

5.3.3 Functional Analysis

The next step in the systems engineering process is to translate information system requirements into functions. The following steps can then be applied:

- Find duplications as opportunities for separation so common services may be identified.
- Identify data used by each function.
- Decompose each function.
- Determine functional boundaries recommended based upon industry standards.
- Understand what is already in place both from a functional standpoint and a technical standpoint. What is the rationale to use something existing, modify it, or develop anew?

This analysis will assist in the definition of the functional structure section.

5.3.4 Functional Allocation

Functional allocation allocates the decomposed functions to hardware, software or human actions. In an SOA, it is necessary to determine what is already in place both from a functional standpoint and a technical standpoint. Functional allocation will also provide material for the structure and behavior sections as well as the post-conditions.

5.3.5 Pattern Selection

The final process step is to select patterns granular enough to foster reuse, but also meet performance criteria. This section should make use of the pattern map described in Section 4-2. Although the pattern map may change over the course of the pattern development, it will assist the developer in getting started with a notional granularity. Granularity is the key in developing a net-centric information pattern that will be useful in net-centric architectures. The purpose of pattern development is reuse. So, it may be important to show how a particular architecture fragment may be used across multiple domains. If this fragment, or pattern, is not specific enough to show how it can be applied in a single domain, and instantiated in a building block, it may not be for its intended purpose.

Appendices

A.1 References

NATO Core Enterprise Services Framework V1.2
NCOIC NCSF version 2
NATO Information and Integration Services (NIIS)
DISA NCES
SoSCOE/SARM Information Layer
Ucore http://www.ucore.gov
NIEM Dept. of Justice http://www.niem.gov/
DDMS http://metadata.dod.mil/mdr/irs/DDMS/
FEA Architecture Framework Models
DoDAF Version 1.5, 2.0
UDEF
OASIS Reference Architecture Foundation (August 23, 2011 Draft)
OASIS Reference Model (2006)
DoD Enterprise Architecture Data Reference Model, v0.04, 20 Aug 2005

A.2 Acronym List

AHAW	All Hazards Alerts and Warning
AI	Artificial Intelligence
BCNF	Boyce-Codd Normal Form
C2	Command and Control
CME	Communications Mesh Element
DAF	Defense Architecture Framework
DAM	Digital Asset Management
DoD	Department of Defense
DoDAF	Department of Defense Architecture Framework
FoF	Framework of Frameworks
H2M	Human to Machine
ICP	Information Curation Plan
IDSD	Information Dissemination Shared Database
IP	Internet Protocol
IPT	Integrated Product Team
LTIOV	Latest Time Information/Intelligence Is of Value
M2M	Machine to Machine
MNE	Mobile Networking Evaluation
MNO	Mobile Networking Overview
MoDAF	Ministry of Defense Architecture Framework
MOM	Message-Oriented Middleware
NAF	NATO Architecture Framework
NATO	North Atlantic Treaty Organization

NCIF	Net-Centric Information Framework
NCOIC	Network-Centric Operations Industry Consortium
NCSF	Net-Centric Services Framework
NCSysMF	Net-Centric System Management Framework
NIF	NCOIC Interoperability Framework
ORB	Object Request Broker
OWL	Web Ontology Language
PM	Policy Manager
RDBMS	Relational Database Management System
RDF	Resource Description Framework
SF	Specialized Framework
SOA	Service-Oriented Architecture
SysML	Systems Modeling Language
TOGAF	The Open Group Architecture Framework
UCore	Universal Core
Ucore-SL	Universal Core Semantic Layer
W3C	World Wide Web Consortium
WCM	Web Content Management
XML	Extensible Markup Language

A.3 Definitions

General definitions pertinent to NCOIC are contained in the NIF Lexicon, which is found on the KAVI web site. Definitions pertinent to the NCIF are contained in the body of this document in accordance with the NIF directions. An exception is the definition of terms contained in the ontology described in Section 2. These definitions are contained in Table A.3-1.

Table A.3-1 Ontological Terms

Term	Meaning
Application	System Software related to System function
Business Alignment	Business alignment is the capacity to demonstrate a positive relationship between information technologies and the accepted financial measures of performance. (Wikipedia)
Business Goals	Businesses set goals that describe what will be accomplished over a future time period. These goals align actors in a business environment to work together effectively. Often these goals are very tactical, such as achieve 10% revenue growth in the next 3 months", but may also define visionary goals that are more strategic and emotionally compelling. (adapted from Wikipedia)
Consumer	User of a service in a SOA
Context	An operating context (OC) for an application is the external environment that influences its operation. For a mobile application, the OC is defined by the hardware and software environment in the device, the target user, and other constraints imposed by various other stakeholders, such as a carrier. (Exerpted from Wikipedia)
Data	Paragraph 2.1.4 of this document
Decision	A decision is the selection between possible actions. (Wikipedia)
Device	Computer Hardware, display, or any device attached to a computer that expands its functionality (extracted from Wikipedia)
Information	Paragraph 2.1.5 of this document
Information Context	An operational context is a defined environment in which specific information exists. (Derived from Wikipedia)

Knowledge	Paragraph 2.1.6 of this document
Mediator	A node that mediates address requests and connections between consumer and provider
Network	A set of interconnected nodes using Internet Protocols
Policy	A statement of obligations, constraints or other conditions of use of an owned entity as defined by a participant. (Oasis SOA Reference Model)
Processing Node	A network node that processes data
Provider	A node providing a service
Resource	A function that a system can address
System	A set of interacting or interdependent components forming an integrated whole (Wikipedia)
System Component	System components and their composition define the structure of a system. (extracted from Wikipedia)
System Data Structure	System Data Structure describes the organization of Data in a system.
System Information Model	The characterization of the information that is associated with the use of a service. (Oasis SOA Reference Model)
System Management	Systems management refers to enterprise-wide administration of distributed systems including (and commonly in practice) computer systems.[
System Semantics	See 2.1.2 of this document. Also, from Oasis Reference Model: A conceptualization of the implied meaning of information, that requires words and/or symbols within a usage context.

A.4 NCOIC Principle Interrelationships

There are several sets of principles described within NCOIC. Table A.4-1 shows these groupings. The principles contained in the NIF may have a more general context than principles contained in a specialized framework such as the NCIF, even though the title is similar. These are also depicted in Figure A.4-1 in a different format.

Table A.4-1 is a matrix that serves as a relationship map among the principles of several NCOIC documents. In this matrix, the term “principles” includes principles from the over-arching Net-Centric Principles document, the NIF, the NCSF and this, the NCIF. In some documents, the term “tenets” is used to describe what are listed here as principles. This is true in the NIF, and even in documents such as the mobile networking overview (MNO) and mobile networking evaluation (MNE), which are early extensions to the NIF and can be considered “proto-specialized frameworks”. Another specialized framework, the Net-Centric System Management Framework (NCSysMF) is a draft NCOIC document and has its own set of principles which are also shown in this matrix.

If this seems somewhat arbitrary, consider the analogy of building a house. It is known that footers must be dug and poured below the frost line before the foundation can be poured. After that, framing, sheathing and roofing occur before the internal HVAC, electrical, communications, and plumbing can occur. The electrical and plumbing contractors do not wait for the previous steps to be complete before drawing plans and ordering materials. In a similar manner, several of the NCOIC specialized frameworks have been created in parallel with their ostensible “parent” documents. Knowing that certain services are required in net-centric operations, the NCSF “plumbers” shaped principles even as the underlying footers of the Net-Centric Principles were being poured. Indeed, the concrete is barely dry yet. The result is that some overlap has occurred and some rationalization of terms must occur. This matrix reflects this and attempts to relate the terms in this context.

In response to a recent United States Department of Defense request to review their net-centric attribute check list, NCOIC developed a further set of net-centric principles, with a rigorous set of definitions that sets apart principles from attributes.[44] Principles differ from attributes and characteristics as described by the following definitions from WordNet 2.1.

Principle – A basic generalization that is accepted as true and that can be used as a basis for reasoning or conduct.

Whereas an attribute or characteristic is described as

Attribute, property, dimension – a construct whereby objects or individuals can be distinguished.

Characteristic, feature – A prominent aspect of something; a distinguishing quality.

Simply put, principles allow the selection of attributes or characteristics that are deemed useful. Characteristics or attributes are used to distinguish or select systems.

The net centric principles are as follows:

- Explicitness
- Globalism-Universality
- Relationship Management
- Symmetry/Reciprocal Behavior
- Ubiquity
- Open World
- Dynamism
- Entity Primacy
- Pragmatism

Based on net-centric principles developed by authors in the past decade[45], NCOIC has developed the NIF[46]. NIF contains Core NIF Principles that address architecture as follows:

- Connectivity
- Interoperability
- Security
- Discovery
- Agility
- End-to-end quality of service

NIF supplements these by some general purpose design tenets as follows:

- Modularity
- Abstraction
- Explicitness
- Standards use
- Decentralization
- Autonomy

Figure A.4-1 shows a familiar tree structure, which provides a common understanding of how ontologies reflect the domains modeled. This is intended to give a snapshot overview of the structure of the ontology and its relationship to the NIF. It shows an early stage in the development of the ontology for the NCOIC with emphasis on the NCIF. It was redrawn from the OntoViz Plug-In for the Protégé-OWL editor. Note the relationship for Dynamism in the NCSF being derived from the related net-centric principles. Germain to the NCIF, note that “Explicit” is a principle in the net-centric principles, the NIF principles and this document, the NCIF, in slightly different contexts. Not all of the arrows showing relationships between the various sets of principles in the NIF, Net-Centric Principles and this document are shown in this diagram. These relationships are found in the matrix version in Table A.4-1.

[44] In response to a recent United States Department of Defense request to review their Net-Centric Attribute check list, NCOIC developed a further set of Net-Centric Principles, with a rigorous set of definitions that sets apart Principles from Attributes.
[45] Power to the Edge, Alberts and Hayes; Effects Based Operations, Smith et al.
[46] Add standard reference to NIF could be ibid if already

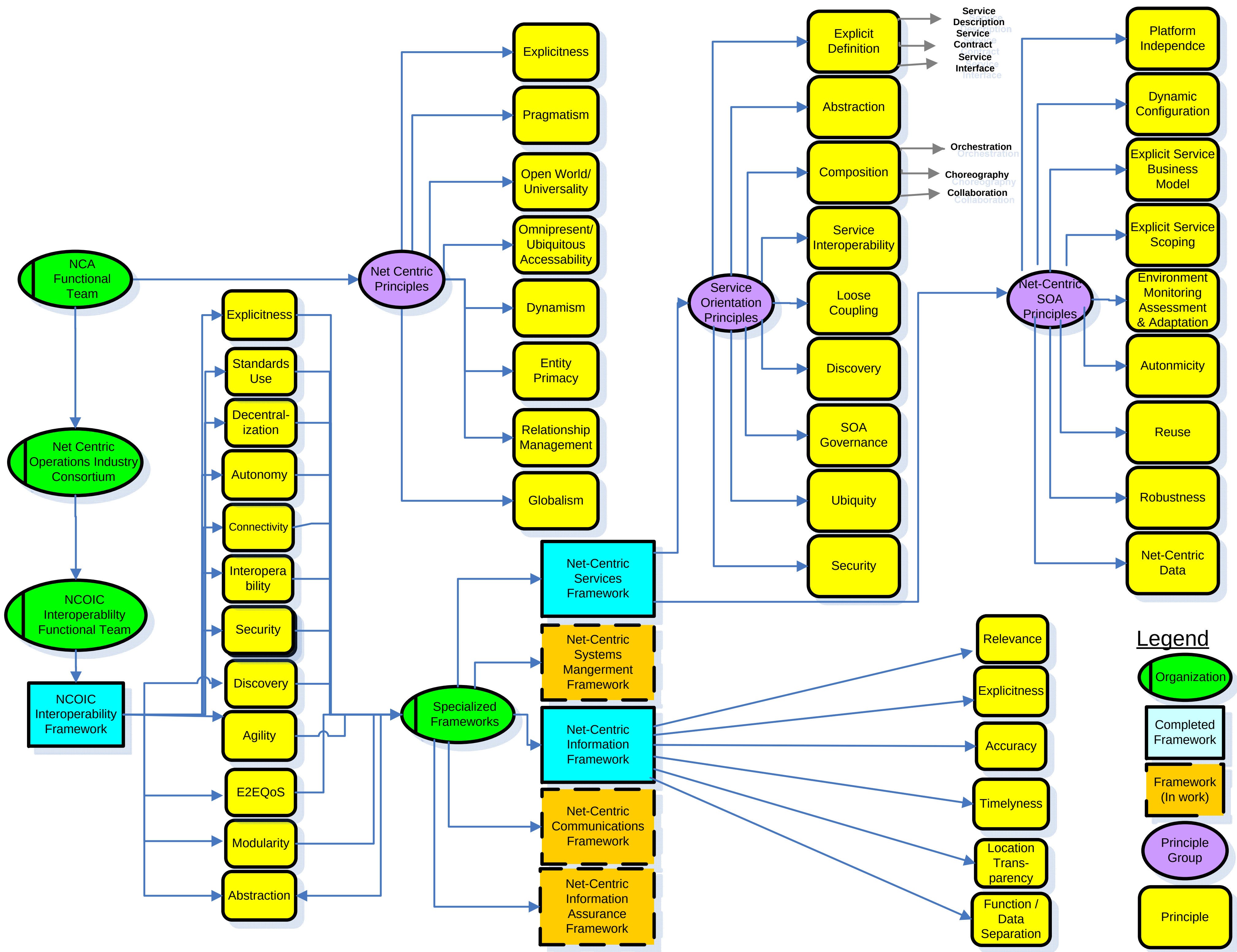


Figure A.4-1. Relationship between NIF, Net Centric Principles and Net-Centric Information Framework Principles

Table A.4-1. Relationships between Principles

	Principle Relationships	NIF											Net-Centric Principles								
		Connectivity	Interoperability	Security	Discovery	Agility	E2EQOS	Explicitness	Decentralization	Abstraction	Standards Use	Autonomy	Explicitness	Symmetry/Reciprocal Behavior	Dynamism	Globalism/Universality	Ubiquity	Entity Primacy	Relationship Management	Open World	Pragmatism
NIF	Connectivity				3	6	3		3												
	Interoperability																		3		
	Security					5			5			5									
	Discovery	6					2												5		
	Agility	3		7								9									7
	E2EQOS	6			5												6				
	Explicitness									6			10								
	Decentralization	6		7								6						3			7
	Abstraction							3			3							3			
	Standards Use									6										5	
	Autonomy			7		8			3					6				3	8		7
Net-Centric Principles	Explicitness							10													
	Symmetry/Reciprocal Behavior											3									7
	Dynamism																				7
	Globalism/Universality																				7
	Ubiquity						3														
	Entity Primacy								6	6		6							3		
	Relationship Management		6		7													6			7
	Open World										7										7
	Pragmatism					5			5			5		5	5	5			5	5	
NCIF Principles	Relevance		3	3				3									2				2
	Explicitness							1													
	Accuracy		7				3				3										
	Timeliness	7			2		3										1				
	Location Transparency	7	2			3	3		3								1				
	Function & Data Separation									2								2			
NCSF Principles	Service Description							8					8								
	Service Interface	2																	8		
	Service Contract		6																8		
	Service Abstraction									8								8			
	Loose Coupling	8										1				8					
	Service Interoperability		8																		7
	Service Composition	3																	8		
	Service Orchestration										2	3							8		
	Service Choreography											7							8		
	Discovery				10									8							
	SOA Governance			7															8		
	Location Transparency					8						8		8							
	Security			10															7		
	Execution Platform Independence											8								8	
	Dynamic Configuration					6						8			8						
	Explicit Service Business Model							8					8								
	Explicit Service Scoping						8	8					8								
	Environment Monitoring, Assessment, & Adaptation					8	8						8		8						
	Autonomicity				8							8						8			
	Reuse					8						8			8						
	Robustness (Graceful Degradation)			8					8												8
	Net-Centric Data									8	8										3
NCSysMF	Service Management	3	3									4									
	Capacity Management											4									
	Fault Isolation											4									
	Root Cause Analysis																				
	QoS Management								3												
	Quality of Operations Management											3									
	Data Access Management																				
	Configuration Management										3										
	Usage Management											3									

	Principle Relationships	NCIF Principles						NCSF Principles																					
		Relevance	Explicitness	Accuracy	Timeliness	Location Transparency	Function & Data Separation	Service Description	Service Interface	Service Contract	Service Abstraction	Loose Coupling	Service Interoperability	Service Composition	Service Orchestration	Service Choreography	Discovery	SOA Governance	Location Transparency	Security	Independence	Dynamic Configuration	Explicit Service Business Model	Explicit Service Scoping	Assessment, & Adaptation	Autonomicity	Reuse	Degradation)	Net-Centric Data
NIF	Connectivity				5	5			2			9		6															
	Interoperability	6		5						3			8																
	Security	6																3		10	4							9	
	Discovery																10									9			
	Agility					6													9			3							
	E2EQOS			6	6	6																		9	9				
	Explicitness	6	9					9																					
	Decentralization					6																							
	Abstraction						9				8																		9
	Standards Use			6			4																						
	Autonomy	8													6	5			9			9					9		
Net-Centric Principles	Explicitness		8																					9	9				
	Symmetry/Reciprocal Behavior																												
	Dynamism																												
	Globalism/Universality																												
	Ubiquity				9	9																							
	Entity Primacy						6																						
	Relationship Management																										4		
	Open World																												
	Pragmatism																												6
NCIF Principles	Relevance																												
	Explicitness																							3	3				
	Accuracy																												
	Timeliness																										7		3
	Location Transparency																		10								7	3	
	Function & Data Separation										8																	5	
NCSF Principles	Service Description		4											8															
	Service Interface		4																				6	6					
	Service Contract																												
	Service Abstraction						9																						
	Loose Coupling																												
	Service Interoperability																												
	Service Composition		4												9	9													
	Service Orchestration													8							6								
	Service Choreography		4				7							8															
	Discovery																												
	SOA Governance																												
	Location Transparency					10																							
	Security																												
	Execution Platform Independence														3														
	Dynamic Configuration																												
	Explicit Service Business Model								3																				
	Explicit Service Scoping		6						3																				
	Environment Monitoring, Assessment, & Adaptation		6																										
	Autonomicity																												
	Reuse				5	5																							
	Robustness (Graceful Degradation)					6																							
	Net-Centric Data				6																								
NCSysMF	Service Management																												
	Capacity Management																												
	Fault Isolation																												
	Root Cause Analysis																												
	QoS Management																												
	Quality of Operations Management																												
	Data Access Management																												
	Configuration Management																												
	Usage Management																												

	Principle Relationships	NCSysMF Principles								
		Service Management	Capacity Management	Fault isolation	Root Cause Analysis	QoS Management	Quality of Operations Management	Data Access Management	Configuration Management	Usage Management
NIF	Connectivity	6						4		6
	Interoperability	6			8					
	Security							4		
	Discovery		4							
	Agility									
	E2EQOS						4			
	Explicitness									
	Decentralization					6				
	Abstraction									
	Standards Use								6	
	Autonomy	6	6				6			6
Net-Centric Principles	Explicitness									
	Symmetry/Reciprocal Behavior									
	Dynamism									
	Globalism/Universality									
	Ubiquity									
	Entity Primacy									
	Relationship Management									
	Open World									
	Pragmatism									
NCIF Principles	Relevance									
	Explicitness									
	Accuracy									
	Timeliness									
	Location Transparency									
	Function & Data Separation									
NCSF Principles	Service Description									
	Service Interface									
	Service Contract									
	Service Abstraction									
	Loose Coupling									
	Service Interoperability									
	Service Composition									
	Service Orchestration									
	Service Choreography									
	Discovery									
	SOA Governance									
	Location Transparency									
	Security									
	Execution Platform Independence									
	Dynamic Configuration									
	Explicit Service Business Model									
	Explicit Service Scoping									
	Environment Monitoring, Assessment, & Adaptation									
	Autonomicity									
	Reuse									
	Robustness (Graceful Degradation)									
	Net-Centric Data									
NCSysMF	Service Management									
	Capacity Management									
	Fault Isolation									
	Root Cause Analysis									
	QoS Management									
	Quality of Operations Management									
	Data Access Management									
	Configuration Management									
	Usage Management									

Legend:

1	Is derived from
2	Is dependent on
3	Is affected by
4	Includes
5	Constrains
6	Affects
7	Is constrained by
8	Is contained in
9	Contains
10	Is equivalent to

A.5 Information Model Terms

Contained in Table A.5-1 is a description of the components contained in the example information model described in Figure 5-3. Each of these components is based on standards, specifications, and protocols.

Table A.5-1. Model Component Descriptions

Layer	Category	Component	Component Description
Knowledge		Agent Framework	The operational environment for collaborative agents (standards, protocols, rules, inter-agent communications, etc.) shall be contained in the Agent Framework Component
Knowledge		Relational Database	A relational database matches data by using common characteristics found within the data set. The resulting groups of data are organized and are much easier for many people to understand. For example, a data set containing all the real-estate transactions in a town can be grouped by the year the transaction occurred, by the sale price of the transaction, by the buyer's last name, and so on. Such a grouping uses the relational model (a technical term for this is schema). Hence, such a database is called a "relational database." The software used to do this grouping is called a relational database management system (RDBMS). The term "relational database" often refers to this type of software
Knowledge		Flattening	More commonly referred to as normalization in the field of relational database design, flattening is a systematic way of ensuring that a database structure is suitable for general-purpose querying and free of certain undesirable characteristics—insertion, update, and deletion anomalies—that could lead to a loss of data integrity.[1] Edgar F. Codd, the inventor of the relational model, introduced the concept of normalization and what we now know as the First Normal Form (1NF) in 1970.[2] Codd went on to define the Second Normal Form (2NF) and Third Normal Form (3NF) in 1971, [3] and Codd and Raymond F. Boyce defined the Boyce-Codd Normal Form (BCNF) in 1974.[4] Higher normal forms were defined by other theorists in subsequent years, the most recent being the Sixth normal form (6NF) introduced by Chris Date, Hugh Darwen, and Nikos Lorentzos in 2002.[5] Informally, a relational database table (the computerized representation of a relation) is often described as "normalized" if it is in the Third Normal Form.[6] Most 3NF tables are free of insertion, update, and deletion anomalies, i.e. in most cases 3NF tables adhere to BCNF, 4NF, and 5NF (but typically not 6NF). A standard piece of database design guidance is that the designer should create a fully normalized design; selective denormalization can subsequently be performed for performance reasons.[7] However, some modeling disciplines, such as the dimensional modeling approach to data warehouse design, explicitly recommend non-normalized designs, i.e. designs that in large part do not adhere to 3NF
Knowledge		Collaborate	Collaboration Services are technologies that help facilitate communication, information sharing, and coordination among colleagues and teams.
Knowledge		Interpretation	Resources that are based on rules supporting specialized processing engines designed for rule-set execution; Chaining (forward, backward, and hybrid) and Reasoning (Constraint based and Case-based). These algorithms can utilize many different techniques including priority based scheduling and fuzzy logic that helps manage business rules by allowing users to register, classify and manage rules and verify consistencies between them. The methodology used within these engines can represent and reason based on prior experience to analyze or solve new problems' allowing for techniques in providing flexibility while responding to dynamic changes in the guise of user's requirements.

Layer	Category	Component	Component Description
Knowledge		Correlation	In statistics, correlation and dependence are any of a broad class of statistical relationships between two or more random variables or observed data values. Familiar examples of dependent phenomena include the correlation between the physical statures of parents and their offspring, and the correlation between the demand for a product and its price. Correlations are useful because they can indicate a predictive relationship that can be exploited in practice. For example, an electrical utility may produce less power on a mild day based on the correlation between electricity demand and weather. Correlations can also suggest possible causal, or mechanistic relationships; however, statistical dependence is not sufficient to demonstrate the presence of such a relationship.
Knowledge		Inference Engine	Engines that derive conclusions from facts and rules contained in a repository using various artificial intelligence techniques. Inference Engines are characterized by their use of forward chaining, backward chaining, hybrid chaining, and fuzzy Logic. These engines use a registry to include meta-information about the engine itself and its rules for adding new entries, identifying core inference rules, and associating core rules with the core inference engine. This type of engine works as an interpreter (matching rules), a scheduler (known criteria applied) and a consistency enforcer (execute or dismisses rule) and is often applied to a specific domain.
Knowledge		Reasoner	Constraint Engines are characterized by their use of case-base reasoning, constraint-based reasoning, and priority-based scheduling. This group of engines does not require specifying a step or sequence of steps to execute but rather the properties of a solution to be found. They are not limited to an explicit domain and the tasks become gathering case histories that are managed by database techniques that can manage large volumes of information, making maintenance easier
Knowledge		Relationships	Paradigms where relations between variables can be stated in the form of constraints, parameters or priorities.
Knowledge		Extraction	Data extraction is the act or process of retrieving (binary) data out of (usually unstructured or poorly structured) data sources for further data processing or data storage (data migration). The import into the intermediate extracting system is thus usually followed by data transformation and possibly the addition of metadata prior to export to another stage in the data workflow.[1] Usually, the term data extraction is applied when (experimental) data is first imported into a computer from primary sources, like measuring or recording devices. Today's electronic devices will usually present a electrical connector (e.g. USB) through which 'raw data' can be streamed into a personal computer. Typical unstructured data sources include web pages, emails, documents, PDFs, scanned text, mainframe reports, spool files etc. Extracting data from these unstructured sources has grown into a considerable technical challenge where as historically data extraction has had to deal with changes in physical hardware formats, the majority of current data extraction deals with extracting data from these unstructured data sources, and from different software formats. This growing process of data extraction from the web is referred to as Web scraping. The act of adding structure to unstructured data takes a number of forms, e.g., (1)Using text pattern matching also known as Regular expression to identify small or large-scale structure e.g. records in a report and their associated data from headers and footers; (2) Using a table-based approach to identify common sections within a limited domain e.g. in emailed resumes, identifying skills, previous work experience, qualifications etc using a standard set of commonly used headings (these would differ from language to language), eg Education might be found under Education/Qualification/Courses; and (3) Using text analytics to attempt to understand the text and link it to other information

Layer	Category	Component	Component Description
Information	Metadata	Vocabulary	Provides the technology to develop, establish, and sustain controlled vocabularies to facilitate better information organization and retrieval. Vocabulary Management Services is comprised of glossary, thesaurus, taxonomy and ontology services. Some of the vocabularies include: metadata for labeling documents, images, records, and other resources; and classification and structure for organizing, protecting and retaining all information assets, e.g., documents, records, and images.
Information	Metadata	Models	Business Model Manages the descriptive information of business models and their relationships to other model types, e.g., data, functional, technology. Supports the life cycle management of business model metadata, which includes descriptive information of the business, the business process and the business information assets. Data Model Supports the life cycle management of data model metadata. Manages the descriptive information of data models and their relationships to other model types, e.g., business, functional, technology. Functional Model Supports the life cycle management of functional model metadata. Manages the descriptive information of functional models and their relationships to other model types, e.g., business, data, technology. Technology Model Supports the life cycle management of technology model metadata. Manages the descriptive information of technology models and their relationships to other model types, e.g., business, data, functional.
Information	Metadata	Support	Provides the technology to develop, establish, and sustain controlled vocabularies to facilitate better information organization and retrieval. Vocabulary Management Services is comprised of glossary, thesaurus, taxonomy and ontology services. Some of the vocabularies include: metadata for labeling documents, images, records, and other resources; and classification and structure for organizing, protecting and retaining all information assets, e.g., documents, records, and images.
Information	Quality	Monitor	Information Quality Monitoring enables the assessment or monitoring of information to validate its syntactic and semantic correctness and its integrity. Uses business rules to enable assessment of information correctness.
Information	Quality	Analyze	Information Analysis Service enables the discovery of patterns, ranges, identifiers, categorization, structures, relationships, and components found in a body of information. These discoveries help drive out common vocabulary, models and their relationships for information consistency and reuse
Information	Quality	Report	Information Quality Reporting forms the basis for collaborative analysis and remediation
Information	Info Dissemination Mgt	Awareness	Functions that provide the ability to discover what information is available and determine what information has changed shall be contained in the Awareness Component. The Awareness Component regulates the availability of information with regard to discovery, registration, and change notification. The Awareness Component can also provide filter, translation, and registration functions as additional services.
Information	Info Dissemination Mgt	Access	Functions that permit applications to describe their information needs without having to know the originating location of the information shall be contained in the Access Component. The Access Component provides a centralized point in the system for components such as Information Brokering or Knowledge Management to understand information content and format needs of data consumers.
Information	Info Dissemination Mgt	Delivery	Functions that use underlying communications and storage infrastructure to disseminate information to the proper destination(s) shall be contained in the Delivery Component. The Delivery Component maintains integrity of the information while granting access to only authorized entities. The Delivery Component determines and utilizes the appropriate dissemination method (publish/subscribe, peer-to-peer, multicast, etc.) for the environment
Information	Info Dissemination Mgt	Support	Functions that provide interfaces to directory, security, operations, and schema management services to enable information awareness, access, and delivery shall be contained in the Support Component. The

Layer	Category	Component	Component Description
			Support Component provides a centralized point in the system for components such as the Information Broker to utilize the other components of the IDM Component group
Information	Business Analysis	Interactive	Interactive Analysis technologies provide the capability to interact with the report to better understand information that has been derived from historic data. They provide the ability to drill up / down / across.
Information	Business Analysis	Forecasting	Forecasting technologies use historical business data to create models that can be projected into the future to help predict business requirements, volumes, or performance
Information	Business Analysis	Mining	Data Mining technologies use statistical or AI (artificial intelligence) techniques to discover trends, patterns, and relationships in data that may not be immediately visible or may be counter-intuitive
Information		Message Oriented Middleware	Functions that allow an application to send a message to another application without the other application being available shall be contained in the Message Oriented Middleware (MOM) Component.The MOM Component provides an event-driven, synchronous or asynchronous, non-blocking, and message-based communication paradigm that guarantees message delivery to registered recipients of the information contained within each message. The MOM Component also provides high-speed, connectionless messaging services that are deployed to support multiple, concurrently-running applications dependent on data from common non-blocking providers of information. A distinct functionality provided by the MOM Component is the ability to receive information, without knowing the location of the source, and the ability of the source to publish information with some anonymity.
Information		Object Request Broker	Functions supporting client/server or service request/reply interactions between distributed objects over a network shall be contained in the Object Request Broker (ORB) Component. The ORB provides a framework for cross-system communication between objects. It allows applications at different locations, developed by different organizations to communicate via a network through an "interface broker."
Information		Video Processing	Video processing provides image matching. In terms of video codecs, video filters are divided into two types: Postfilters: used after decoding; Prefilters: used before encoding
Information	Content	Document	Document Management technologies manage the complete life cycle of critical business documents from collaborative authoring to archival; key features include robust auditable records, check-in/checkout, and versioning, annotations, workflow and life-cycle management
Information	Content	Component	Component Content Management technologies enable the creation, collection, staging, assembly, maintenance, and use of content components for the primary purpose of assembling documents. Components are content fragments that have independent identities, names, versions, and life cycles. Components are the basis for reuse among assembled documents
Information	Content	File Based	File-based content management services enable collaboration of content within the desktop office environment. Key features include search, versioning, enriched collaboration, limited workflow and limited life-cycle management.
Information	Content	Web Content	Web Content Management (WCM) technologies enable the collection, assembly, staging, maintenance and delivery of textual and graphic content for the primary purpose of disseminating information via the Web. The standard definition of WCM includes both a staging and delivery component.
Information	Content	Digital Asset	Digital Asset Management (DAM) technologies enable life cycle management of large collections of digital assets such as photographic images, graphics, brand logos and compound documents. DAM systems must include support for thumbnails, and an important feature is the ability to provide a large number of output formats for delivery across different communication channels such as the Web, CD-ROM and print for a single asset. DAM also encompasses media asset management and other specialized asset management systems as identified by the industry classifications.

Layer	Category	Component	Component Description
Information	Content	Parse	Tools enabling separation of text into structures.
Information	Conversion	Map	Information Mapping Service provides the mapping of information into an interchange structure necessary to support the synthesis and aggregation of information for delivery or presentation.
Information	Conversion	Synthesize	Information Synthesis Service provides for the compilation or aggregation of information to meet the requested criteria
Information	Conversion	Translate	Conversion of text from one language to another, i.e., natural language translation. Translation does not change the meaning of the information.
Information	Conversion	Mediate	Mediation provides a domain dependent set of standard format conversion functions at the edge of the network where there is a discontinuity from high quality information communication to potentially disconnected, intermittent and limited information communication
Information	Fusion		Provides a best estimate for true values of information obtained from multiple independent sources
Information	Retrieval	Search	Provides the means to find candidate data, information or metadata from an information collection or selected information class. Captures the criteria which support ranking and filtering, which help in the identification of candidate results. Enables the customization of the parameters that will be used to filter (determine) which candidate objects will be searched or retrieved
Information	Retrieval	Navigate	Provides the technology to browse information regardless of the media type or format. Navigation is usually accomplished by traversing some information structure. Navigation provides a mechanism that offers the user a clear and simple way to access all pages in a site, reflecting the site structure, even when the structure is complex.
Information	Retrieval	Subscribe	The Subscription Service provides criteria to identify candidate information and the types of notification required, the mechanism to subscribe to events against the candidate information and the required notification when the conditions have been met
Information	Report		Reporting technologies provide the capability to collect, organize, classify, rank, filter and manipulate data to present the derived information in a form that can be navigated and understood by a user with appropriate skills and experience
Information	Information Management Modeling	Development	Information model development service includes the methodology and tools that capture the information objects that support the business processes of the business. Captures the common business names, definitions, rules, and relationships that may result in classification schemes and information structures. It is organized into information structures, supported with information integrity rules. Addresses the quality and completeness of an information model and ensures that all information models are structurally consistent.
Information	Information Management Modeling	Implementation	This service translates a logical information model from a technology-independent model into a platform-dependent model that is a physical instantiation of the model, which includes all the physical attributes of the target platform, i.e., location, OS, language.
Information	Information Management Quality	Analysis	Information Analysis Service enables the discovery of patterns, ranges, identifiers, categorization, structures, relationships, and components found in a body of information. These discoveries help drive out common vocabulary, models and their relationships for information consistency and reuse.
Information	Information Management Quality	Monitor	Information Quality Monitoring enables the assessment or monitoring of information to validate its syntactic and semantic correctness and its integrity. Uses business rules to enable assessment of information correctness.
Data	Data Warehouse	Extract	Functions that support the manipulation of data [in a Data Warehouse] shall be contained in the Data Extraction Component

Layer	Category	Component	Component Description
Data	Data Warehouse	Transform	Functions that support the change of data [in a Data Warehouse] shall be contained in the Data Transformation Component
Data	Data Warehouse	Load	Functions that support the population of a data source with external data shall be contained in the Loading Component.
Data	Data Warehouse	Capture	Methods, techniques and tools to capture and propagate changes of sepcified data in a source system of interest to the target system.
Data	Quality	Cleanse	Functions that support the removal of incorrect or unnecessary characters and data from a data source shall be contained in the Data Cleansing Component.
Data	Quality	Monitor	Provides methods, techniques and tools to assess and monitor data according to business rules in order to validate syntactic, semantic, referential, and data integrity.
Data	Quality	Alert	Triggers actions by higher authority to potential errors
Data	Quality	Profile	Data Profiling provides the methods, techniques and tools to examine data record content to identify values, and relationships, and to discover issues such as inconsistent data range, and use of null values
Data	Quality	Structure	Data Structure provides the methods, techniques and tools to examine data structure to identify formats, and relationships, and to discover issues such as inconsistent data format.
Data		Performance Monitoring and Tuning	Performance monitoring and tuning services provide management of response times and efficient allocation of data resources. Elements include data access performance monitoring, evaluation, and operational parameter adjustment.
Data		Metadata	Functions that define or describe data shall be contained in the Metadata Management Component.
Data		Archiving	Functions that support the preservation of a data with internal source data shall be contained in the Archiving Component.
Data		Data Mart	Functions that support a subset of a data warehouse for a single department or function within an organization shall be contained in the Data Mart Component.
Data	Digital Asset Management	Content	Functions that manage the authoring, storage, maintenance and retrieval of documents and information of a system or website shall be contained in the Content Management Component. Content Management includes the Content Authoring, Content Publishing and Delivery, Content Review and Approval, Syndication Management, and Tagging and Aggregation elements.
Data	Digital Asset Management	Record	Functions that support the storage, protection, archiving, classification and retirement of documents and information shall be contained in the Record Management Component. Record Management contains the Digital Rights Management, Document Classification, Document Retirement, Record Linking and Association elements.
Data	Digital Asset Management	Document	Functions that support the management of documents and artifacts, both electronic and physical shall be contained in the Document Management Component. The Document Management Component includes the Categorization, Document Conversion, Document Imaging and OCR (optical character recognition), Document Referencing, Document Review and Approval, Document Revisions, Indexing, Library and Storage elements.
Data	Digital Asset Management	Storage	Management of storage devices, RAID support, printers, adapters, buses, and pseudo-devices such as logical volumes, volume groups, physical volumes, and paging spaces, as well as print queues and print jobs in both local and remote queues shall be included in the Resource Management Component.

Layer	Category	Component	Component Description
Data		Classify	Functions that support the classification of data [in a Data Warehouse] shall be contained in the Data Classification Component. Data Classification includes the Pattern Matching, Precision and Recall Ranking, and Query elements.
Data		Verify	Functions that support the confirmation of authority to enter a Data Warehouse shall be contained in the Verification Component.
Data		Audit	Mechanisms to trace administrative actions and subject/user authorizations and accesses shall be contained in the Auditing Component. Elements include accountability of subject-to-object access/usage, special protection, in the form of encryption, digital signing, and/or message digest (MD5) against inadvertent or malicious alteration or substitution, This component facilitates intrusion/attack attribution by eliminating authorized subjects/principals as possible sources, and supports non-repudiation and detection of illegal activities by those that misuse/abuse their privileges, as trusted insiders. ATL capability could make use of the Logging Component, provided it satisfies rigor for security ATL purposes.
Data		Backup and Recovery	Performance of incremental (delta) and full backups of operating system files, application software files, and/or source data files for single and/or networked computer systems shall be contained in the System Backup Administration Component. In some cases it may include software to capture, compress, and incrementally restore operating system or other volume images.
Data		Distribution and Data Exchange	Functions that support the distribution and interchange of information between multiple systems or applications [to or from a Data Warehouse] shall be contained in the Data Exchange Component. Elements include Distribution and Interchange.

A.6 Comparison of Net-Centric Definitions

Table A.6-1 describes the sources of the definition for net-centricity contained in Section 2.

Table A.6-1. Comparison of Net-Centric Definitions

DOD-CIO/NII	Joint Capability Areas Lexicon:	DoDD 8000.01	NCOIC Lexicon	From Wiki:
Net-Centricity is the DoD's vision for a global,Internet/web-enabled environment that ensures user-focused information sharing. Rather than viewing information handling from the perspective of an information producer, net-centric operations instead views it from that of a user (whether human or software agent). The nature of a net-centric environment is complicated because of the people, processes, and organizations involved, and the wealth of information housed within the DoD and its mission partners. That said, there are several key attributes that characterize it. First and foremost, it must adapt Internet and World Wide Web constructs and standards. It must also be a "smart pull" atmosphere, in which users can find and pull information directly, subscribe, or use value-added services to obtain the information they need. Perhaps most critical, however, is the ability to post in parallel. Publishers must make information visible and accessible without delay so users get the information when and how they need it. http://cio-nii.defense.gov/docs/NetCentricAttributesOfficial.pdf	Net-Centric: The ability to provide a framework for full human and technical connectivity and interoperability that allows all DoD users and mission partners to share the information they need, when they need it, in a form they can understand and act on with confidence, and protects information from those who should not have it. http://www.dtic.mil/futurejointwarfare/strategic/jca_framework_defs.doc	Net-Centric. Relating to or representing the attributes of a robust, globally interconnected network environment (including infrastructure, systems, processes, and people) in which data are shared timely and seamlessly among users, applications, and platforms.	Net-centricity: A system perspective that views system components as network nodes. Net-centricity focuses on the problem of allowing authenticated, trusted, and verified information to be provided and shared among authorized users, applications, and platforms in a seamless fashion without a priori knowledge of what information is available or needed. Enabled by current and emergent networks and network technologies, net-centricity describes the approach to designing new systems that interoperate with existing networks, and the benefits of interoperating with existing applications and services. Synonyms: Net-Centric, Network Centric.	Netcentric, or "network-centric", refers to participating as a part of a continuously-evolving, complex community of people, devices, information and services interconnected by a communications network to optimize resource management and provide superior information on events and conditions needed to empower decision makers. Many experts believe the terms "information-centric" or "knowledge-centric" would capture the concepts more aptly because the objective is to find and exploit information, the network itself is only one of several enabling factors along with sensors, data processing and storage, expert analysis systems and intelligent agents, and information distribution.

A.7 Information Curation Plan Content

The following is a typical outline of an Information Curation Plan:

- System Description
- Referenced Documentation
  - Regulations
    - System Documentation
      - Development Documents
      - Interface Description
    - External Regulations
      - Legislation
      - National and International Standards
      - Licenses
      - Policies
      - Frameworks
    - Internal Regulation
- Data hierarchy
    - Data pool
    - Access Data
    - Governance- und Process-data
    - other building blocks
- Individual descriptions
  - Content (Relevance)
  - Owner
  - User
  - Stakeholder
  - Information Life Cycle
  - CRUD
    - Access restrictions
    - Secondary usage
      - Information Warehouse
    - Archiving
      - Comparison to previous values
      - Provision for decision support
      - Prediction
- Continuous Product Improvement
    - Assessment of stored data values
    - Quality of values and format as stored
    - Usefulness determination