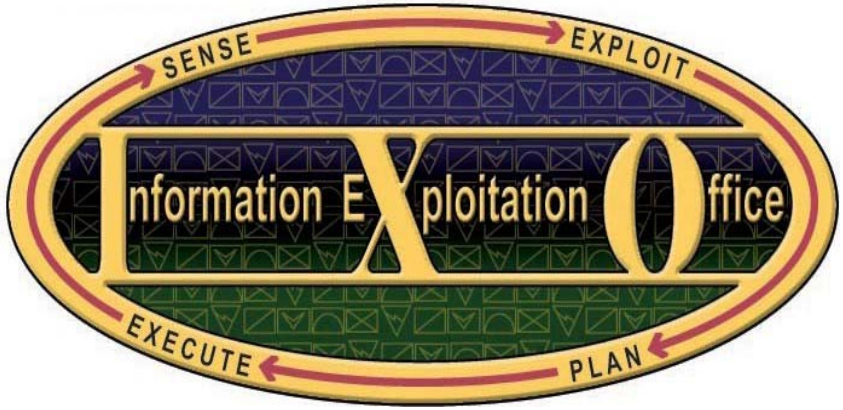

DARPA Agent Markup Language (DAML)

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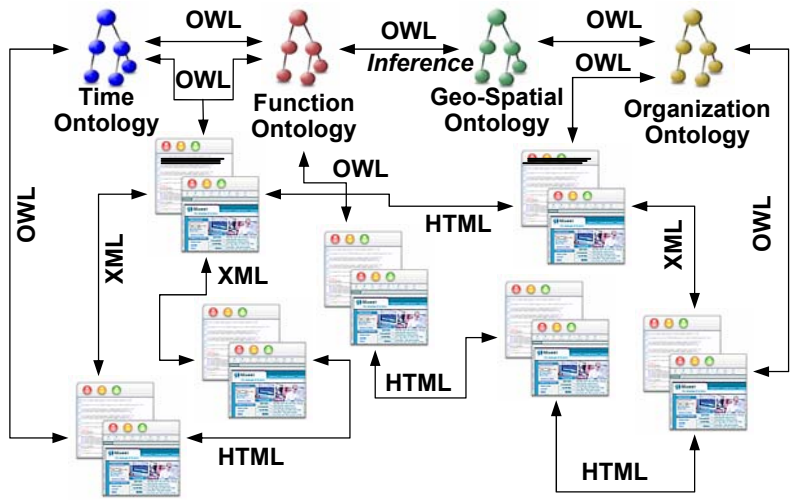
Where DAML is Taking the Web

The WWW has been primarily about presenting documents and data to people – we have created a revolutionary *web of data* by using HTML over HTTP to create the hypertext web

The direction of WWW research is toward exploiting the data on the web to link machines – to create a *web of capability* by using RDF/OWL over HTTP to create a knowledge web

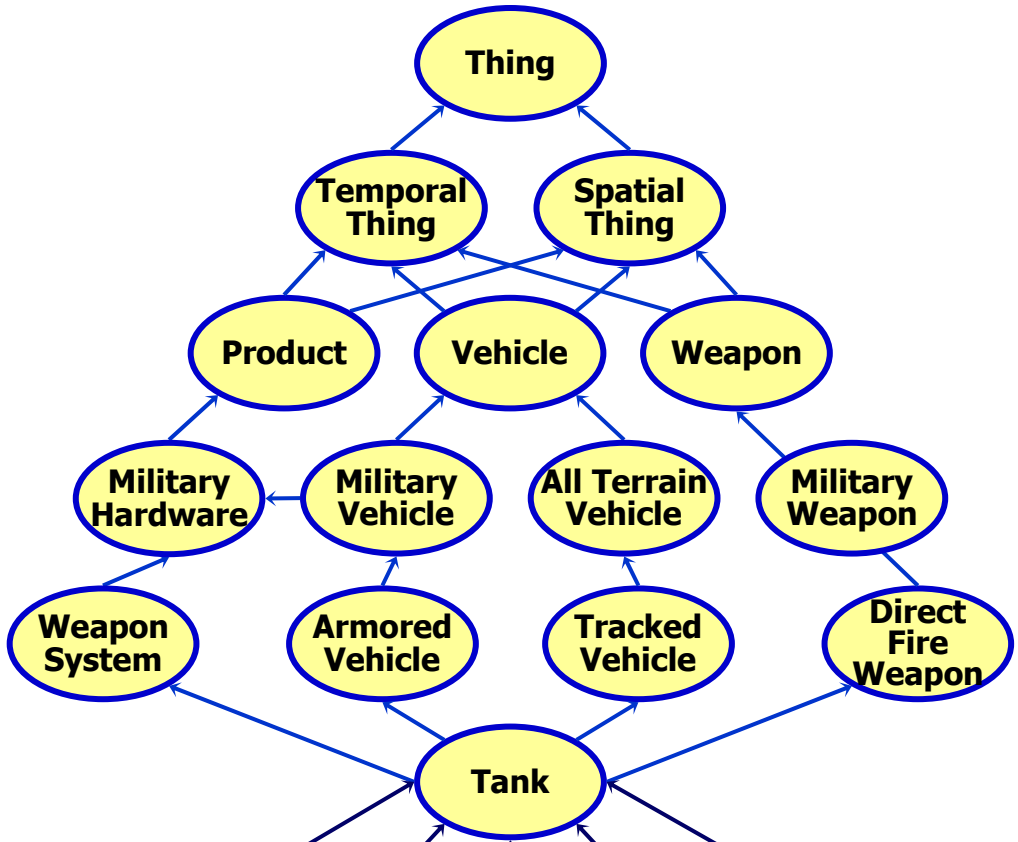
- Critical components of C2I are moving to the Web
  - Information sources (text, imagery, plans, email, GCCS…)
  - Sensor control and tasking
  - Logistics support
- Current Web Technology Is Not Machine Processable
- DAML enables the Semantic Web - Machine readability with very rich semantics to support web-based software for:
  - Intelligence Analysis and Production
  - Military Planning and Operations
  - Software C4ISR Agents
  - Sensor Fusion



The DAML Vision: Adding Formal Knowledge Structures (Ontologies) via RDF/OWL Markup in order to make the Web Machine Processable

What do we mean by an Ontology?

Ontology / Schema (Semantics of the Data)



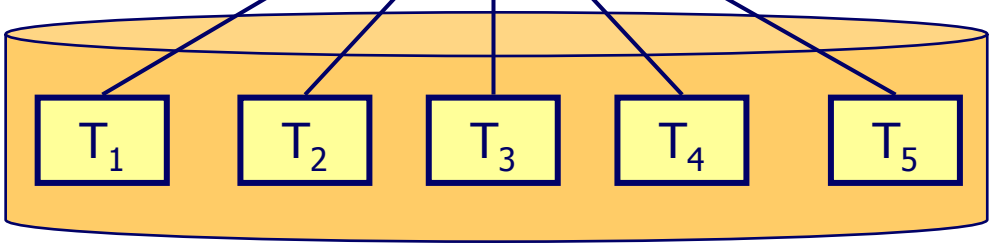
Vocabulary (Terms)

- Concepts (Types)
- Predicates (Relations)

Axioms (Statements)

- Definitions
- Constraints
- Axioms
- Rules

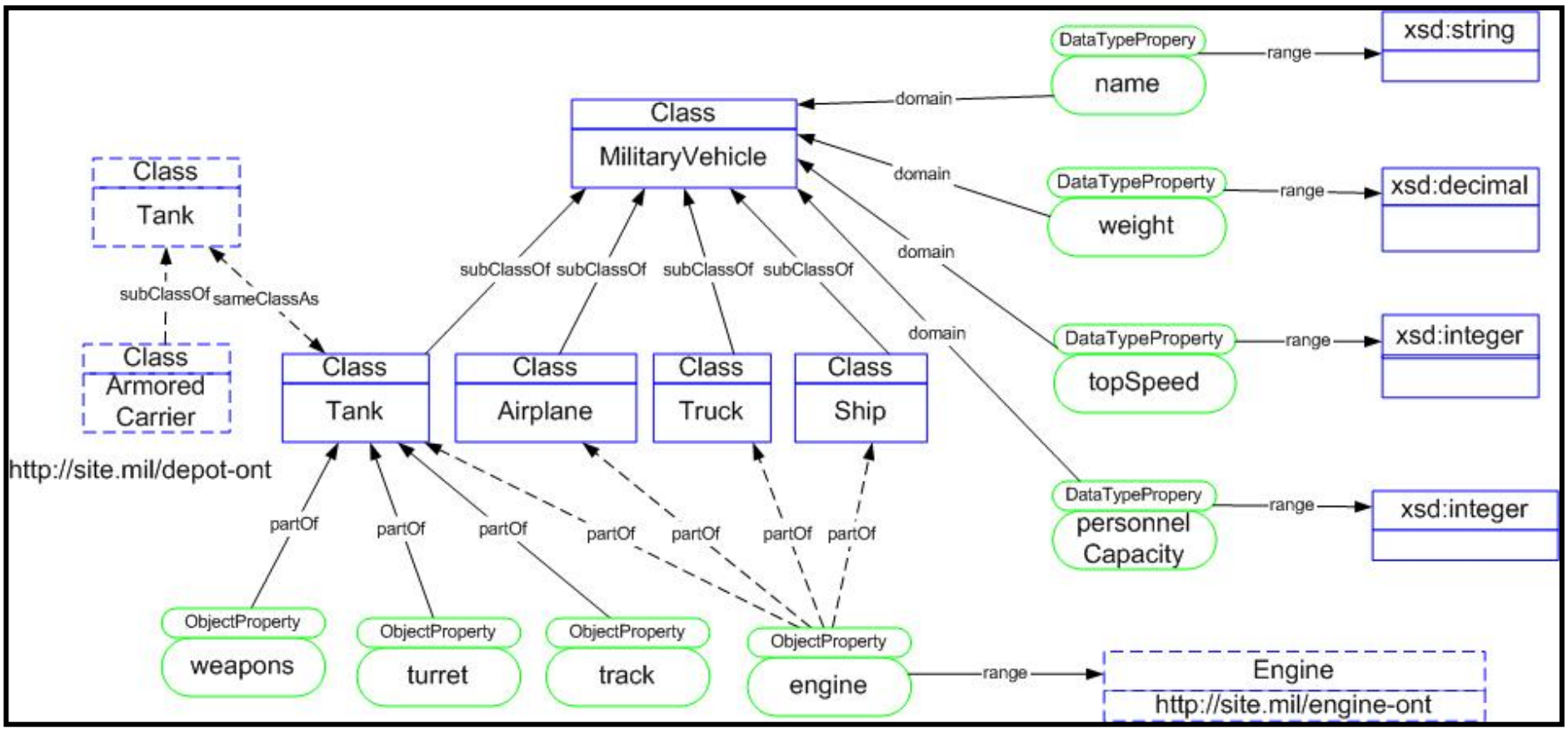
Data (Instances)



Data

- Instances of Concepts
- Instances of Predicates

A Sample DAML Ontology



- Multiple types of links
- Classes, objects, and instances
- Networked ontologies with partial overlaps
- Compatible with XML and RDFS
- Based in Description Logic
- Supports tractable inference

DAML = XML + Ontologies

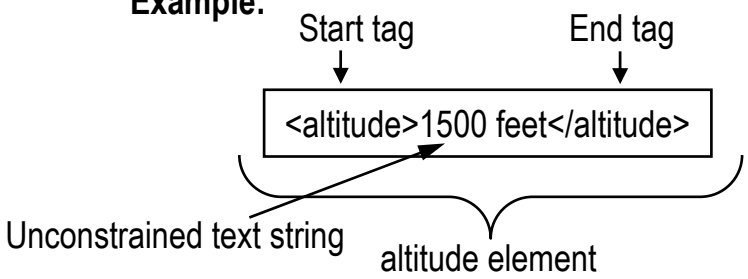
- The concepts and relationships that describe sets of information
- The AI field of knowledge representation has been developing ontologies for years
- DAML uses classes, properties and specific types of relationships between classes and properties to express ontologies
- Ontologies can represent generalized relationships as well as specific instances
- DAML is specifically designed to create ontologies in a distributed web environment

DAML has created a Web Ontology Language (OWL) to enable creation of a *Web of Knowledge*

Web Languages: From XML to OWL

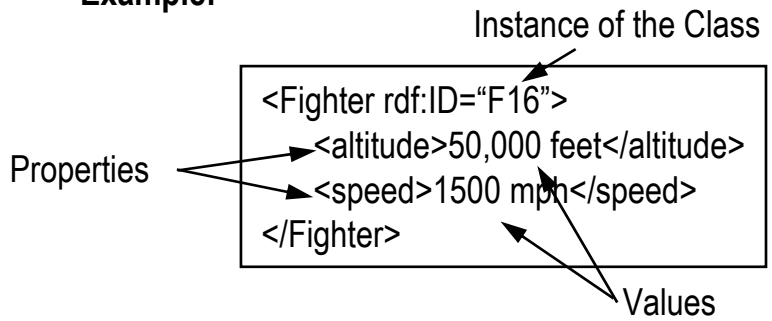
XML

Issue addressed: how to express data in text?
XML Solution: "wrap" data within start tag/end tags, and empower users to create their own tags
Example:



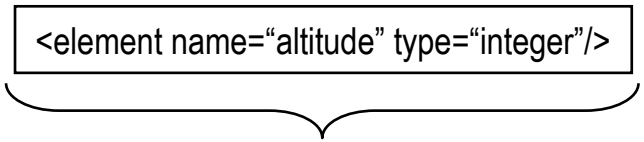
RDF

Issue addressed: how can data be classified by type?
RDF Solution: use an *class, property, value* pattern
Example:



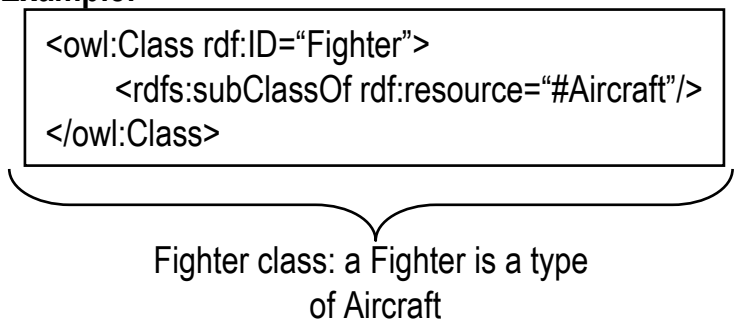
XML Schema (XMLS)

Issue addressed: how should the structure of the data be expressed?
XML Schema Solution: XML templates
Example:



DAML's OWL

Issue addressed: how to express data semantics?
OWL Solution: use a description logic
Example:



HTML → XML & XMLS → RDF → OWL

OWL is a W3C Recommendation

World Wide Web Consortium Issues RDF and OWL Recommendations

Semantic Web emerges as commercial-grade infrastructure for sharing data on the Web

Contact Americas, Australia -- Janet Daly, <janet@w3.org>, +1.617.253.5884 *or* +1.617.253.2613
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(This press release is also available in French and Japanese)

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http://www.w3.org/ -- 10 February 2004 -- Today, the World Wide Web Consortium announced final approval of two key Semantic Web technologies, the revised Resource Description Framework (RDF) and the Web Ontology Language (OWL). RDF and OWL are Semantic Web standards that provide a framework for asset management, enterprise integration and the sharing and reuse of data on the Web. These standard formats for data sharing span application, enterprise, and community boundaries - all of these different types of "user" can share the same information, even if they don't share the same software.

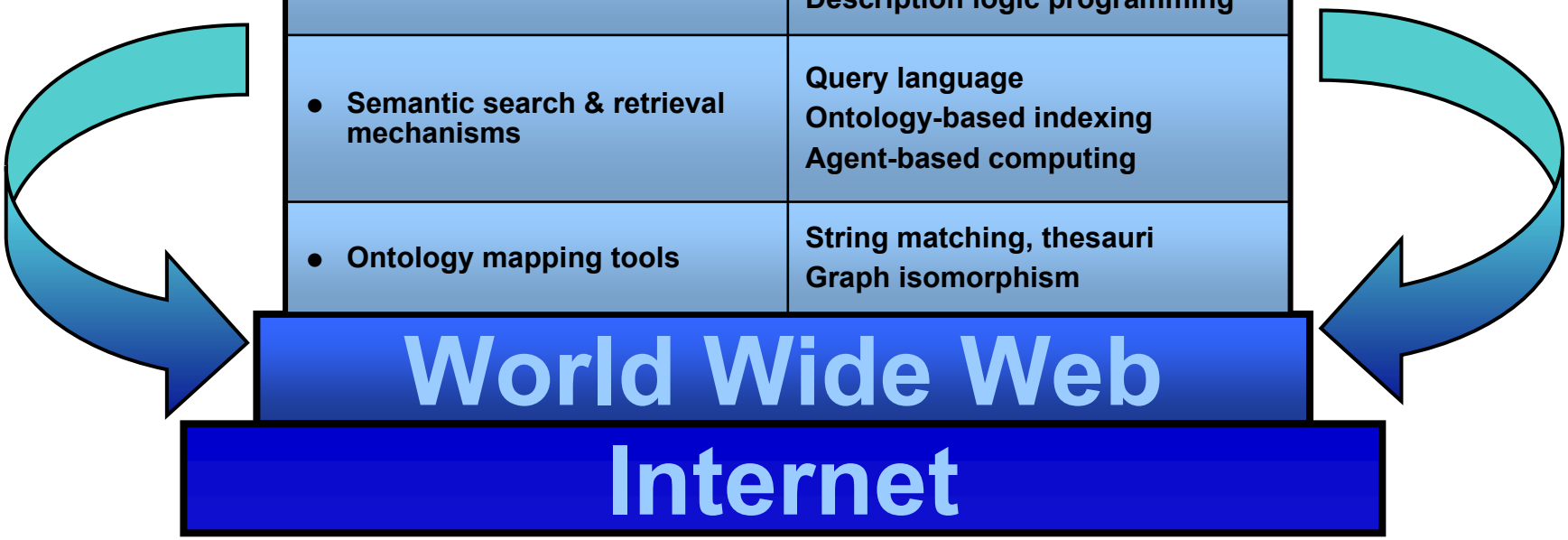
Today's announcement marks the emergence of the Semantic Web as a **broad-based, commercial-grade platform** for data on the Web. The deployment of these standards in commercial products and services signals the transition of Semantic Web technology from what was largely a research and advanced development project over the last five years, to more practical technology deployed in mass market tools that enables more flexible access to structured data on the Web. Testimonials from enterprise-scale implementors and independent developers illustrate current uses of these standards on the Web today.

DAML Tools Make OWL Real

*Supplying the essential **semantic layer** to today's Web*

Tools	Tech Approach
• Ontology editors, browsers, servers	Description Logic
• Annotation tools	Ontology-based natural language processing
• Inference engines	Theorem proving Description logic programming
• Semantic search & retrieval mechanisms	Query language Ontology-based indexing Agent-based computing
• Ontology mapping tools	String matching, thesauri Graph isomorphism

- Scaleable
- Interoperable
- Open



DAML Specific Tools by Category

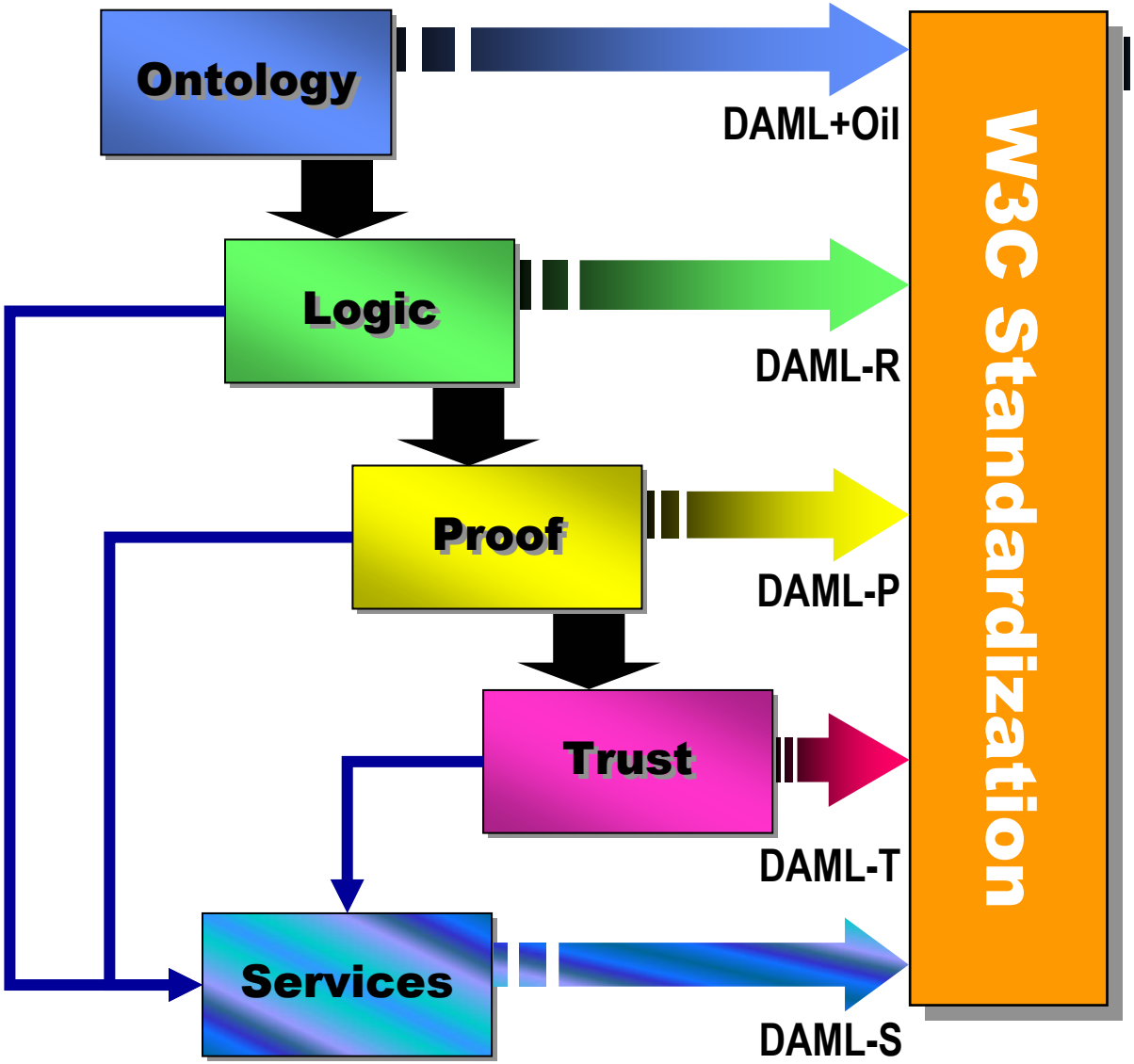
http://www.daml.org/tools/

Category	Tool
DAML Annotation	AeroDAML
DAML API	DAML API
DAML API	DAMLJessKB
DAML API	Jena
DAML Browser	DAML Markup Tool
DAML Browser	DAML Sidebar
DAML Browser	HyperDAML
DAML Browser	OntoDoc
DAML Crawler	DAML Crawler
DAML Crawler	RDF Crawler
DAML Editor	DAML Emacs Mode
DAML Graph Visualization	DAML VisuaLinks
DAML Graph Visualization	IsaViz
DAML Graph Visualization	Object Viewer
DAML Graph Visualization	VisioDAML
DAML Markup tool	Semantic Markup, Ontology & RDF Editor (SMORE)
DAML Transformation	DAML/XSLT Adapter
DAML Validator	DAML Validator
DAML Viewer	DAML Viewer
DAML Viewer	PalmDAML
Export	OWL Converter
Import	Excel to RDF converter
Import	PDDL to DAML Translator
Import	RDF Web Scraper
Import	Unicorn System
Import	XML Schema to DAML Translator
Inference Engine	owm
Inference Engine	Euler proof mechanism
Inference Engine	Java Theorem Prover (JTP)
Inference Engine	OpenCyc
Inference Engine	TRIPLE
Knowledge Base	OpenCyc

Category	Tool
Knowledge Base	OpenCyc
Ontology Analyzer	Chimaera
Ontology Analyzer	ConsVISor
Ontology Analyzer	DAML+OIL Ontology Checker
Ontology Editor	DAML+OIL Plugin for Protege 2000
Ontology Editor	DAML UML Enhanced Tool (DUET)
Ontology Editor	OilEd
Ontology Editor	OntoEdit
Ontology Editor	Unicorn System
Ontology Library	OntoMap.org
Ontology Translation	Articulation Service
Ontology Translation	OntoMerge
OWL Validator	OWL Validator
Persistence	DAML DB
Persistence	Jena
Persistence	Sesame
Query	Sesame
RDBMS Mapping	KAON-REVERSE
RDBMS Mapping	Unicorn System
RDF/DAML Authoring	RDF Instance Creator (RIC)
RDF Parser	DAML dotnetAPI
RDF Parser	Drive
RDF Parser	Jena
RDF Parser	Jena Location Modification
RDF Parser	RDF API
RDF Parser	Source and Dynamic Loading Extensions for Jena
RDF Parser	Wilbur RDF Toolkit
RDF Query	Algae
RDF Query	Jena
Report Generation	Webscripter
Search Engine	DAML Semantic Search Service
XML Editor	RDFedt

See also: http://www.semwebcentral.org/

Overall DAML Strategy: *Beyond Ontologies*



OWL
Web Ontology Language

The first step!

Formal Semantic
Underpinnings
Guarantee
Consistency

Model-Based

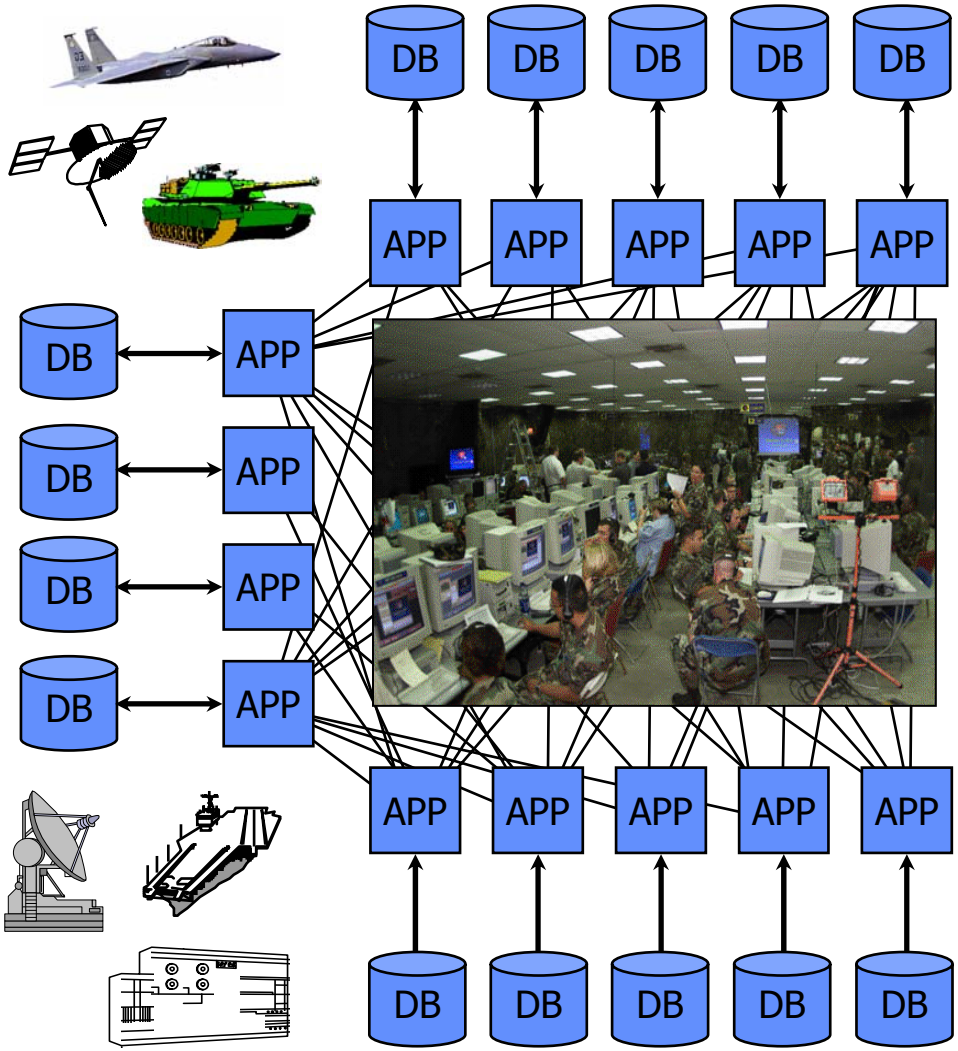
Axiom-Based

From Ontology Description to C2I Software Interoperability

- **The goal of the DAML Program is to use explicit ontologies, web technologies, and agent systems in order to achieve software/data interoperability and composability**
  - The DAML ontology description language is the foundational technology for the semantic web revolution
  - OWL allows data mark up with precise terminology, so searching and browsing become even more effective
  - OWL's DL basis and axiomatic semantics allow *subsumption* reasoning to fill certain knowledge gaps

- **From Description to Interoperability**
  - DAML/Logic – Include a rule language in DAML to allow users to not just describe their ontologies, but also to specify non-class relationships between elements
    - Allow OWL to express relationships like "in this database, a battalion B is operating in an area A if B has a company C and C is operating in A."
    - Allow OWL applications to include arbitrary relationships between element classes
    - Allow OWL-described services to specify preconditions, postconditions, and exceptions
  - DAML/Proof – Include a specification for using DAML logic and rule elements to construct supports and refutations
    - Allow OWL applications to add confirming or disconfirming information for a DAML assertion
    - Allow OWL to express general processes, like negotiations
  - DAML/Trust – Include a specification for using DAML proofs to describe information provenance and pedigree
    - Allow OWL applications to reason about trustworthiness of information sources

The Military Problem: Fragmented Information



- **Information overload**
  - Need to get the *right* info to the *right* person at the *right* time.
- **Individual Stovepipe Systems**
- **Little Interoperability**
  - Joint Operations
  - Coalition Warfare
- **Difficult to Integrate**
- **Labor Intensive Collection and Coordination**
- **Scattered Snapshots of the Battlefield**
  - Different views
  - Different times
  - Different names
- **Fraction of the Information Sources Used**

Selected DAML Transitions

Selected Pilot Projects that Show how Different Services Use OWL to Integrate Information

- AF-AMC: Foreign Clearance Guide (FCG)
- AF-AMC: Notices To Airmen (NOTAMs)
- AF-AFRL: Joint Battlespace Infosphere (DAML-JBI)
- ONR: Expeditionary Pervasive Sensing (EPS)
- Army Knowledge On-Line (AKO)

Summary

Opportunity

- Military adopting WWW technologies extensively (HTML/XML)
- OWL builds upon and extends HTML/XML to provide information "meaningful" to computers
- Enormous military and world wide commercial interest in OWL because of W3C acceptance

Approach

- Networks of linked ontologies are at the heart of the OWL idea
- Extensive set of prototype DAML tools under development

Transition

- Several pilot projects in DoD; OWL-enabled commercial software is being readied now by a large number of significant software vendors
- Tools being finalized and ready for use