VerticalNet Solutions
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COMMUNICATION AND COLLABORATION IN A LANDSCAPE OF B2B eMARKETPLACES

A Business White Paper

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Further information can be obtained at www.verticalnetsolutions.com, or www.verticalnet.com

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Introduction And Summary

Successful digital markets will provide the simplicity and sophistication required to create a substantial value proposition for major buyers and sellers in the B2B economy.

It is common to read that the destruction and reconstruction of the modern corporation is at hand. Recent studies from Morgan Stanley Dean Witter (2000), Forrester (2000), McKinsey and a new book by Tapscott (2000) draw on the early work of Coase (1937) and Williamson (1975) to develop a dramatically new view of the Internet-based enterprise. The consensus conclusion is clear: the Internet has indeed "changed everything" and is rapidly transforming both supply and demand chains into business webs of collaborative electronic commerce. Thus the focus is no longer on the enterprise per se but rather on its partnerships and relationships.

At the same time, the rise of Internet-based Business to Business (B2B) digital marketplaces (from catalogs to auctions to spot exchanges to automated RFQs) is progressing rapidly in many industries as new software platforms are implemented and links to legacy computer systems are developed. No-one doubts the new fact of life that the networked economy will dramatically transform the landscape of corporate transactions.

Despite the widespread acceptance of these two important trends, there has been surprisingly little research that ties the two together. How will business webs operate in this landscape of digital markets? What new building blocks will be required? How will the modern enterprise remain connected as it disperses functions and tasks to partners? What are the critical success factors of competitors in this new environment? We offer three observations to help outline some answers:

1. Intelligent software agents ("bots") and the XML platform will play key roles in connecting business webs and digital marketplaces. But it is becoming clear that a more advanced infrastructure will be needed as the enterprise disperses into the web. We believe that both ontologies and interoperability will play important roles as B2B relationships evolve in the networked economy.

2. Interoperability—the way information and transactions are processed among entities, firms, and markets in the new digital economy—will be a key to survival as multiple standards proliferate and webs of marketplace consortia multiply. "Bankcard ubiquity"—the internetworking of diverse systems in a common, easy to use, and widely-accepted format— will be an important objective of all participants since it solves important customer, supplier, and partner coordination problems.

3. Ontologies—intelligent blueprints of the new Internet-based economy—will be critical as commercial data describing information and transactions is reorganized to effectively operate in a world of digital marketplaces. This framework will become a fundamental building block in the transition to knowledge-bases with formats useful for intelligent processing by myriad forms of software, people, and intelligent agents.

This last observation is extremely important as digital marketplaces transition from myriad homegrown environments to industrial strength global software platforms. It is clear that the architects of the new digital economy will need to provide mediation and translation support for a wide variety of trading cultures and operating procedures. The challenge to software developers is to provide a framework upon which a marketplace infrastructure can be built, without enforcing a uniform standard mode of operation on all participants. This goal is readily achievable with the right approach. And we believe that the answer is based on the new science of ontology.

The observations in this study are designed to begin new dialogues among buyers, sellers, intermediaries, as well as infrastructure builders, software architects, content developers, and investors. Our framework involves approaches defined by the traditional disciplines of economics, management, finance, computer science, artificial intelligence, and linguistics. In this setting, we seek to help outline an innovative blueprint for the enterprise in the networked economy—a world where business webs flourish in a landscape of digital marketplaces. And competing in the networked electronic economy will require state of the art technology to efficiently capture the benefits of Internet-based B2B digital marketplaces.

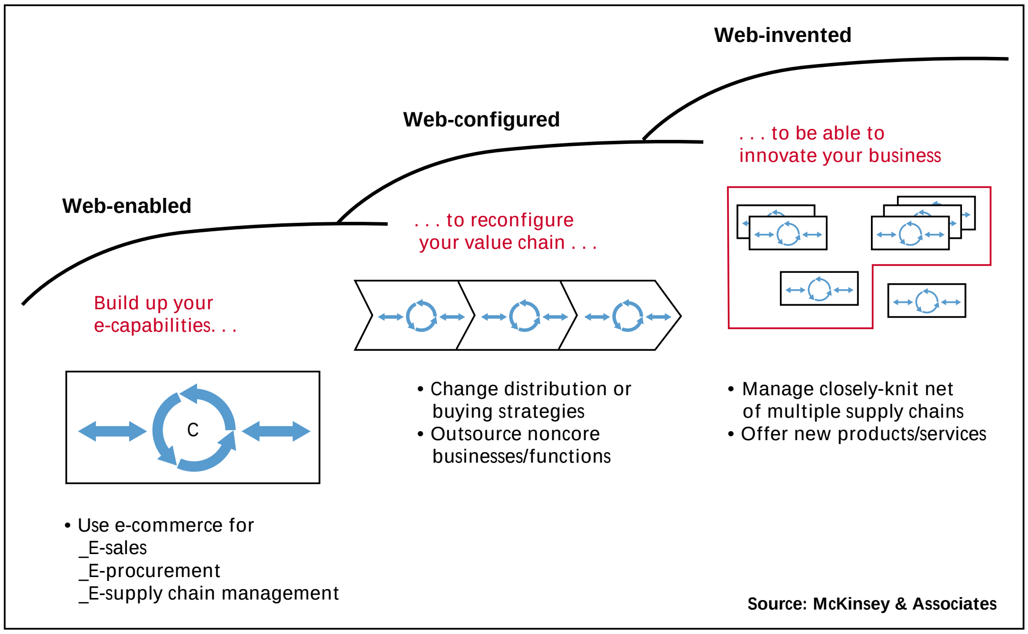

Figure 1. Evolution of Companies via the Web

Transaction costs, business webs, and the reorganization of the firm

As the digital economy evolves, there will be an increasing tension between the functions of the marketplace and the role of the firm. Indeed, the changing relationship between the two is a critical feature of the developments that we see on the horizon. For example, there will be constant questions for companies as to what functions to perform on its own and what functions to outsource to other participants in the marketplace. In a sense, these ideas simply flesh out the fundamentals underlying the views of McKinsey in *Figure 1.* There, firms in the economy progress through three Internet-caused stages: web-enabled, web-configured, and web-invented. In the web-enabled stage, firms build up their e-commerce capabilities. In the web-configured stage, firms reconfigure their supply and demand value chains to increase efficiency. Finally, in the web-invented stage, firms innovate their value proposition to transform into a truly flexible organization that dynamically assembles virtual products to quickly take advantage of fast-moving market opportunities.

> ***A firm has therefore a role to play in the economic system if transactions can be organized within the firm at less cost than if the same transactions were carried out through the market.***
> ***—Ronald Coase (1937)***

In our view, McKinsey's analysis is simply the logical outcome of the integration of the cost-efficient Internet infrastructure with the transaction cost economics observations of Coase (1937) and Williamson (1975). That branch of economics states that the enterprise will expand until the cost of conducting transactions among groups within the firm is greater than the costs of conducting transactions via marketplaces, external partners, and external buy-sell relationships. Thus the lower connectivity costs of today's Internet -- via Moore's Law, Metcalfe's Law, and low-cost telecom bandwidth -- imply that firms will naturally begin to disperse certain parts of its operations into combinations of alliances, partnerships, and assorted cyberspace relationships.

A more-focused description is provided in the recent book by Tapscott, Ticoll, and Lowy (2000) where they define a new concept:

"A business web is a network of suppliers, distributors, commerce service providers, and customers that conduct business over the Internet to produce value for end- customers and for each other."

Again, this is a relatively straightforward application of transaction cost economics—keeping in mind that there remain costs associated with the development and coordination of external relationships as well as the costs required to establish the trust needed for truly liquid electronic commerce. Thus while firms in the late 1960's formed conglomerates to economize on transaction costs with external companies, today we see just the reverse. The government-funded Internet infrastructure, combined with the extensive software platforms of myriad venture capital—backed companies, provides a sound foundation for a cost-efficient dispersal of large sections of the modern enterprise in many industries. B2B digital marketplaces are just one component of the new platform.

Integrally related to this development is an evolving view of how the enterprise (and the economy) views labor, more recently referred to as 'human capital'. Many believe that the Internet dramatically empowers individual employees because their own transaction costs of finding and changing employers have also been lowered significantly in the networked economy. The recent work of Davis and Meyer (2000) extends this view by noting that labor should not be treated as an expense but more accurately as a form of capital. Consequently, labor represents a cumulative investment that should be recorded in balance sheets as an asset. Taken to an extreme, individual employees might even have a market capitalization much like companies today; and eventually shares in labor 'superstars' could be bought and sold in market exchanges.

Along this vein, several observers have noted that a "movie production model" may come to characterize a significant number of business operations. That is, an ad hoc (but complete) business web organization comes together temporarily via the Internet—bound by secure contracts and trusted relationships—in order to achieve a given objective. Capital, raw materials, labor, process, and technology all are assembled at short notice via low cost digital marketplaces on the Internet. In this orientation, one can envision the modern enterprise as a combination of four components: the buy-side, the sell-side, the invest-side, and the 'inside.'

Evans and Wurster (2000) extend the model even further by focusing on the breakup of firms into relationships in a geographic market. They describe Silicon Valley as a super-structure of technology and economic forces:

"Individual firms come and go—temporary alliances of people pursuing specific, narrowly defined projects. The more permanent reality is the fluid business eco-system within which these firms compete. In some ways, Silicon Valley performs as a large, decentralized corporation. The Valley, not its constituent firms, owns the labor pool. The Valley, through its venture capital community, starts projects, terminates them, and allocates capital among them."

While this represents a fairly radical view, there are real-world examples that show the beginning of its implementation. For example, John Chambers, the CEO of Cisco, once noted, "We have 32,000 employees, but only 17,000 work at Cisco." Those that do not work at Cisco were trusted alliance partners. There is no doubt that the Internet will enable a further acceleration of this trend to a world where the business web revolutionizes commerce—essentially treating everything as a Lego-like platform: according to Tapscott, Ticoll, and Lowy (2000), the participants will provide value-added capabilities that plug in as they are needed. Yet again, we return to the observations of McKinsey in Figure 1. . . particularly the web-invented stage of Internet-caused business process innovation.

From a slightly different and more concrete perspective, *Figure 2* presents a typical digital marketplace that supports online catalogs, auctions, exchanges, and automated RFQ / RFP systems. As commerce increases rapidly in this environment, B2B digital marketplaces must now communicate with buyers, sellers, intermediaries, and end-customers with an efficient and Internet-based technology. The opportunities for cost reduction and consequent stock price appreciation are substantial as Morgan Stanley Dean Witter (2000) and Credit Suisse First Boston (2000) detail.

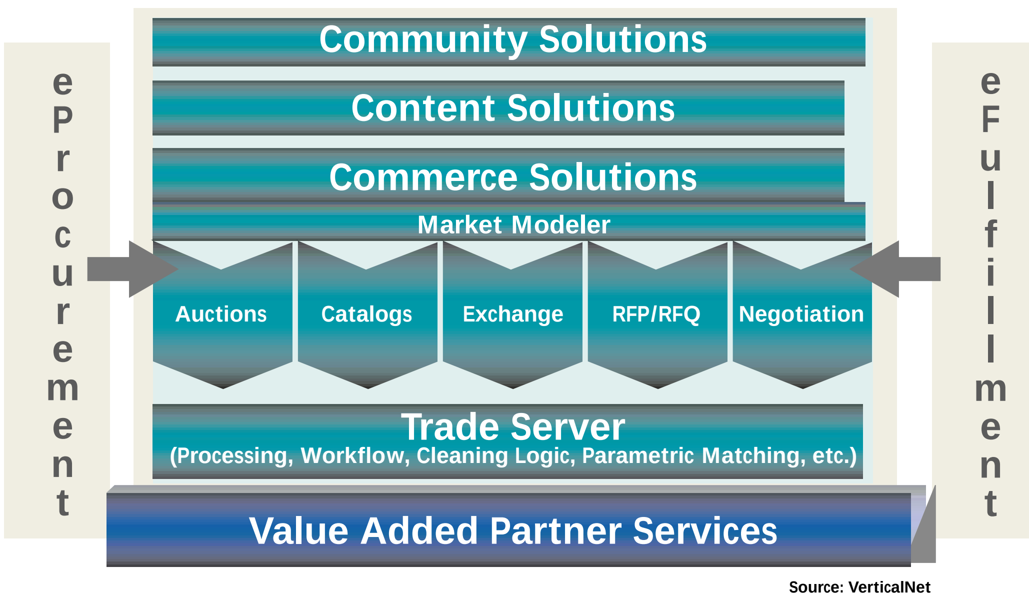

Figure 2. Digital Marketplace Architecture

But firms still need to remain connected as an enterprise at the same time as they are outsourcing to, and coordinating with multiple new partners. Thus there is an increasing need for interconnection and interoperability among these new economic entities in cyberspace. How does the traditional enterprise disperse a cost-efficient amount of its activities into the more open digital market infrastructure and yet still maintain control and focus? The answer is clear: firms and individuals will need a kind of "connectivity glue" among buyers, sellers, marketplaces, and partners. At the same time, some type of cyberspace map or digital blueprint will be required for both humans and software agents to navigate this new and essentially invisible landscape. And, using the transactions cost framework discussed earlier, it is clear that the costs of connectivity must remain below the savings gained in order for the new dispersed enterprise model to flourish.

Certainly, business has always been conducted within a framework of community—a meeting of buyers, sellers, and partners in both public and private market places. And as the economy transitions to the Internet, B2B digital marketplaces will play a key role in the development of these diverse business communities. But, in order to achieve the goal of a substantial reduction in transaction costs, we must exploit and extend the current e-commerce infrastructure to enable even more meaningful business interactions and relationships. In addition to the widely publicized descriptions of the XML platform and intelligent software agents, we believe that deeper fundamentals will be needed in order to develop the next stage of the networked economy; these involve both interoperability and ontologies.

Interoperability, software agents, and ubiquity

Interoperability—the way information and transactions are processed among entities, firms, and markets in the new digital economy—will be a key to survival as multiple standards proliferate and webs of marketplace consortia multiply.

Industry analysts now estimate that as many as 800 vertical market digital exchanges have been launched so far with another 1200 expected by the end of the year 2000. But few B2B players currently provide true end-to-end solutions and value-added services on a large scale. While it is certainly true that several companies are working on solutions to connect back-end operations to open digital marketplaces, the issue has more advanced dimensions.

Consider, for example, the transportation company that would like to sell capacity to customers via chemical, plastics, and steel digital marketplaces. As a second example, consider the large enterprise that buys chemicals, plastics, and steel for use in production. In a third context, consider the widely discussed case of the large enterprise with complicated back-end processes that need to be connected to the buy-sell operations of digital marketplaces. Fourth, consider the case of a vertical industry marketplace with an order to buy or sell that it cannot fill. How should it communicate with other competing (and cooperating) marketplaces in order to attempt a completion of the transaction?

Clearly, companies and markets today cannot implement the multiple number of software translation mechanisms that will be required tomorrow. After all, the promise of digital markets is reduced transactions costs—but the complicated interfaces to multiple digital markets would seem to cause more costs than the savings would justify. Significant questions arise: For these four cases, what generic format might these companies and marketplaces use to efficiently connect to the multiple software systems involved? How many standards do they have to implement in order to operate in this new world of digital marketplaces? What is required to be successful in this new networked economy?

In a word, the requirement is 'interoperability'. This new meta-framework (one step above the XML and intelligent agent level), might be described as "bankcard ubiquity" since it should be as easy to use as the common currency of the ATM card. Interoperability—the way information and transactions are processed among entities, firms, and markets in the new digital economy—will be a key to survival as multiple standards proliferate and webs of marketplace consortia multiply. The bankcard goal is clearly applicable. There are over 100,000 financial institutions that consumers and businesses now use to conduct their local banking. Yet the transaction typically takes minutes from almost any location around the world. The ubiquity offered is based on a sophisticated, efficient, and successful interoperable infrastructure. This is the type of capability that we believe digital marketplaces will have to offer in order to generate substantial transaction liquidity in the new networked economy.

On a more detailed level, interoperability can be divided into three components: connectivity, communication, and coordination. At the lowest level, connectivity, entities need to be able to find each other, link to each other's systems, and transmit data across the network with appropriate constraints on security and permissions. The notion of communication involves not only being able to understand the structure and format of the transmitted documents or messages, but also to unambiguously comprehend the meaning of the content. Coordination refers to potentially complicated multi-party interactions among entities. Although it is fairly simple to address these issues on a small scale among known parties, the diverse and dynamic nature of B2B digital markets will push the requirements for flexible interoperability to a higher level as they transition from homegrown systems to industrial strength interoperable platforms. With the right approach, this goal is readily achievable.

So how are e-commerce companies addressing interoperability today? At the lowest level, network protocols (e.g., TCP/IP, HTTP, secure HTTP, email's SMTP) provide well-understood, universally-adopted forms of connectivity, although the problem of finding partners to connect to has not been addressed in a standardized, widely accepted manner. Proprietary messaging systems such as Microsoft BizTalk, IBM's MQSeries, Netscape's EC Expert, and Sun's JMS offer higher-level services for managing and routing documents, but these systems do not interoperate with each other. XML has been widely heralded as the solution to standardizing data formats, but XML only addresses the syntax of structured documents. XML repositories such as BizTalk.org, XML.org, and cbXML contain what the industry refers to as "schemas" of specific business vocabularies for various domains, but the repositories use different schema definition formats, making interchange difficult.

- Supplier certification, reputation
- Transportation mgmt
- Product Life Cycle Management
- Warehousing and Inspection
- Risk mitigation services
- Catalog display/maintenance
- Financing
- Product Configuration
- Derivative instruments
- Community news, employment, etc.
- Returns processing, Repair Claims
- Payment processing/order mgmt
- Order explosion/routing
- Workflow and Business rules
- Contract administration
- Tariffs and Duties Assessment
- Planning, Scheduling, Forecasting
- Promotions/Campaign Mgmt
- Profiling and personalization
- Authentication/security
- Complex pricing
- Private markets, negotiated terms
- Post sale support, Warranty programs
- Receivables management
- Scrap management/Reverse Logistics
- Inventory availability
- Partner/team selling and promotions
- Backorder management

Source: Morgan Stanley Dean Witter

Figure 3. Potential Capabilities of Digital Marketplace Platforms

In this context, *Figure 3* displays a partial list of e-services that could be offered as part of a trading hub or digital marketplace. As B2B evolves, new service requirements will undoubtedly be added. It seems clear that in order to survive, a digital market platform must facilitate the rapid and flexible integration and interoperation of these types of commerce components in an environment which includes both marketplaces and third-party service providers in a manner that is re-configurable and extensible over time.

In order to address the interoperability needs discussed above and to begin to meet the requirements outlined in Figure 3, we are currently building a marketplace infrastructure that is designed to form the foundation of what we call 'Business Process Networks.' This new framework makes it possible to leverage domain-specific and company-specific business knowledge and rules; to construct and customize new business processes from reusable components; to easily insert new services, including third party services, into a vertical B2B digital marketplace; and to take advantage of brokering capabilities to compose services and functions on-the-fly. Our technology draws upon advances in several areas, including intelligent software agents, process knowledge specification, and ontology construction & management.

Intelligent Software Agents

Thanks to recent advances in artificial intelligence and software engineering, a new class of systems is beginning to emerge under the designation of "Intelligent Software Agents." Compared to traditional systems, agents offer enhanced capabilities for autonomously reasoning about their environment to make informed decisions, learning and adapting over time from their experiences, and for communicating with other agents, with legacy systems, and with human users at a much higher, more interactive level. Although there are many advantages to building systems that involve software agents (see, for example, Jennings (1999)), one of the most important from the viewpoint of economics is the dramatic reduction in transaction costs that can be achieved as 'machines' take over much of the work of people.

These kinds of software agents are now beginning to flourish in the context of electronic commerce. See Moukas, Zacharia, Guttman,and Maes (2000), for a good introduction and a report of actual operations of agents in constructed digital marketplaces. Daley (1999), Syed (1999), and Martin, Cheyer, and Moran (1999) describe the details of how brokering, translation, and other coordination services can help manage flexible interactions among distributed agents and market components. In our framework, agents can also be imbued with knowledge of the organizational structures and societal rules of marketplaces, allowing them to move between companies, trading partnerships, and markets, automatically adjusting to differences in market practices and business processes. Although a full treatment of agent-based computing is beyond the scope of this document, we consider the functions and benefits to be an inevitable and obvious progression for business-to-business e-commerce.

Process Knowledge Specification

It is often observed that adding value to business transactions depends critically on knowledge about how businesses operate. Capturing this knowledge poses a number of important requirements. Businesses and external partners must be able to integrate process knowledge quickly and easily, but at the same time, this knowledge should be reused as much as possible. The requisite knowledge may vary from industry to industry, and from company to company. Processes frequently cut across vertical market areas, and typically will include a mixture of information of several different types. For example, these might include steps in a procurement process, roles of persons who need to be involved, or critical parameters of the item being purchased or sold. A useful interoperability framework needs to provide the capability to construct and customize new business processes, using a adaptable specification language, without requiring a large investment of engineering skills. For these and other reasons, a flexible representation of process plays a central role in our unique technology.

In our approach, processes can be created as customizations of existing process templates, which may be drawn from both public and private repositories. Processes may invoke sub-processes, and are configured at runtime with appropriate service components. Processes are enacted by a process execution engine, which includes a brokering or delegation component that is responsible for the selection of applicable service components.

Ontology Construction and Management

The third component of our technology, ontology construction and management, deserves its own section. Very little has been written about the application of ontology to B2B marketplaces to date; yet anyone working on digital market interoperability knows that it will be a key factor in tomorrow's networked economy.

The critical blueprint role of ontologies

Over the last ten years, electronic data interchange (EDI) supported many business transactions via structured forms, a few common data elements, and free form text. EDI formed a common structuring of data, specific field definitions and what data the fields were to carry. EDI enabled the early days of e-commerce. Today, existing and emerging standards support e-commerce interactions by providing enhanced descriptions of data elements that use universal data encoding via XML as well as formatted transaction types. We believe that tomorrow will bring a more automated picture to B2B e-commerce with opportunities to use intelligent software agents to find the best buy/sell/partner opportunities for products and services in a market environment—and that framework will contain ontology blueprints to help navigate the networked economy's new digital landscape.

Tomorrow brings a more automated picture to B2B e-commerce: promises of intelligent software agents (as well as humans) seeking the best buy/sell/partner opportunities for products and services in an online market environment that contains blueprints, landscapes, and maps to guide the way.

But today, different trading communities operate in diverse ways, use different languages, and even perform transactions in different ways. Any survey of B2B trends reveals the same conclusion: digital marketplaces will need to provide mediation and translation support for a wide variety of trading cultures, procedures, and Internet formats. The challenge to software developers is to provide a framework upon which a marketplace infrastructure can be built, without enforcing a uniform standard mode of operation on all participants. This goal is readily achievable with the right approach. And we believe that the answer is based on the new science of ontology.

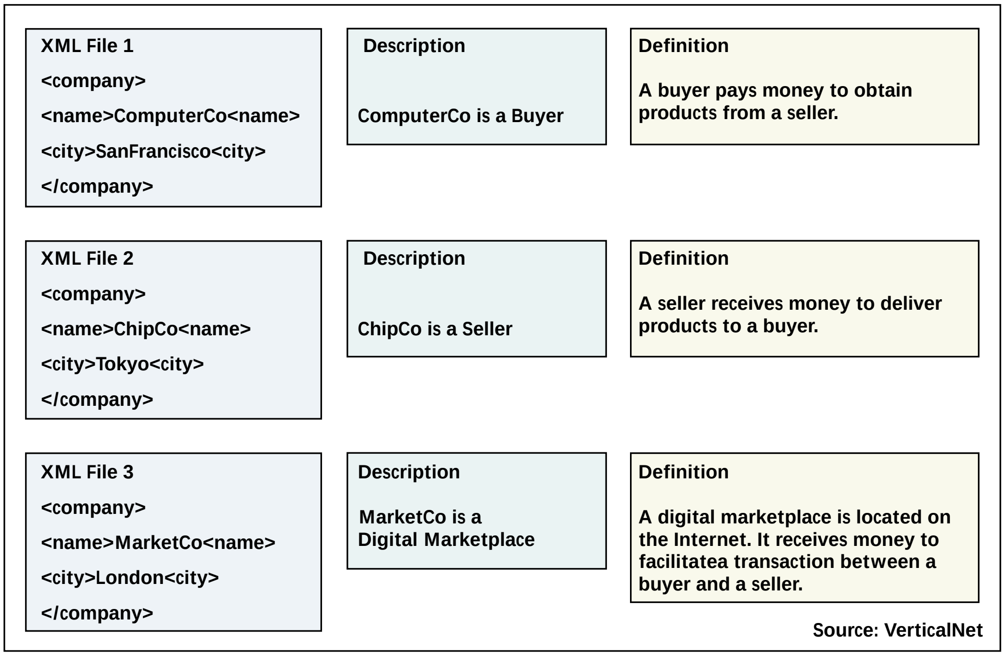

Figure 4. Introduction to Ontologies—An informal Example

Introduction to Ontology

But what is an ontology? The best way to begin an explanation is with an example. Column 1 of *Figure 4* shows very brief XML files of 3 different companies: ComputerCo, ChipCo, and MarketCo. Each file contains the name and addresses of the company in correct XML syntax. A common schema (a modern version of a DTD) would simply say that the XML files of such companies are required to contain entries for both name and address in the format shown. Thus, a software program to check to see if the files in column 1 had the correct syntax would report success. That is the extent of the XML platform coordination process. Almost any further framework to interpret the data would be beyond the capabilities of XML.

Column 2 starts to add additional meaning to the raw data shown in column 1. It says that one of the companies is a buyer, one a seller, and one a digital marketplace. Column 3 adds further meaning by specifying the kinds of tasks and relations that these terms imply. Thus, in this very simple informal ontology, we are going beyond syntax—an inquiry as to whether the XML file is correctly written. We are now beginning to add semantics—a specification as to the context and meaning of the data. The ontology here tells us that buyers and sellers meet in digital marketplaces to exchange products for money. To a learning software agent, this is very useful information about the process used in digital marketplaces.

We use the terms syntax and semantics above; it is important to distinguish between the two. Syntax asks whether a combination of words like ‘ I go to the store’ is really a sentence. It has a subject, verb, and object. Semantics begins to deal with much more important issues: ‘What is a blueprint to explain what ways there are to go, and what do people do at a store.’ Clearly, both components are important.

Suppose we add a list of the products that are bought and sold in the marketplace shown in Figure 4 and that the list contains “memory chips”. Then the statement “ComputerCo bought memory chips from ChipCo at MarketCo “ is not only in a correct syntax (as defined by the marketplace), but it also contains a wealth of meaning that would allow intelligent agents as well as humans to make a variety of correct inferences and to draw conclusions about associated events. For example, various movements of product and money will be required to complete this particular transaction. The details of these movements would require additions to the ontology to specify the applicable processes. As these are constructed, they can then be shared among e-commerce participants to lay even more extensive foundations for true interoperability. We believe that many ontology components can be shared across industries. Clearly, we have gone far above a simple XML list of companies with names and addresses. And the techniques discussed here certainly go beyond a simple taxonomy of multiple catalogs. This represents a fairly broad view of the ontology concept; but we think it is a very useful one in our context.

For these and many other reasons, we believe that ontologies, or structured knowledge, are essential to the construction of a truly flexible trading environment in cyberspace. Whereas XML represents documents in a simply-typed, hierarchically-structured format, ontologies typically model complex relationships among entities, with inheritance of attributes and definitions of real-world constraints and rules that permit more complex inference of the content. Moreover, although our introduction is relatively informal, there does exist a formal approach to ontology construction and management that includes a rigorous structure and numerous tools. A more formal discussion is provided in the Technical Appendix. The ultimate goal is to provide a rich interlingua for B2B trade that can greatly facilitate interoperability, enabling each participant to interface with the digital market infrastructure view in their own unique way.

At this point, one might ask: ‘Doesn’t the XML platform enable the necessary connectivity now?’ Although XML is a critical component, the answer seems to be a fairly clear ‘No’. Ontology expert Howard Smith of CSC explains:

> “The great thing about XML is that it enables the incredible experimentation we see in the marketplace. But there are hundreds of XML groups creating Internet commerce 'languages'. This, coupled with the various transaction standards in common use, presents formidable obstacles to organizations wishing to build or participate in global trading webs using XML alone.”

This is the same conclusion that we illustrated earlier in the example with the three companies. XML descriptions are indeed very useful; however they only go so far towards our goal of large-scale connectivity, communication, and coordination.

Applications of Ontology in Digital Marketplaces

There are two primary uses for ontologies in B2B e-commerce. First, there is an informational use: because the ontology is a structured model of the e-commerce vertical domain, it supports parametric search and navigation using product and service knowledge to discover what to buy, and subsequently to determine pricing and availability. In this case, the relatively static knowledge of the ontology maps to the relatively dynamic data of the vendors.

Medium to long term, we see ontologies being used across the Internet to efficiently facilitate the automation of B2B ecommerce among enterprises.

It is worth emphasizing that the ontology can model not only commodities and other passive entities, but also active agents—buyers and sellers. In the future, such knowledge of agents could be applied by employing user role knowledge to aid, augment, or direct search by applying a profile of the user to tailor queries to that user's known functions, and interests, perhaps based on previous experience with that user. Thus ontology construction is far more than just a taxonomy of related catalogs; rather it is a whole new organization of transactions in cyberspace. And the ability to incorporate new knowledge—to learn—is yet another advantage of an ontology-based system.

The second primary use of ontologies in e-commerce is transactional: knowledge of company organizational structure, workflow, processes (and process templates mentioned in the earlier section on interoperability), and products/services can be used to actually assist in buying and selling directly. For example, Figure 5 outlines one view of an architecture and flow of knowledge within a prospective ontology-driven B2B marketplace infrastructure, linking buyers to semantically-mapped suppliers via software agents for both informational and transactional purposes. In that framework, multiple heterogeneous databases map to a common ontology that thus enables a meaningful comparative view to be displayed to a prospective buyer.

Our current research and development efforts focus on digital marketplaces that provide trading hubs where catalogs, auctions, exchanges and contracting relationships are fostered. The trading hub identifies a shared and common business vocabulary and product views tailored to a particular industry. Further, the hub establishes and uses the shared meaning of these products to dynamically add more participants at a low integration cost. On a larger scale, by utilizing and contributing to emerging standards via ontologies that are easy to implement, B2B digital marketplaces will be able to establish scalable and cost-efficient trading hubs to support the virtual open markets of the future.

Ontologies certainly do not mean the end of the XML platform—rather they represent a semantic superstructure for more effective use of it. Robin Cover, the noted XML expert, explains:

> "Interoperable computing solutions imply the existence of a sharable ontology, or common set of object semantics. Implementers will still be able to use localized and otherwise customized XML markup languages if they choose, but it should be possible to express and validate the semantics of the design as well as the raw XML syntax."

Thus, we expect that efforts to create and codify standards via XML DTDs and Schemas will continue to proliferate. However, we believe those that focus on coordination among each other in an ontology-based meta-system are most likely to be used in future marketplace implementations.

Near term, our current program uses the ontology framework to specify as precisely as possible, and as needed for our applications, a vocabulary and conceptual model and the constraints on that model, thereby enabling informational and transactional capabilities for B2B e-commerce in our vertical trading communities. Medium to long term, we see ontologies being used by intelligent agents (as well as by humans) across the Internet, eventually learning and extending themselves, enabling other advanced applications such as natural language understanding as well as being used as executable models for automation of enterprises and commerce.

With these new tools, B2B digital marketplaces will lead a significant economic transformation based on new ways of representing and using knowledge. For buyers and sellers, it will no longer be necessary to spend significant effort to maintain interfaces with multiple B2B portals; rather they will simply present to interested parties definitions of their “haves” and “needs”, their business rules for buying and selling, their trading cultures, and their operating procedures. At the same time, advances in ontology and interoperability over the next several years will also enable a trading partner’s own systems and business processes to seamlessly integrate with multiple marketplaces, enabling services that are not central to the business to be outsourced through dynamic hyper-partnering.

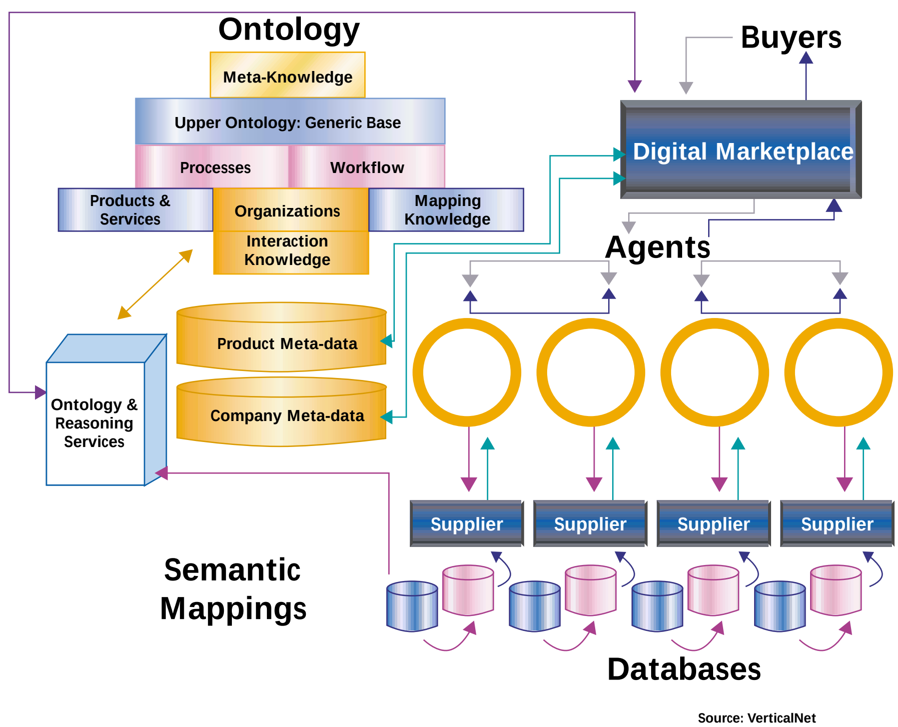

Figure 5. Knowledge Flows in a Prospective Ontology—Driven B2B Marketplace

Final thoughts

Most observers believe that the bandwidth-rich environment of the rapidly evolving Internet will enable firms to continue to break apart into combinations of markets, buyers, sellers, and other partners. And B2B digital marketplaces that allow both spot and contract electronic trading via catalogs, auctions, and exchanges will be key enablers of this new economy.

Yet the speed of the transition of firms into markets is uncertain. No one knows how rapidly organizations and governments can reinvent themselves and their infrastructures into the Internet age. Will it be a gradual change as some analysts predict? Or will it be more dramatic and disruptive? If it does happen quickly, the observations of Christensen (1997) will be relevant as he describes the history of several old-economy Global 2000 corporations:

> "We see that in their straightforward search for profit and growth, some very capable executives in some extraordinarily successful companies, using the best managerial techniques, have led their firms straight toward failure."

In such an environment—where innovation destroys planning—the role of entrepreneurs with good ideas in a dotcom corporate structure could flourish. On the other hand, the recent financial re-adjustments in capital markets and revised views of Internet company stock values could produce a much more gradual evolution. And different geographic sectors of the global economy will undoubtedly proceed at a variety of speeds.

However, no matter what pace the digital economy takes, there is no turning back on the direction that the firm is taking to disperse part of its internal buy-sell activity into more fluid and open Internet-based digital markets. A key requirement will be the foundation elements that provide connectivity to allow smooth operation of the reinvented but widely scattered enterprise. In this context, both ontologies and interoperability will play critical roles along with intelligent software agents and the XML platform. The challenge to software developers is to provide a framework upon which a marketplace infrastructure can be built, without enforcing a uniform standard mode of operation on all participants. This goal is readily achievable with the right approach. And we believe that the answer is based on the new science of ontology.

Technical appendix

We do not start our ontology construction and management task in a vacuum. In fact, there is a large base of knowledge and techniques that have been developed over the last thirty years in a variety of related fields of study. Our mission is to apply this historical knowledge base to the new requirements of Internet-based digital marketplaces. This section summarizes a small part of the technical fundamentals at a more detailed level. We start with a view of the problems that need to be addressed.

There are at least three significant obstacles to successful B2B e-commerce. The first is one of sheer numbers: if there are M buyers and N sellers, the potential number of distinct connections needed is M*N—clearly a difficult situation in terms of communication. A partial solution to this is the notion of a mediator—an online exchange or trading hub: if all commerce is transacted through the mediator, the most distinct connections required it M+N, a manageable number even for relatively large values of M and N.

What problems in E-Commerce do Ontologies solve?
The heterogeneous vendor database problem
Distributors, Manufacturers, Service Providers have radically different databases
Different syntactically: what's the format?
Different structurally: how are they structured?
Different semantically: what do they mean?
They all speak different languages
The standards and common vertical conceptual model problem
Ontologies act as semantic conceptual model representing common standards
Well-defined, sound, consistent, extensible, reusable, modular, logical

The second is a structural and syntactic problem: different distributors, manufacturers, and service providers will use a wide range of information systems—hardware hosts, database systems, schemas, etc.—that require different protocols, access schemes, and even DML (data manipulation language). This problem can be overcome to a certain extent by the use of standard protocols and powerful data mapping capabilities.

The third is the most imposing: a sort of Babel effect. Even if it were possible to resolve syntactic and structural problems completely—and it is not—the problem of semantics remains: given that one can access a vendor's database, and even the data, what is the meaning of the data? Furthermore, even in business areas where the underlying technical nomenclature is relatively standardized, the nomenclature used in catalogs and other sources of product data is typically idiosyncratic to a particular vendor, so after all other problems are solved, it is very difficult to recognize that two products from different sources are similar, and without this recognition it is difficult to make sensible comparisons.

Why the Problem? Humans have been conducting business in this environment for years without any difficulty; why is it such a problem for an e-commerce system? To understand this, it's necessary to understand clearly the difference between data and knowledge. Presented with a set of facts—data—a human has no problem interpreting these facts, understanding them in a manner that permits intelligent action. In other words,

Knowledge = Data + Interpretation

Interpretation is a reasoning process, the process of mapping between some structured set of data and a model of some set of objects (in a universe of discourse) with respect to the intended meaning of those objects and the relationships between those objects. What is missing in current e-commerce systems is a model, sufficiently detailed and structured to permit interpretation, one in which the meaning of the data—the semantics—is represented in a manner that permits a computer program to interpret the data in a manner similar to a human. An ontology is just such a model. *(See Figure 6.)*

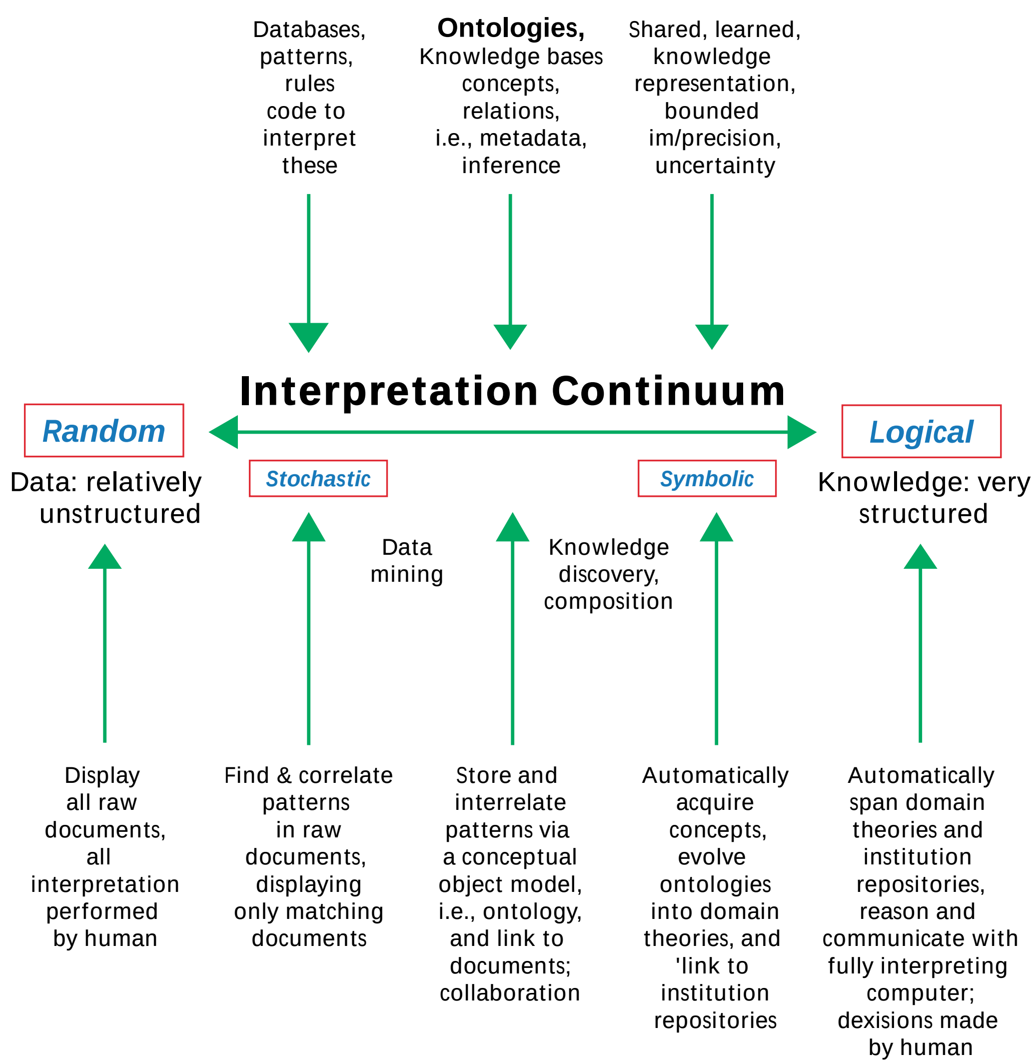

Figure 6. Interpretation of Data Via Ontologies

An Ontology includes:
entities (things) the relationships between those things
the properties (and property values) of those things
the functions and processes involving those things
constraints on and rules about those things

An ontology differs from other data models in that it is as concerned with the relationships among entities as in the entities themselves, and in the fact that the semantics of these relationships is applied uniformly. In a typical data structure, the relationships among data are ad hoc, and all interpretation is necessarily performed by a program accessing the data. In a typical database, the relationships among the data are partially represented by the data schema; nevertheless, nearly all interpretation is performed by a program accessing the data. A human, or another program, lacking knowledge of the specific semantics of a particular data structure or database is clueless as to what it means. In an ontology, relationships are defined more or less formally, and the semantics of a given relationship are consistently observed. If these relationships are given names that are appropriate to their meanings, a human viewing an ontology can understand it directly; and because a program can assume uniform semantics for a given relationship, it can act consistently across the whole ontology.

Figure 7 shows that what is considered an ontology can range from the simple notion of a Taxonomy (knowledge with minimal hierarchic structure) to a Vocabulary (machine-usable knowledge as standardized terminology) upward to a Conceptual Model (with more complex knowledge representation), finally culminating in the notion of an ontology as a Logical Theory (with very expressive, complex, consistent, meaningful knowledge). The more complex notion of ontology is what we aspire to construct and use, i.e., viewing an ontology as primarily a conceptual model and a logical theory. Ontologies thus act as semantic conceptual models representing common knowledge in a well-defined, sound, consistent, extensible, reusable, and modular fashion.

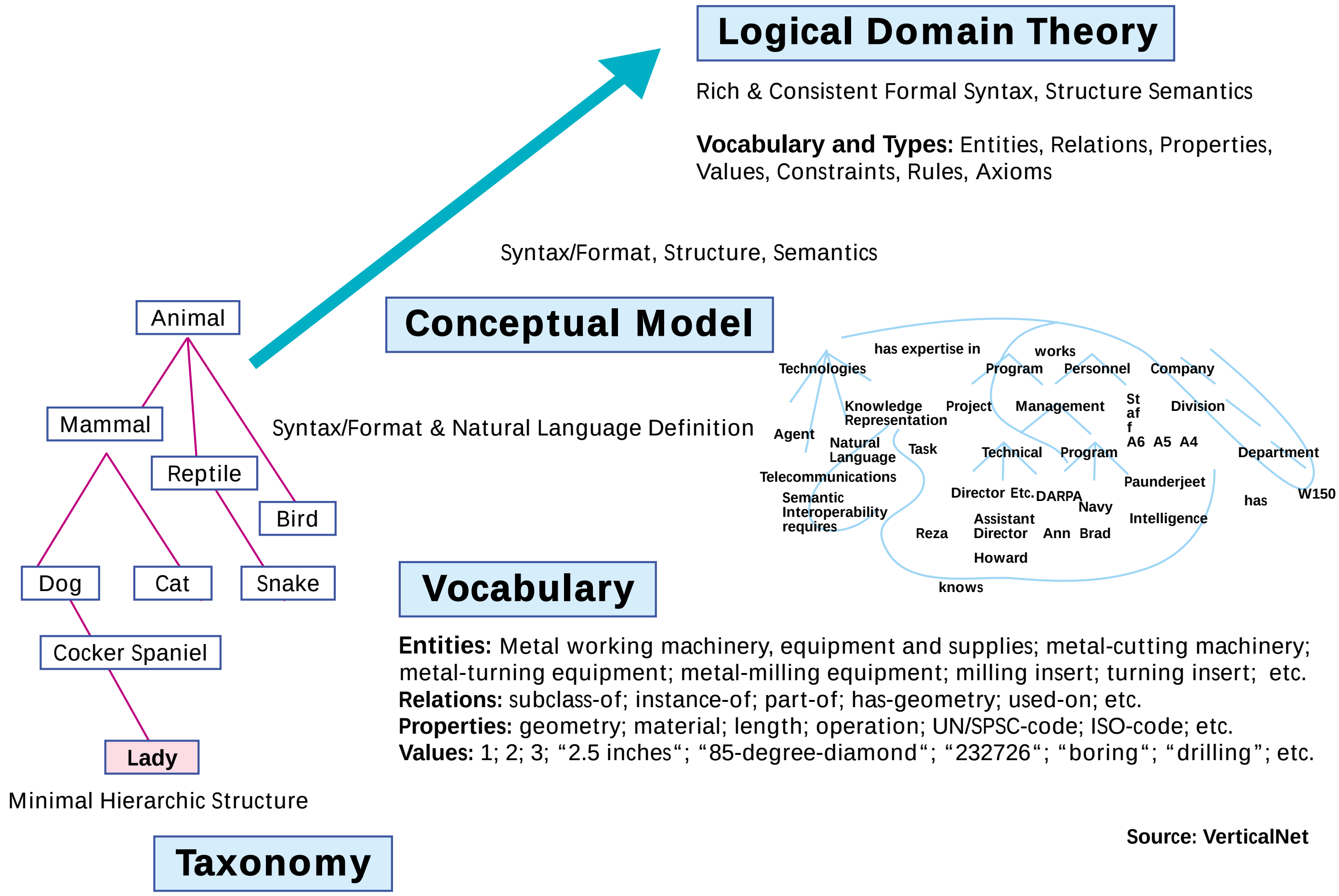

Figure 7. Simple and Complex Ontologies

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Notes

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