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A Digital Ecosystem for Extended Logistics Enterprises

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Abstract: The connectivity and information richness arising from the advent of the web has contributed to an increasingly dynamic business environment and marketplace, forcing a change in traditional business thinking from a static, closed and competitive business model to open, flexible and collaborative conceptualisation. It is this radical shift in business thinking and implementation that has created a need for new business paradigms and new organisational forms. This chapter presents a new business paradigm known as Digital Ecosystems, its concept, underling issues and its application to Extended Logistics Enterprises. We provide a novel Digital Ecosystem approach to the logistics industry and create a digital service framework which will foster logistics partnerships and collaborative supply-chains.

Keywords: Digital Ecosystems, Loosely coupled, demand driven, proactive, responsive, interaction and balance, Digital Logistics Service Ecosystems

Introduction

The advent of the web and its intrusion into business, commerce, government and health have provided mechanisms for binding organizations together, for carrying out activities over great distances and at any time. This has created new modes for marketing and enabled partnerships previously inconceivable within a wide array of business as well as other human activities. A consequence of this connectivity and information richness is that we are now faced with an increasingly competitive and rapidly evolving environment. We now require new business paradigms and organization forms that transcend the previous static, closed models and move to open, flexible, and collaborative models that are able to respond to the environment dynamics inherent within the networked economy. This new model and business paradigm is defined as a Digital Ecosystem.

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1. Digital Ecosystems

In an ecological system environment (Figure 1), we consider species in analogy with biological species, create and conserve resources that humans find valuable. The Software, Databases, Applications, or Software Services in Digital Ecosystems are referred to as *digital species*.

Figure 1: The Analogy with Ecosystems

Economic species in analogy with Biological species, such as business entities, together form a dynamic and interrelated complex ecosystem (Figure 2). The *Complex ecosystem* is defined as a composition of mixed multiform heterogeneous entities participation in domain and cross domains interaction and engagement. A *Domain* is defined as a specific field or environment where participants have something in common or share the same interests, such as Corel Reef Ecosystem in the biological sphere (Figure 1), Rain forest Ecosystem, etc. *Cross Domain* is defined as inter-Domain interaction, such as a Corel Reef Ecosystem interacting with the Human Domain or Ocean Ecosystems.

Figure 2. Business Ecosystem

Therefore, we define a **Digital Ecosystem** as a loosely coupled, demand driven collaborative environment where each digital species is proactive and responsive for its own benefit or profit.

We define *loosely coupled* as a freely bound open relationship between participants or entities within a virtual community. This term is opposite to the tightly coupled relationship, where each party is heavily dependent on one another and the roles are pre-defined. Participant is defined as an entity who wants to join a group or an environment or a community based on its own interest.

Demand Driven is defined as the driving force coming from outside 'push-in' rather than 'pull-in'. For example, the current networked economy has led to supply chains to demand chain, where demand is volatile and supply is uncertain. Another negative example is that the current collaborative environment is not a demand driven environment, because humans are told to collaborate, and humans may be forced to collaborate. This is not a demand driven, and human is forced to be there for the sake of collaboration rather than enjoying collaboration arising from a perceived mutual interest of the parties collaborating. There is no real honest consideration about whether there will be a benefit or a profit from the collaboration to the collaborating parties.

Collaborative environment is defined as an environment which contains human individuals, information technologies that human can capitalise, tools that facilitate interaction and knowledge sharing, and resources that help maintain synergy among human beings or software agent.

Human Agents and Software Agents in a digital ecosystem are referred to as Eco-agents. *Eco-agents* are capable of acting autonomously often capable of decision making and responses with in the context of a digital ecosystem.

Proactive is defined as an agent or eco-agent who is full of enthusiasm to participate in team work or community work.

Responsive signifies an agent or eco-agent who demonstrates willingness, is passionate about the issues, is cooperative and takes responsibility for its action.

Benefit refers to an advantage that an agent can take without any risks.

Profit refers to personal financial gain.

Digital ecosystems transcend the traditional rigorously defined collaborative environments, such as centralised (client-server, where each node in the collaboration network is predefined as either the client or the server, and they highly dependent on each other to perform the function) or distributed (such as peer-to-peer, where each peer is pre-defined as either a peer or a server, and communicates only via client to client or server to server) models. Digital Ecosystems, in contrast, are agent-based (human or intelligent digital species), loosely-coupled (the participants are free to join the virtual community), domain-specific (the participant have similar backgrounds) and demand-driven (they choose that they want to join the collaboration and determine their own requirements and expectations of the system) interactive communities which offer cost-effective digital services and value-creating activities (every agent or digital species is doing positive things for the community) that attract agents to participate (it is this freedom and open environment that is attractive) and benefit from it.

A *Digital ecosystem* is a self-organizing digital infrastructure aimed at creating a digital environment for networked organizations (or agents) that support cooperation, knowledge sharing, and development of open and adaptive technologies and evolutionary domain knowledge rich environments. It is a business model innovation in the Digital Economy.

2. Characteristics of Digital Ecosystem

Several factors characterise "Digital Ecosystems" namely:

- It has a strong information infrastructure that extends beyond the original closed walls of the individual organization.
- It is a domain-oriented *Cluster,* which forms an interactive community that has attracts to it similar species which challenge and support each other to survive.
- It contains rich resources that can offer cost-effective digital services and value-creating activities for the participants.
- It utilises new forms of electronic interaction, provision of digital services and use of services.

- It carries high connectivity and electronic handling of information of all sorts including data and documents.
- It offers multiple channels for buying and selling of services.
- It captures and utilises business intelligence from data, document and other agents and has *smart information use*.
- It is an integration of business, human endeavours and advanced information systems within the digital ecosystems.
- It facilitates close interaction between participants and cross fertilisation and nourishes each other and supports different needs within the digital ecosystem and between different digital ecosystems.
- It is a cross-disciplinary interaction and engagement, which offers a mix of expertise that preserve and enhance productivity, prosperity and international competitiveness.
- There is always an underlying knowledge base available to support information communication that enables shared understanding of concepts.
- Information is highly distributed, heterogeneous and massive, like a huge library without a catalogue system.
- Ecosystem participants or agents are autonomous, highly interrelated and dynamic and able to coordinate among themselves.
- "A Digital ecosystem is a self-organising digital infrastructure aimed at creating a digital environment for networked organisations (or agents) that support cooperation, knowledge sharing, and development of open and adaptive technologies" [40] and "evolutionary domain knowledge rich enviornemnts" [15].

The European Union defined Digital Ecosystem as a new initiative [40] and announced "Innovation Ecosystem Initiative" as part of the European Seventh Framework Proposal, and part of the i2010 initiative [38]. It is also noted that there will be a first inaugural IEEE International Conference on Digital ecosystems and Technology to be held in Cairns, Australia in Feb 2007 (www.IEEE-DEST.curtin.edu.au). This demonstrates the innovation and significance of the research at international level.

3. Digital Logistics Ecosystem

Transportation and warehousing logistics are activities that require strong information systems and communication infrastructure support. This requirement has grown with the advent of e-commerce. Companies such as FedEx and UPS now allow their customers to receive end-to-end service, track and trace and monitor the fulfilment, and quality evaluation of their requested services on the Internet.

Recent P2P e-commerce has resulted in an increasing tendency for virtual service providers to assemble several companies (or Partners) into strategic alliances that allow sharing of their physical facilities to achieve utilisation of logistic services beyond their own region of operation. For example, the pooling of warehousing and transportation facilities over a widely geographical distributed area of operation through an integrated

virtual logistics hub. This creates special needs for inter-organisational information exchange and data integration and an architecture to support a virtual logistics cluster.

Today, logistics enterprises are threatened by global enterprise services. Companies are facing a challenging missions every day to improve operational costs, increase productivity and customer service through optimising inter-company processes rather than just focusing on intra-company processes. Virtual Collaborative Consortia logistics are a prime example of Digital Ecosystem. Collaborative Supply Chains involve vertical industry collaboration and the *logistics network* involves horizontal industry collaboration. Logistics activity represents approximately 9% of Australia's GDP - or $57 billion - and it has been found that the introduction of collaborative logistic systems can achieve a 500% return o n investment (Talevski, A., Chang, E., Dillon, T.S. 2005). Weakness in logistic capabilities creates a multi-billion dollar cost burden on the Australian economy. Logistics and supply-chains are vital to the global economy, especially in developing countries where the 90% of logistics companies are SMEs.

In order to compete in a global market, it is thus vital for logistics enterprises to share logistics information for cooperation. A Digital Ecosystem can provide logistics consumers with transparent information about services within the ecosystem community that allow quality of service evaluation, service negotiation and quality-of-service guarantees. Current internet service requests, find and bind tools are inadequate for logistics and supply-chain consumers and providers, because the services available in the network are often limited, have poor semantics involved, short-cuts and are incomplete and there is no quality-of-service information available. Suppose a logistics customer needs to find out about a goods yard. A query to a web service registry or www.google.com for 'goods yard' lists 72,900 items. Moreover, there has not been a web service designed targeted specifically for the transport logistic industry today in the world.

A *Digital ecosystem* can be specifically developed for the Logistics Small Medium Enterprise community (Figure 3), where species in the ecosystem such as heterogeneous enterprise systems, business portals, service brokers and organizational databases occupy the Digital ecosystem. Digital ecosystem technologies provide transparent, micro, open ICT technologies that advance the ecosystem through its intelligence and knowledge based development to move away from isolated business to business competition to improve the collaboration, competition, quality and quantity and synergies between partners, enabling local value chains and enhancing their competitiveness over the global market. The proposed system generates a new solution for the extended logistics enterprises, especially e-logistics and e-warehousing environments which is essential for the extended enterprise and business intelligence. SMEs provide the engine for growth of value added products and services in the extended enterprise and logistics marketplace, and so can deliver substantial economic benefits to ICT and logistics industries, deployment of improved trade and export industry infrastructure – based on Digital Ecosystems solutions.

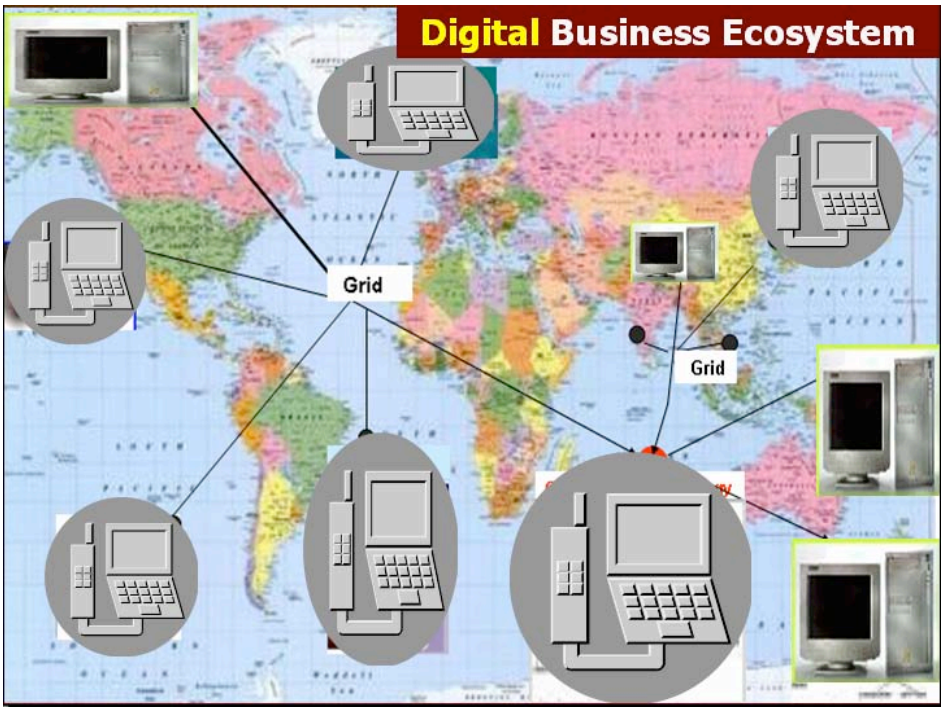

Figure 3: Digital Logistics Service Ecosystem

4. An Intelligent Digital Ecosystem for Extended Logistics Enterprise

An Intelligent Digital ecosystem (Intelligent DES) advances the ecosystem through its knowledge base development from Orchestration to Choreography. The key technologies underpinning this development are Ontology, Agent-based systems, automated digital service discovery. Eco-agents within the Digital ecosystem are a departure from the traditionally defined 'agent' in Multi-agent Systems where an agent only represents an application that operates in a system or a database, whereas Eco-agents represent the economic organisms or digital organisms which is a system that incorporates loosely coupled applications and their information resources or databases. Ontologies help to organize the logistics domain-specific knowledge that tells the on-line customer about the structure of the ecosystem and its Eco-agents' (species') functions, personality, who they are, what they do, and how they do. Onto-agents are Ontology-based intelligent leading software species have strong reasoning capabilities which can manage, coordinate and collaborate between ecosystem agents (Eco-agents*)*. Therefore, we could represent:

Digital ecosystem(DES)= Eco-environment + Eco-agents

Intelligent Digital Logistics Ecosystem = Onto-Eco-environment + Onto- Eco-agents

where Ontology-based Eco-environment for logistics is the Eco-system adopting an Ontology as it shared knowledge base. Ontology-based Eco-agents are Eco-agents which annotate themselves through the Ontology and the Onto-agents are special Eco-agents, designed for Ontology utilization and to manage Ontology-based Eco-agents' interaction and coordination.

The Intelligent Digital Logistics Ecosystems have the following significance:

- All SME partners (agents) should join the logistics network, as each acts as an intelligent agent, sharing expertise, resources and business. For example, if a SME provider is fully occupied with their business for one month, they should refer the extra business to the nearest partners, so that in return, he will be treated reciprocally in future.
- Each logistics Provider shall be an intelligent agent that is an autonomous entity which participates in the community on its own initiative.
- Small Medium Logistics Enterprises are heterogeneous; therefore, they only need to form loosely coupled relationships between other SMEs, rather then traditional environments where entities are carefully blended together with predefined roles to play.
- Ontology-based logistics back-end database services in the ecosystem share commonly agreed vocabulary and concepts and they communicate knowledge through the commonly shared Ontology.
- Each Logistics SME can be a client (when querying) or a server (when queried) in a collaborative environment, whereas in a traditional setting, a communication entity or object is either a client or a server or other roles that are predefined.
- Demand-driven participation shall be a primary characteristic of logistics SMEs (Eco-agents) and they understand that they collaborate in the ecosystem is for their own benefit or profit. They remedy problems through collaborative effort, sub-tasking, coordinated actions, shared intelligence and skills. Unlike the traditional collaborative environment (such as client-server), it is a controlled environment, where entities or objects may not have direct benefit or profit from the collaboration.
- Human Experts are able to design and access intelligent logistics agent systems so that they can work together and coordinate with each other.
- Intelligent Logistics SMEs are proactive, adaptive and responsive eco-agents within an ecosystem thus provide the ecosystem with dynamism, efficiency and stability.

Conclusion

In this chapter, we have given a conceptualisation of Digital Ecosystems, its characteristics and its application to the Digital Logistics Ecosystem. A Digital ecosystem is able to employ the relationships and interactions between human, digital species, and infrastructure within the digital ecosystem. Finally, the chapter proposes an Intelligent Digital Ecosystem for Small Medium Logistics Enterprises.

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