DIGITAL ECOSYSTEMS A NEXT GENERATION OF THE COLLABORATIVE ENVIRONMENT

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Abstract

Digital ecosystems transcend the traditional, rigorously defined, collaborative environments from centralised, distributed or hybrid models into an open, flexible, domain cluster, demand-driven, interactive environment. A digital ecosystem is a new-networked architecture and collaborative environment that addresses the weakness of client-server, peer-to-peer, Grid and web services. In this keynote, we will provide a detailed explanation of digital ecosystems, their analogy to ecological systems, their scientific innovation, technical exploration including architecture, swarm intelligence, design and implementation, their comparison to existing networked architecture, social, cultural and economic impact the networked economy. We will also provide several practical examples as well as demonstration of swarm intelligence-based self-organised digital ecosystems.

Keywords: Digital ecosystems, digital ecosystems architecture, swarm intelligence, self-organisation, self-empowerment, self-coordination, self-defence

1. The Essence of Ecosystems

An *ecosystem* is defined as a loosely coupled, domain clustered environment where each species conserves the environment, is proactive and responsive for its own benefit.

There are two key elements in an ecosystem, namely: the species and the environment. *Species* need to interact with each other and balance each other (even though some species may play a leading role at times) and an *environment* that supports ecological needs of species so it can continue generation after generation. An example of coral reef ecosystem is shown in Figure 1.

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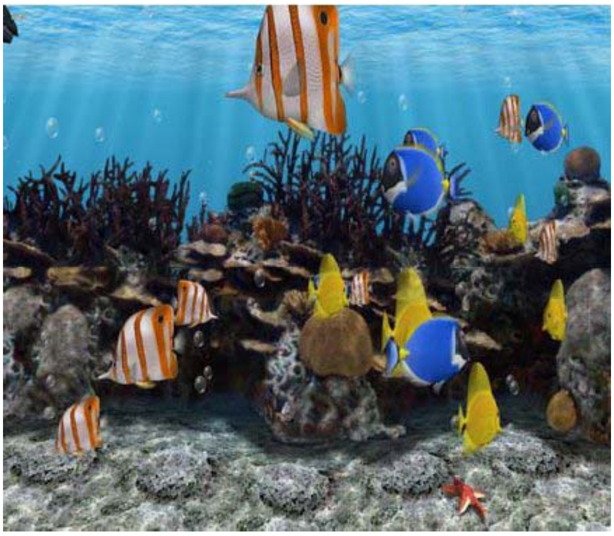

Figure 1 A coral reef ecosystem.

Species are living organisms and is made up of living organs; see figure 2 (a) and (b). Within the body of a specie, it is also an ecosystem.

Figure 2(a) Organs within a specie form an ecosystem

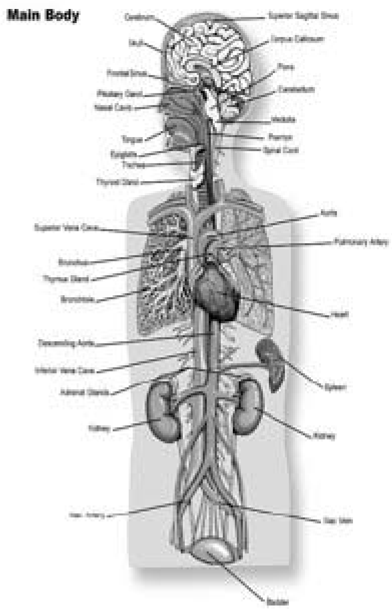

Figure 2(b) The interaction between human organs form an Eecosystem

Each *organ* carries out their tasks. They need to interact with each other and balance between each other (even though some organs are more important than others). A *system* (body) support organs collaboration and communication in order to achieve a healthy state.

Species are grouped by biological classification through genus, it is composed of related individuals that resemble one another and are able to live together, cross fertilise and interbreeding.

There are four essences of ecosystems:

(1) Interaction and engagement
(2) Balance

(3) Domain clustered and loosely coupled
(4) Self-organisation

Interaction and engagement
It signifies inter-disciplinary interaction, such as coral polyps, tiny animals that live in colonies and together they interact with nudibranchs, fish of varying types, turtles, sea snakes, snails and molluscs. They together in warm, open, clear, shallow waters. They need to interact between each other for social well-being and to engage with each other to find interesting things, to share the resources and sometimes they need to unite as a group to defend against threats from human interference, pollution or natural disaster.

Balance
It signifies the harmony, stability and sustainability within an ecosystem. If some species or parts of an ecosystem are getting disproportional tensioned, dried, over heated, dividend, the whole ecosystem may collapse. No benefit or gain, but pain. However, a single point of failure may not be interpreted as a disaster but is recognised as a contribution to the balance of welfare to the whole ecosystem. For example, if coral polyps die, they become a stony, branching structure as part of a reef and can still provide shelter and maintain the balance of the reef for generations.

Domain clustered and loosely coupled
In an ecological environment, species come to an ecosystem by their own choice (Figure 1). They are loosely coupled, taxonomic groups of which the members have similar culture, social habit, interests and objectives. Each species preserves the environment and is proactive and responsive for its own benefit. They are able to live together and support each other for sustainability.

Self-organisation
It signifies that each species is independent, self-empowered, self-prepared, undertakes self-defence, is self-surviving and undertakes self co-ordination through swarm intelligence. In case of natural disaster one can not ask 'where is the president', 'what logistics systems are provided' and so forth.

2. From Ecosystems to Digital Ecosystems

With the advent of the web and its intrusion into families, governments, businesses and commerce, there is no longer just an ecological environment that people live in but dual environments namely: ecological and digital environments. No one human or organisation can afford to ignore its' dominate force and impact on social well-being, growth and prosperity.

It has shifted the economy from the world of a physically connected economy to the digital networked economy. This has discharged everyone from traditional individual forms or close-walled organisational operations to an open, dynamic and networked collaborative environment known as Digital Ecosystems (Figure 3).

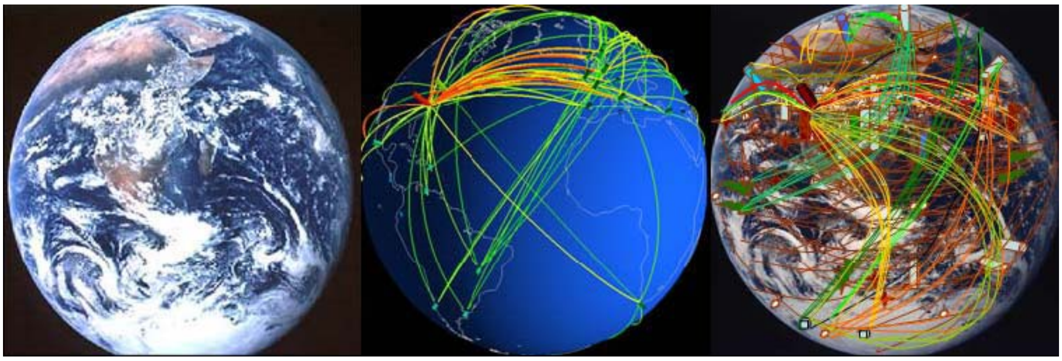

Figure 3 From ecological systems, digital systems to Digital Ecosystems

We propose, by analogy to the ecosystem, the digital ecosystem is defined as an open, loosely coupled, domain clustered, demand-driven, self-organising agents' environment, where each specie is proactive and responsive for its own benefit or profit.

'Open' is defined as a transparent environment. 'Loosely coupled' is defined as a freely bound, open relationship between species or entities within a virtual community. This term is opposite to the tightly coupled relationship where each party is heavily dependent on another and the roles are pre-defined. 'Species' are entities that join an environment or a community based on its own interest. 'Domain clustered' is a colony or a field where species have something in common or share the same life or interests such as an ocean habitat of a coral reef or exotic tropical plants in a rainforest. 'Demand driven' is defined as the driving force to join a community - 'push-in' rather than 'pull-in'. In many current collaborative environments, it is not a demand driven environment because people are told to collaborate or forced to work together, rather than enjoying collaboration arising from a perceived mutual interest of the parties collaborating. There is a lack of consideration about whether there will be a benefit or profit from the collaboration to the collaborating entities. 'Self-organising' refers to the species or agents being capable of acting autonomously, making decisions and fulfilling responsibilities. 'Agents environment' is defined as an environment which contains human individuals, information technologies and tools that facilitate interaction and knowledge sharing along with resources that help maintain synergy among human beings or organisations. 'Proactive' is defined as an entity being full of enthusiasm to participate in team work or the community. 'Responsive' signifies an agent that demonstrates willingness, is cooperative and takes responsibility for its action. 'Benefit' refers to an advantage that an agent can take without any risks. 'Profit' refers to social and economic gain.

There are two key elements in a digital ecosystem namely:
1) Species, and
2) The underlying technologies and services to support the digital ecosystems.

2.1 Species in the Digital Ecosystems

There are three types of species within a digital ecosystem namely:
a) Biological species;
b) Economic species; and
c) Digital species.

In analogy with ecosystems, we note that Human are a species. They come to an ecosystem on their own initiative; they eat, drink and look for interesting things. They need to interact with each other, balance between each other and they need to preserve the environment for their benefit or profit. They are known as a biological species.

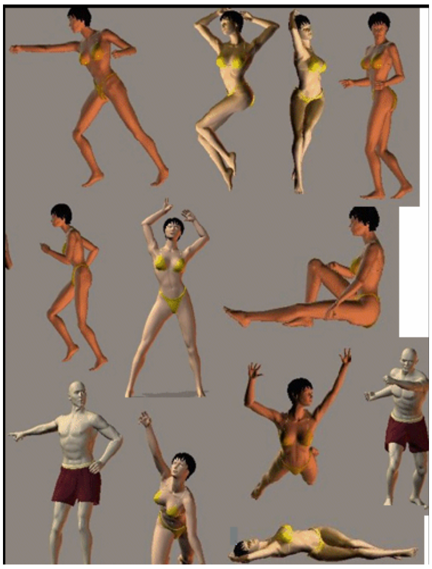

Figure 4(a) Human species in the digital system

Figure 4(b) Economic species in the digital ecosystem

We also see that Organisations are also a kind of species. They come to the business environment and need to interact with each other. They need input and produce output for sustainability. They are known as an economic species.

Computers, software, and applications are also a kind of species. They are linked via networks and interact with each other to achieve benefits and objectives. They need to take data as input and generate output (information, reports, data) and they have live time constraints (versions). They are called a digital species.

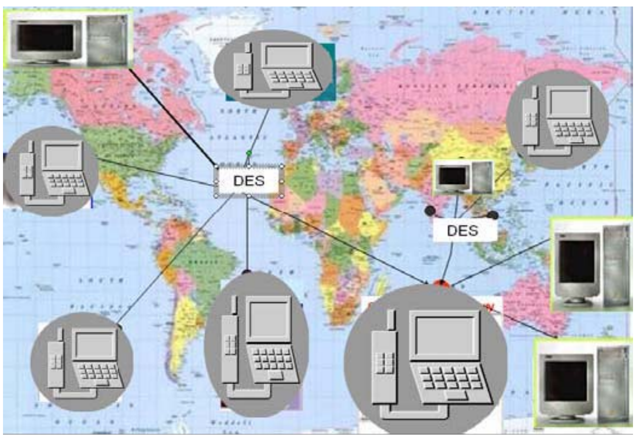

Figure 4(c) Digital species in the digital ecosystem

- Species in an ecosystem come from the same domain (or background, such as business domain, health domain, education domain etc) rather than a traditional, collaborative environment where mixed domains co-exist.
- Species in an ecosystem are autonomous agents. They participate in the community of their own initiative.
- Species are heterogeneous and encompass loosely coupled relationships within an ecosystem. Unlike traditional networked environments where entities or objects are carefully blended together and the community encapsulates all individuals.
- Species share commonly agreed vocabulary and they communicate knowledge through commonly shared ontology
- Species can be a client (need services) or a server (provide services) in a collaborative environment. Where in a traditional collaborative environment, they are either clients or servers and their role is predefined.
- Species come to an ecosystem of their own demand. They are motivated by their own benefit or profit. They remedy problems through collaborative effort, self-organising, sub-tasking, coordinated actions, and share intelligence and skills. Unlike the traditional collaborative environment (such as client-server), it is a controlled environment, where entities or objects may not gain direct benefit or profit from the collaboration.
- Digital species are human designed intelligent software agents. They are designed to work together and communicate with each other.
- Species provide an ecosystem with dynamism, efficiency and stability and they are proactive, adaptive and responsive.

2.2 The Underlying *Technologies* and *Services* to Support the Digital Ecosystems

The underlying technology for digital ecosystems is composed of extended web services architecture, self-organising intelligent agents, ontology-based knowledge sharing and a swarm intelligent-based recommendation system. These technologies provide services that are required for digital ecosystems.

The technologies and *services* for digital ecosystems include:

- A strong information infrastructure that extends beyond traditional human reach or the original closed individual organisation.
- An interactive community that directs similar species to a domain-oriented cluster.
- A rich data and information resource that offers cost-effective and value added customer or agent services.
- A new form of electronic interaction, provision of digital services and use of services.
- A high connectivity and electronic handling of information of all sorts.
- A smart information use through capturing business intelligence from the web.
- A platform for integration of businesses, governments, human endeavours and advanced information systems
- An environment for cross fertilisation and nourishing each other and supporting different needs within the digital ecosystem and between different digital ecosystems.
- A cross-disciplinary interaction and engagement for productivity, prosperity and growth.
- An underlying knowledge base through ontologies to support information communication that enables shared understanding of concepts.

- Provision of self-organising, self-empowered, self-prepared, self-survival, self-coordination, aimed at creating a sustainable environment for networked organisations or agents.

The European Union defined digital ecosystems as a new initiative [15, 40] and announced 'Innovation Ecosystem Initiative' as part of the European Seventh Framework Proposal and part of the i2010 initiative [37, 38]. It is also noted that there will be an inaugural IEEE International Conference on Digital Ecosystems and Technologies to be held in Cairns, Australia in February 2007 (www.ieee-dest.curtin.edu.au).

Digital ecosystems capture the essence of the classical complex ecological environment in nature, where biological organisms or digital organisms form a dynamic and interrelated complex ecosystem. They shall conserve the environment and resources. It is a new mind-set thinking in the *Digital Economy*. Digital ecosystems transcend the traditional rigorously defined collaborative environments, such as centralised (client-server) or distributed (such as peer-to-peer) models or hybrid model (web services) into a self-organised interactive environment which offers cost-effective digital services and value-creating activities that attract human, organisation and software agent participate and who benefit from it.

3. Evolution of Digital Ecosystems Architecture

In Figure 5, we present the evolution of Digital Ecosystem Architecture.

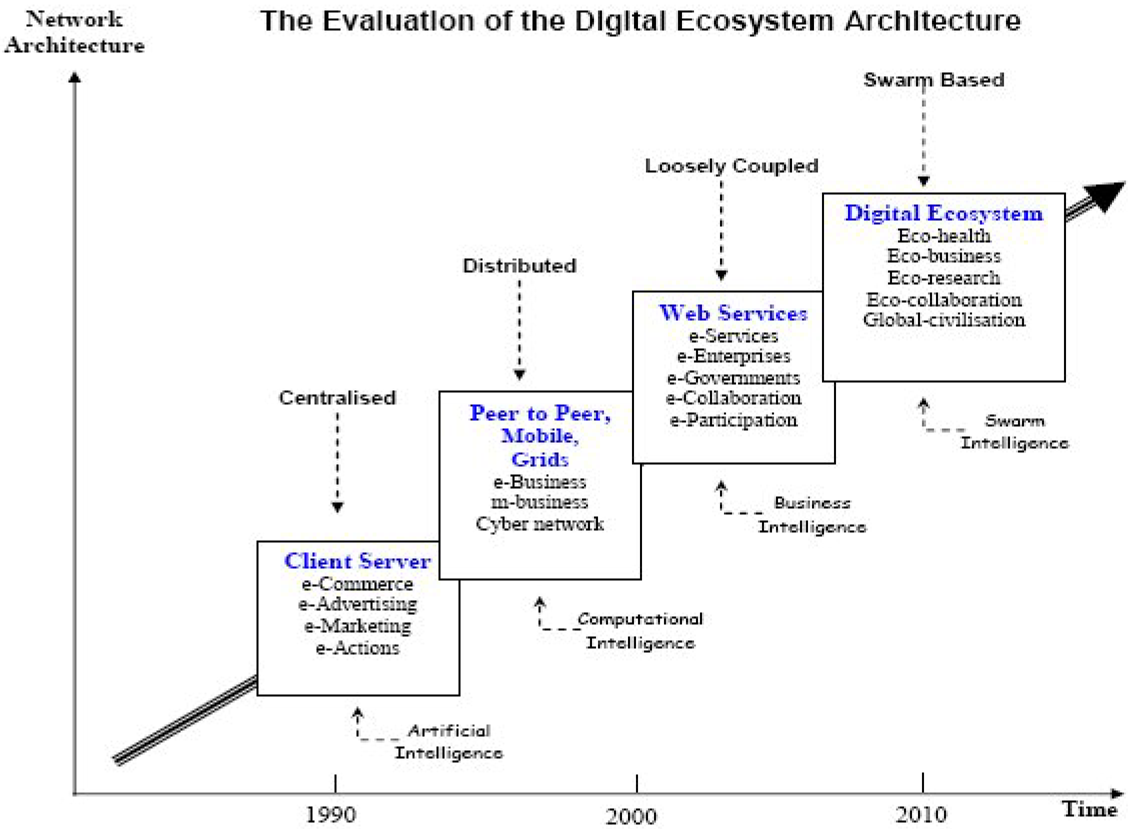

Figure 5 Evolution of Digital Ecosystem Architecture

3.1 Client-Server Architecture

The *client-server architecture* depicts that one computer acts as the server and others act as clients. This digital infrastructure defines that there is only one server in the collaborative environment and has full control of data and information as well as the network. Everyone else is a client only and this role of communicating (either clients or server) is clearly defined from the beginning. For example, a client cannot be changed to a server for the same transactions once the infrastructure is set up [10].

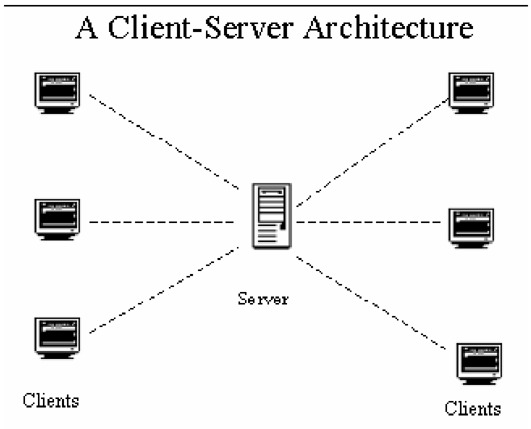

Figure 6(a) Client-Server Network

3.2 Peer-to-Peer Architecture

The *Peer-to-Peer (P2P) Architecture* denotes that each computer has the same roles and functions [31]. A P2P network distributes information among the nodes directly instead of interacting with a single server [25]. P2P supports heterogeneous systems [29]. Each node has its own repository for distribution to other nodes. There is no central repository in a P2P network as information is automatically spread in the network [31]. Napster, Gnutella, Kazaa and Freenet are among the most popular P2P applications [32]. For an anonymous network, the identity of the node is unknown [19]. Among the four most popular applications, as previously mentioned, only *Freenet* provides anonymity in accessing the network [32].

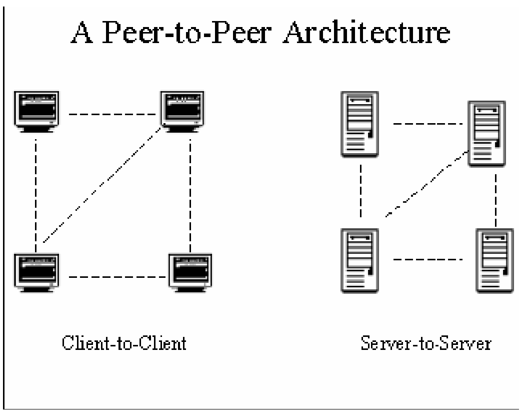

Figure 6 (b) Peer-to-Peer Networks

3.3 Grid Architecture

Grid Architecture assembles the existing components and information resources in order to be able to share them among the users [26]. The grid network provides a resource-sharing paradigm for clients. In particular, the grid network is a collection of servers and clients working together [15]. Each node is autonomous. There is no central management. A grid network is similar in a few respects to P2P in that they both provide the sharing of resources and components among the nodes in the network [20]. Even though the grid network supports heterogeneous systems, to integrate enormous numbers of heterogeneous components and resources it is expensive and with the current available technology poses difficulties. See Figure 6(c).

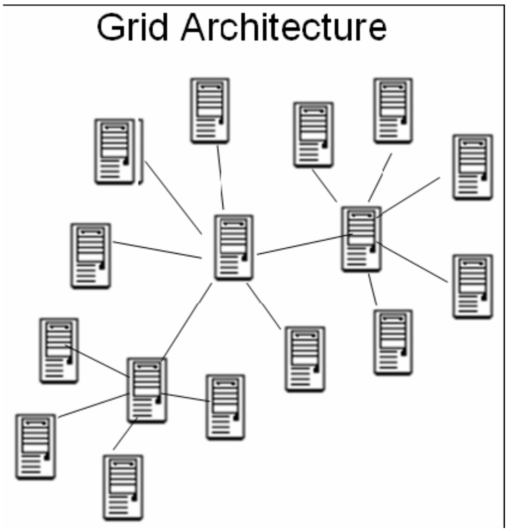

Figure 6(c) The Grid Network

3.4 Mobile and Ad-hoc Network Architecture

Mobile network architecture provides infrastructure for the user to access the network wherever they want without being tied to a fixed location PC, as they change their geographical location, using compact devices such as PDAs, smart phones and internet appliances [35].

An *ad-hoc network* is a local area network (LAN) or small network, where the connection is temporary. The communicating parties are in the network only for the duration of a communication session.

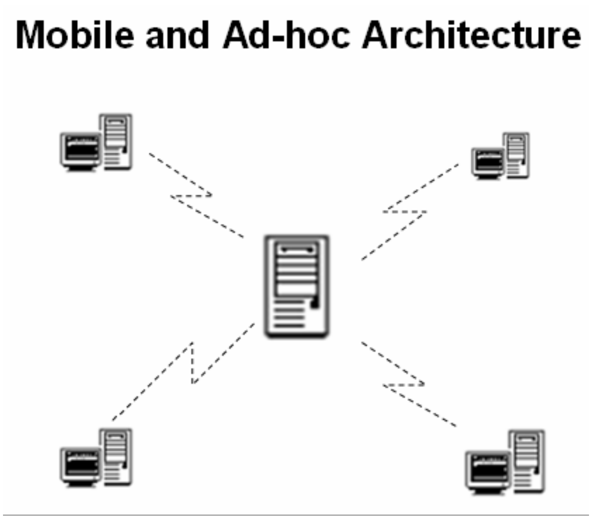

Figure 6(d) The Grid Network

3.5 Web-Service Architecture

A typical SOA consists of the interactions between three roles, namely Service Providers, Service Requesters and Service Brokers. They also involve three distinct activities namely 1) *Publishing*, 2) *Finding* and 3) *Binding*. Broker is centralised, and Service Providers and Service Consumers are distributed. It is a hybrid architecture that provides a better mechanism for e-business. However, it does not guarantee the quality of Goods and Services. To reshape the world of e-business we need a *trusted business* processes and the reputation of the services. The next generation of the Internet must have some degree of quality control over business conduct in the Internet through measuring or recommendation of goods and services or agents.

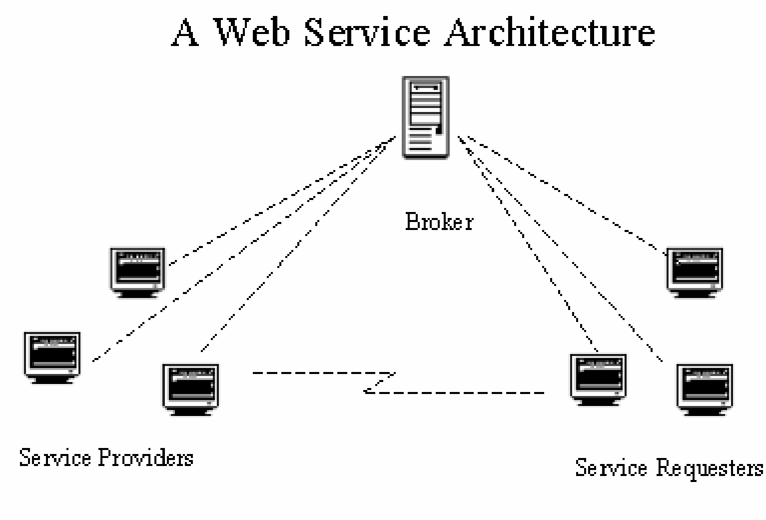

Figure 6(e) A Web-service Network

3.6 Digital Ecosystem Architecture

The Digital Ecosystem is an open, loosely coupled, domain clustered, self organised, intelligent agent based community, where each agent has *dual roles*. They can be *client* and *server* at the *same time*. They may offer their service to others as a Server and request a help as a Client. There is no centralised control or fix roles. There is no fixed architecture. The communication and collaboration is through swarm intelligence.

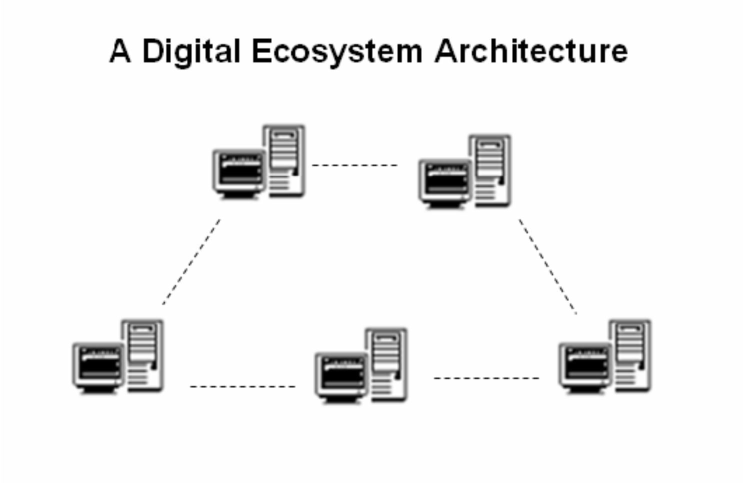

Figure 6(f) A Digital Ecosystem Architecture

4. Swarm Intelligence for Self-organising Digital Ecosystem

Unlike traditional environments, digital ecosystems are self-organising systems which can form different architectural models through Swarm Intelligence. Sometimes, species or intelligent agents may form a hierarchical organisation where the communication channel is defined.

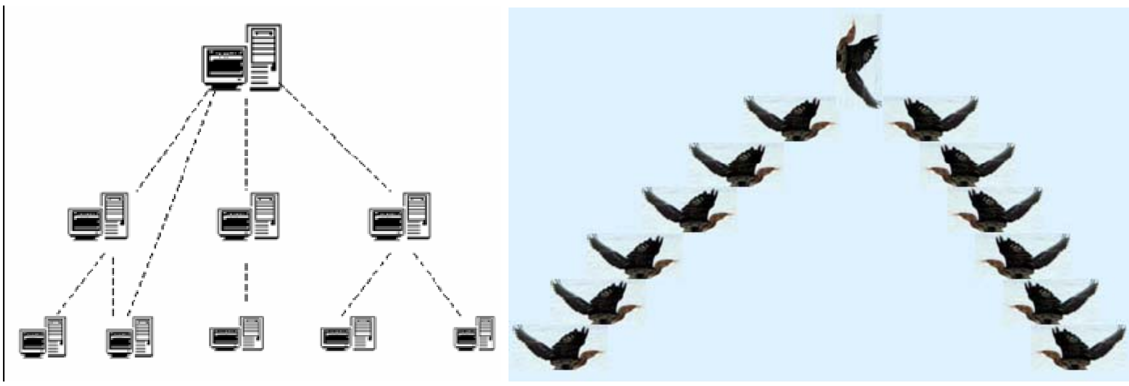

Figure 7 (a) In an ecosystem, a self-organising *hierarchy of swarms* may be formed through swarm intelligence or a leading specie (Leading bird or Queen Bee) and a communication channel is defined.

Sometimes species or intelligent agents institute a work-flow process, where sequential ordered tasks and flow of operations and collaboration are well defined.

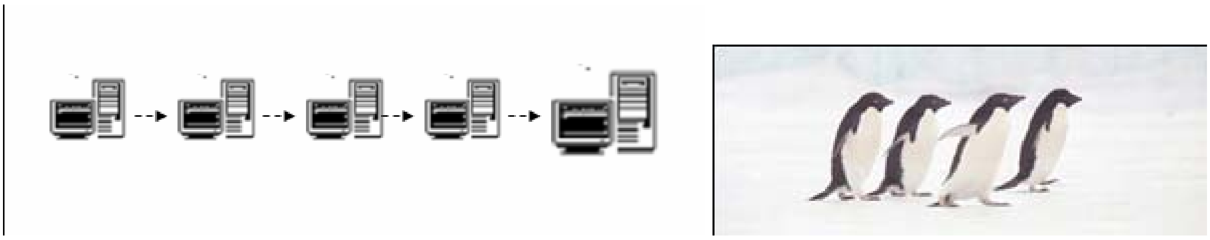

Figure 7 (b) In an ecosystem, a self-organising *sequential workflow* architecture may be formed through swarm intelligence

Sometimes species or intelligent agents could collaborate in a circular fashion, where every agent is self-coordinated and put their energy together to tackle issues or have fun.

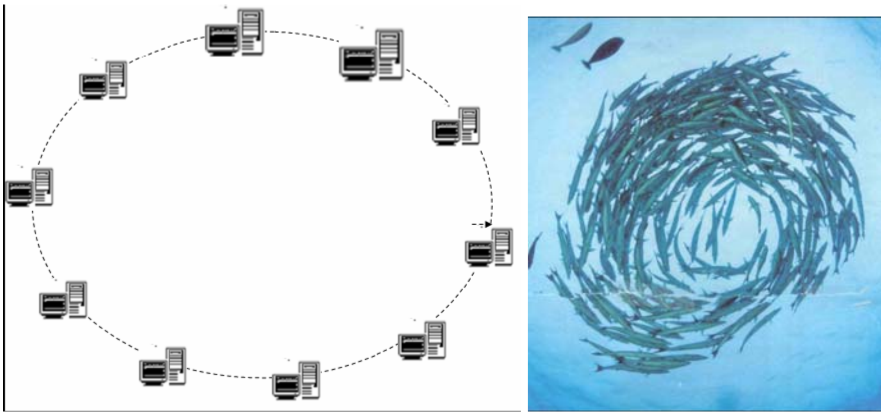

Figure 7 (c) In an ecosystem, a self-organising *circular* architecture may be formed through swarm intelligence

A *swarm* is a set of species which has common characteristics and are able to interact and engage directly or indirectly with each other. They collectively carry out a task or share the problem. Swarm Intelligence is an important property of ecosystems. We often see a collective behaviour of species or agents interacting with each other and the environment and generate a coherent functional global pattern. Swarm Intelligence is now widely researched as it provides a basis to explore collective behaviour for problem solving without centralised or command and control systems and the provision for flexible, dynamic interactive models, see Figures 7 (a), (b) and (c).

There are two elements in Swarm Intelligent:

(1) Species or Agents

- They are the foundation of the intelligence
- They can be viewed as an individual or an organisation
- Each has its own niche or role to play
- Each has dual functions or roles, they can be client and they can also be server
- Each one can carry out bi-directional communication, not just one way.

(2) Leading Specie or Agent

- It facilitates, leads and directs the collaborative swarms

- It may be the representative of the domain cluster in the interaction with other domain or ecosystems
- It has the same features and functions as any other agent

Animals, humans, software agents or autonomous robots can all be analysed as multi-task autonomous systems. In analogy with biological and ecological systems, one can find a better understanding of intelligence and rationality than that provided by traditional AI [44, 45, 46]. Swarm intelligence can teach us about intelligent behaviour as human models in relation to rational behaviour, goal seeking, task accomplishment, learning and other important theoretical issues [44, 45, 46].

7. Comparison and Contrast with Existing Networked Architectures

Unlike the *client-server architecture*, where the communication is centralised and it is a command and control environment; Unlike the *Peer-to-Peer architecture*, where each agent has well defined roles, they can only be client or server, but not both; Unlike the *Grid architecture*, where it stitches partners together on resource sharing but cannot avoid counter-free riding; Unlike the *Web service network*, where brokers are centralised, service requesters and providers are distributed, and this hybrid architecture does not guarantee trust and QoS - the Digital Ecosystem is an open community, and there is no centralised control or fix roles.

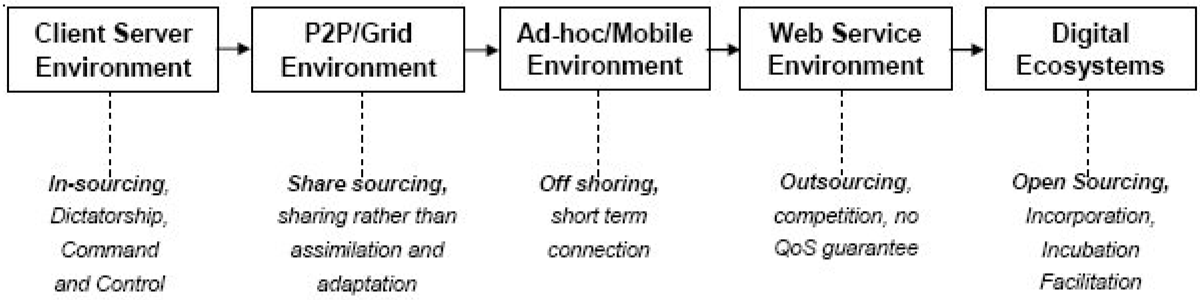

Figure 8 The advances in Digital Ecosystems

In the following section, we offer a comparison and contrast of the feature differences between existing collaborative environments and digital ecosystems. These include the models, architecture composition, roles of each component, communication framework, goals the environment is trying to achieve etc.

We believe the development of digital ecosystems will become mainstream over the next decade in science, social science and engineering and we believe it will result in a great impact to civilised collaboration, growth and economic development.

Table 1. The comparison between Digital Ecosystems and other existing collaboration environments

	Client-Service Environment	Peer to Peer Environment	Grid Network	Web Services Environment	Digital Ecosystems
Model	Centralised	Distributed	Distributed	Hybrid (centralised and distributed)	Swarm based distributed swarms
Composition	Several clients and 1 server	Peers	Notes	Broker, service providers, service requester	Species or Agents
Roles	Either Client or Server, and cannot be changed	Each peer carries a single role and the role cannot be changed	Obey Service Level Agreement	The entity has a well defined role and cannot be changed	Each species or agent has dual roles, it can be a client or a server
Architecture Foundation	3 Tier architecture	Ad-hoc distributed computing	Middleware	SOA Service Oriented Architecture	Swarm intelligence, ontology and agents
Communication	To or from a central server	RFC (Request for Comments) download/uploads	On demand access	Request, find and bind	Supply and demand
Goals	e-Commerce, central information repository	File sharing, anonymous communication	Resource sharing	e-Business, e-services	Collaboration, cooperation, balance, growth, and prosperity

8. The Implementation of Digital Ecosystems

Digital ecosystem consists of two parts namely a) species or agents; and b) an ecosystem environment. Each species or agents can be viewed as an individual or an organisation and has its own niche or role to play. Instead of having clients, peers or brokers in digital ecosystems, we have species or agents. They work together to take care of their living environment. Every specie or agent within a digital ecosystem has dual roles. This is one of the major significant factors of digital ecosystems.

The *leading* specie or agent within a digital ecosystem facilitates, leads and directs the collaborative swarm and may represent the domain in the interaction with other domains (such as animals, humans, plants, earth).

Instead of communication as request, search, find or bind in traditional collaborative environments, the digital ecosystem species or agents communicate via ‘supply’ and ‘demand’ requests. *Supply* is a free service provided by the species or agents who want to share thoughts and opinions. *Demand* is a request from the species or agents, who are seeking services, advice or assistance that is offered by the digital ecosystem. The digital ecosystem aggregates the opinions for its species or agents for the benefit of the ecosystem.

If the communication is via *supply* activities, the species or agents are currently in a state of being a 'Server'. If the communication is via *demand* activities, such as 'request' of a service or seeking recommendation and the like, the species or agents are currently in a state of being a 'client'.

Another distinction is that in the traditional environment, the direction of communication as request, find, search or bind is a uni-directional communication and fixed against the role it designated. However, this is not the case in digital ecosystems. The 'supply' and 'demand' requests can be initiated from one specie or agent (ie: X) to any other units (ie: A, B, C) and from A, B, C to X. It is bi-directional communication.

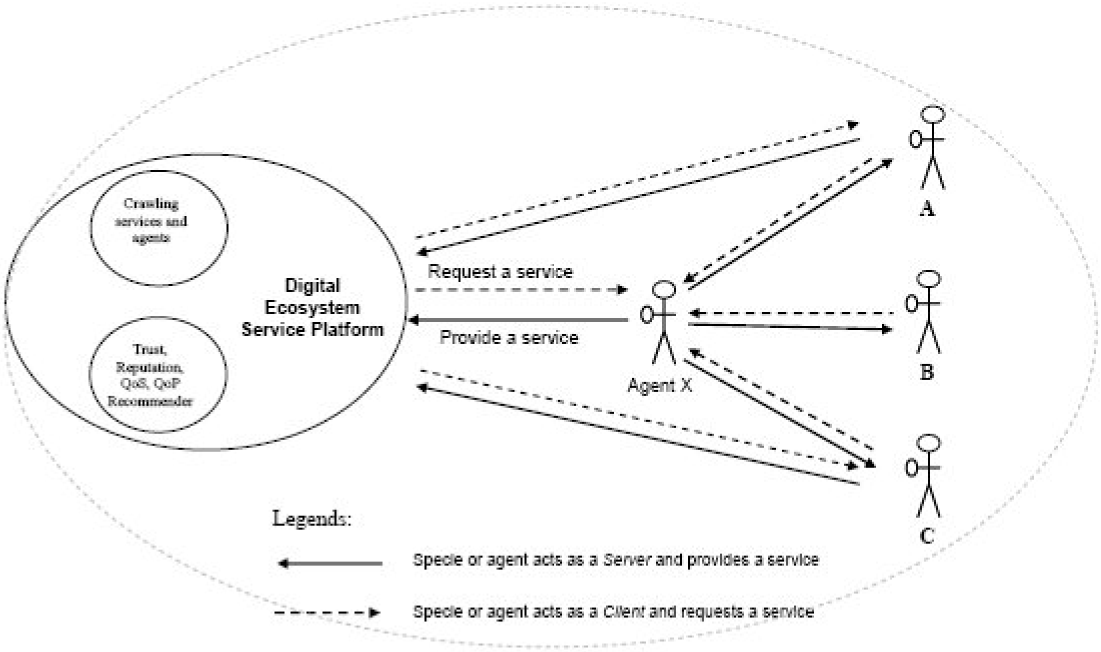

Figure 9 Digital Ecosystem Components and its Agents Interaction

In Figure 9 we see the digital ecosystem is a platform for services. In itself, it has two main swarm-based intelligent components namely: a *Crawler* for crawling services and agents around the Net and classifying domains; and a trust, reputation, quality of service and product recommendation system. The platform offers services for its agents within the community (such as rental service) and it also requests a contribution from its agents, such as feedback or experiences in using the services. The ecosystem then aggregates the feedback and provides the recommendation to both service providers and service requests. It gives an open, transparent environment that agents and the ecosystem as a whole find valuable and benefit from it.

Within an ecosystem framework, an agent can offer a service to other agents or obtain services from others. Refer to Figure 9.

The collection of different digital ecosystems in the world forms today's digital networked economy. Between different digital ecosystems, they can also communicate and cross fertilise each other's fields and work together to preserve quality of life and fighting diseases, as well as providing better services or enjoying peaceful surroundings. However, if they do not, the networked economy and digital ecosystem will fail because they do not maintain their environment, productivity, prosperity and balanced life (see Figure 10 below).

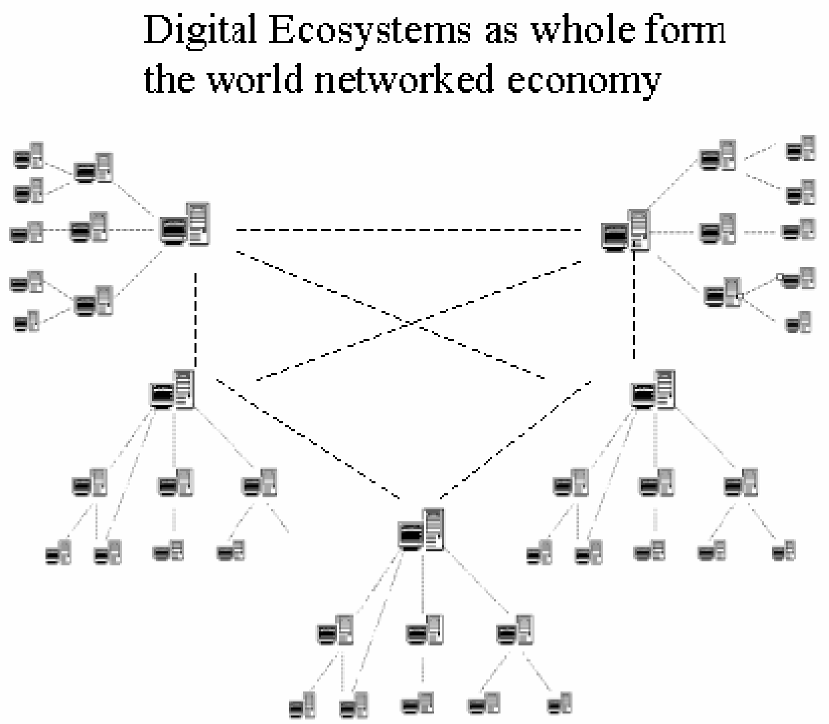

Figure 10 The Biome of Ecosystems

9. Practical Examples of Digital Ecosystems

Example 1: A Digital Ecosystem for Extended Logistics Enterprises

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 ecosystem architecture to support a virtual logistics cluster.

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, contain 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 specifically targeted 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 organisational databases occupy the digital ecosystem. Especially, SMEs cannot afford large infrastructure, lack of capacity in carrying our large contracts, lack of main power and lack of speed in generating output and they do not need competition between each other to survive, as they are small and fragile. They do not have the resources to go through that. They would work better together and form a consortium and partnership to compete against larger players. Ecosystems provide opportunity for synergy, incubation and facilitation, growth and prosperity.

Virtual Collaborative Consortia logistics are a prime example of digital ecosystems. Collaborative supply chains involve horizontal industry collaboration and the *logistics network* involves vertical industry collaboration. Gardner (2002) indicates that 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 on investment (Talevski, A., Chang, E., Dillon, T.S., 2005). Weakness in logistic capabilities creates a multi-billion dollar cost burden on the Australian economy. Logistic and supply-chains are vital to the global economy especially in developing countries where 90% of logistics companies are SMEs.

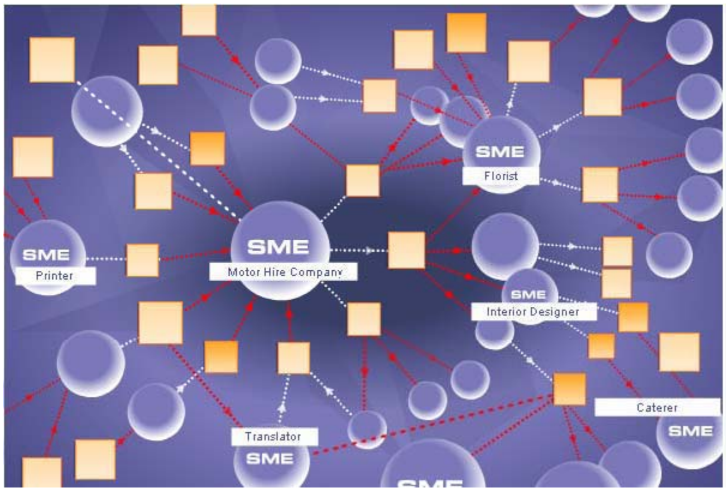

Figure 11(a) A digital ecosystem provides synergy for SMEs to collaborate www.syntelinc.com, http://www.digital-ecosystem.org

The above example demonstrates that SMEs (Small Medium Enterprises) collaborate among themselves. The system has two parts; an ecosystem service platform and agents or SMEs that participate, offering their services and request services. The next example shows that a large organisation can also collaborate through digital ecosystems with SMEs or other large organisations to provide win-win situation.

Example 2: A Digital Ecosystem for Large Organisation Collaboration with SMEs

In recent times, the Department of Defence (DoD) of Australia instituted a RPDE program which enables rapid production of solutions through digital ecosystems. The aim of the program is to support collaboration between the Department of Defence and local industries and to accelerate the network centric warfare solutions into Australian Defence Warfighter organisations. They target rapid production of measurable output and benefit in the near-term in weeks and months rather than years. RPDE has expanded its collaboration with over 100 SMEs in Australia. It is now seeking linkage with institutions and universities. Over the last two years, they forecast spending of up to $13 million on technology and methodology adoption and development.

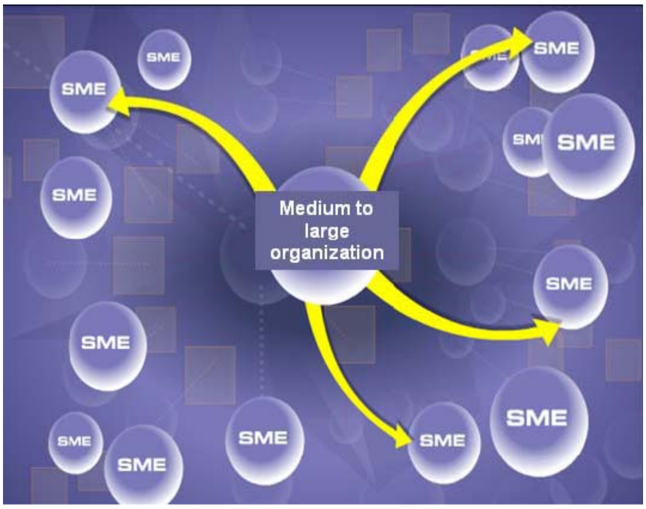

Figure 11(b) A digital ecosystem provides synergy
for large organisation to collaborate http://www.digital-ecosystem.org

Australian SMEs, especially the IT industries, are weak and fragile after the dot.com boom. The DoD is one of largest sponsored government bodies with issues and problems which appear everyday, such as marine safety, border security, logistic tracking, bio-defence technology etc. and requires solution in a relatively short period of time - typically 6-9 months. The DoD understood that they cannot have all the skills and expertise within its own organisation. Therefore, through the RPDE program, they call for expertise within its digital ecosystem, a 1-2 days workshop will be initiated and integrated intelligence and wisdom is obtained from local industry participants and the planned budget, schedule, resources and scope of the project are defined and contracts are issued.

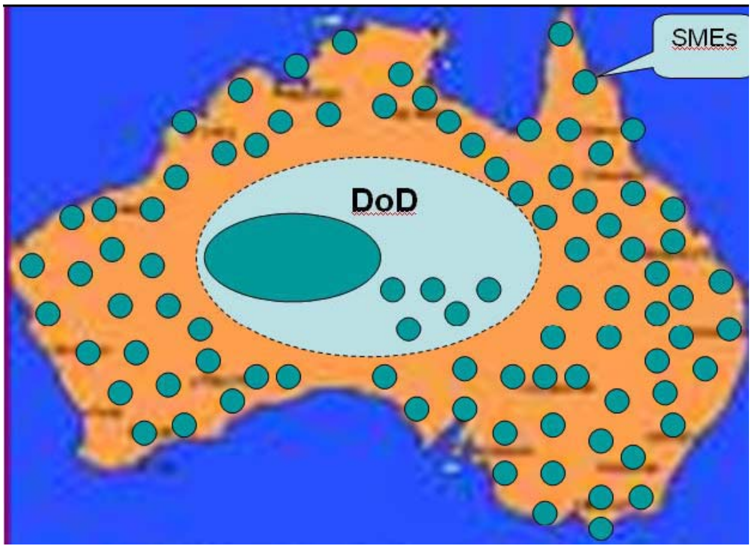

Figure 11(c) View of DoD in collaborating with 100s SMEs around Australia

This is a typical win-win situation. It was this networked environment that has enabled the DoD to link, coordinate and share their issues and tasks at a national level, not just in Canberra or within the DoD. This is an outstanding example of an ecosystem and a digital ecosystem. The system has two main components, a digital ecosystem service platform and agents or organisations that request and offer their services. It is loosely coupled, self-organised infrastructure that provides benefit to all parties involved.

10. Conclusion

This paper provided an extensive explanation of digital ecosystems, their architecture and comparison with most advanced communication platforms or environments such as client-server, P2P and web-services. We also provided two practical examples using digital ecosystems. We hope that this paper will help worldwide researchers to further understand and broadly apply digital ecosystem ideas, principles and architecture in business, government and other domain disciplines to enhance the productivity, growth, prosperity and social, culture and economic balance and sustainability.

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