Emerging Problems in the Digital Business Ecosystem

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Abstract. The current research and development in the ITC has opened new opportunities and threats for both large corporations and SMEs alike. Many SMEs see the new Digital Ecosystem as a new open frontier where they can enter, innovate and compete with large corporations on an equal footing.

This paper examines the role of the large corporations (the keystones) in the digital ecosystem and presents arguments about the emergence of two major problems that if left unanswered will result in creation of major entry barriers for SMEs. It briefly examines the definition and role of the keystones in both the business and digital ecosystems; pointing to the historical tendency of large corporations to try to create entry barriers and hence creating monopolies.

The current structure of the scale-free networks in digital ecosystems, if not changed, provides natural environment for the growth of a few super-nodes or hubs that can in time dominate the networks. Similarly, the current proposed frameworks: Business Transaction Protocol and Web Services transaction (WS-Atomic Transactions and WS-Business Activity) lay the foundation not only for the creation of future monopolies or oligopolies, but also for forcing the SMEs to lose their local autonomy.

Keywords: Keystone, Scale-free networks, Service-Oriented Architecture (SOA), Coordination, Digital ecosystems,

1 Introduction

In 1993 James F. Moore in the article “Predators and Prey: The New Ecology of Competition” compared the business environment to an ecological system. He used the metaphor “business ecosystem” to describe the business environment as an economic community which “is supported by a foundation of interacting organizations and individuals--the organisms of the business world.” [1]

The resemblance between the two systems is of course not complete and there are certain recognisable differences between the two, such as self optimisation [2], conscious decision making [3] or the intelligence of actors in the ecosystem [4].

Nevertheless, this comparison of economy to biology has been seen as extremely relevant and useful, not only because this comparison improves our understanding of the roles and interconnectedness of various actors in the business ecosystem, but also because of increasing connectivity and complexity of these systems.

Of course, one can consider an economy to be a national business ecosystem [5] composed of many smaller systems, all of which are directly or indirectly interconnected. What many call an industry can now be considered to be either an ecosystem or being part of one. These business ecosystems are populated by (some loosely) interconnected organisms: businesses, consumers, the government and other stakeholders.

As far as the business population of each business ecosystem is concerned, majority is composed of Small and Medium size businesses (SMEs) along with a few large ones, the so called keystones. Marco Iansiti and Roy Levin compare the role of these keystone companies to those of keystone species in nature [6].They argue that we live in an interconnected world; landscape of which is made of network of networks, with keystones at the hubs and niche players surrounding the hubs.

Until recently majority of attention of both academia and the governments have been focused on these keystones, believing that what is good for the keystones is good for the business ecosystem and hence the nation. However, over time, it has become clear that, depending on government regulations and policies, these keystones can play either a positive or a negative role in the business ecosystem.

2 Keystone: the Problems of definition and behaviour

In nature a Keystone species is defined as "a species whose effect is large and disproportionately large relative to its abundance" [7]. It is also argued that Keystones help in determining or regulating the number and type of other species in their communities. It is generally believed that keystones play a positive and a necessary function in the ecosystem. This view is also shared by majority of those who have rushed to adopt the concept for the business ecosystem.

But the keystone concept has been adopted in both computer and business literature without actually questioning the correctness of the analogy. Even if, for the sake of the argument, we accept the analogy, we cannot ignore the arguments of the critics of the concept in its original context, namely the definition and role of keystones in ecology. For instance Payton et al. [8] argue that:

> The idea that some species may function as keystones has not been without its critics (Mills et al. 1993; Hurlbert 1997), who argue that while the concept has 'developed tremendous currency and fashionability' it has also become increasingly ill-defined, and now means little more than 'important for something' (Hurlbert 1997). In defence of this position, opponents cite the vagueness of keystone definitions and their inconsistent usage in the literature, and an implied dichotomy between keystone and non-keystone species that has not been demonstrated in nature. Hurlbert concede that the notion was 'appealing and harmless', but as a well-defined concept or phenomenon he concludes it 'has had a stultifying effect on ecological thought and argument'.

It is important to note that in nature a keystone species does not have the ability to freely relocate to another ecosystem, nor does it have the option of outsourcing parts of its activities. And most importantly, in nature a keystone species lacks the intelligence level of its namesake in business ecosystem.

3 Keystones: From industrial age to information age

Technological innovations have always led to the creation of new companies by entrepreneurs who have tried to take advantage of those innovations to create a competitive advantage for themselves in the marketplace; which in turn necessitated the adaptation of those innovations by the older established companies.

Until relatively recently, the rate of diffusion and adaption of new technologies was rather slow. Lack of speedy communication was one of the reasons behind this glacial diffusion rate. For example, new machines were invented and used in one part of the world without it being introduced and used in other parts. A good example of this is the printing press, which was invented in China a few hundred years prior to its "re-invention" in Germany in 1439.

However, Industrial revolution (1760-1840) [9] reduced the distance between the continents. The improvements in steam engine (steam locomotive 1804), invention of telegraph in 1830s and later telephone in 1860s effectively reduced distances between towns, countries and continents. This reduction in distance also opened new markets, allowing manufacturers and producers to increase production capacity which in turn led to increasing size of these companies.

Indeed the origins of the modern diversified corporations can be traced back to the creation of large corporations at the beginning of the last century; when mass-production (brought about by innovations in work methods and mechanical automation) allowed many companies to grow rapidly and prosper at a rate that had never been seen before in history. Companies such as Ford, General Motors, Standard Oil Company and others grew from small businesses to large corporations (keystones), whose turnover matched the GNP of many small nations.

Until early 1920s, these corporations were primarily single business units. Ford manufactured cars, while Standard Oil was concerned with oil exploration, extraction and refining. The driving force behind these corporations was their owners who knew their businesses well and exercised total control. However changes in size and organisational forms required new strategies.

In this era competition, by and large, was seen as "dominate or absorb" with one exception: the creation of cartels. "Price competition among large-scale rivals proved mutually destructive to profits and after a brief period of cut-throat competition, business enterprise turned to cartels, trusts and other monopolistic forms of organisation designed to eliminate price competition" [10]. Here the theories of Cournot [11] (monopoly, duopoly, and oligopoly), first published in 1838, were put to work. This allowed the owners, the so called "robber barons" [12], to concentrate on increasing internal efficiency

of their organisations.
Part of this internal efficiency was achieved by focusing on economies of scale, i.e. to produce a product faster, better and cheaper than competitors, using mass-production (changes in the supply side). As the competition intensified and marketing and customer demand became more important, these companies began to change their focus to economies of scope [13]; that is producing "different products" faster, better and cheaper.

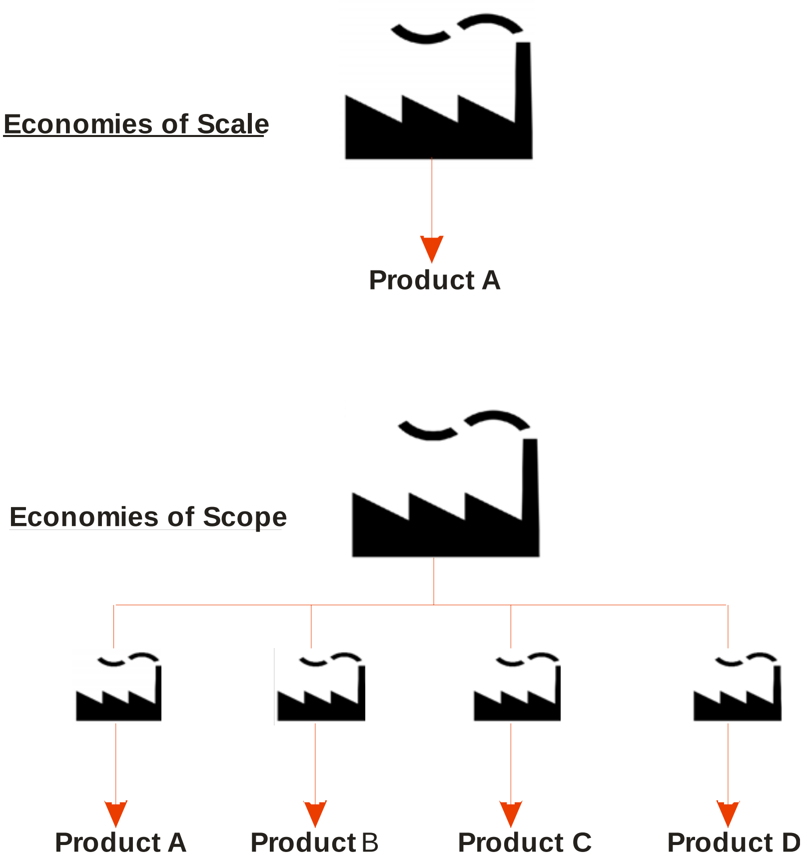


Figure 1. This is the figure text

As can be seen, there is a marked difference between the economies of scope and economies of scale. Economies of scale spread fixed cost over a large number of units of production of the same product or enterprise while economies of scope involve spreading the cost of a set of resources or skills over two or more products or enterprises. One should also note that economies of size and scope are not mutually exclusive. While economies of scope allow costs to be spread over several enterprises, the size of each enterprise can be increased to also achieve economies of scale.

The improvement in internal efficiency was not limited to the production technologies. The management practices, routines and business processes were also examined and improved. As businesses, especially manufacturers sought ways to reduce their costs and improve their responsiveness; they adopted new concepts such as Just-In-Time (JIT) system, which demanded a closer cooperation (i.e., timely access to information and products) between producer, suppliers and customers.

Intranet and extranets were the answer to many of these problems. Intranets allowed big firms to create their own private internet, sharing organisation's information or operations with their employees. Extranets (which can also be an extension or part of the Intranet) in turn allowed these firms to connect to suppliers, vendors, partners, and customers.

Intranet and extranet were the result of the general works done in the late 60s and early 70s by the Advanced Research Projects Agency (ARPA) on the creation of the first internet connection (between UCLA and SRI International in Menlo Park, California), the start of the so called ARPANET. By mid 1980s the internet had changed from NetWare Core Protocol (NCP) protocols to Transmission Control Protocol/ Internet Protocol (TCP/IP). In 1991, the European Organization for Nuclear Research (CERN) publicised its World Wide Web project which laid the foundation for the following explosive growth of the internet.

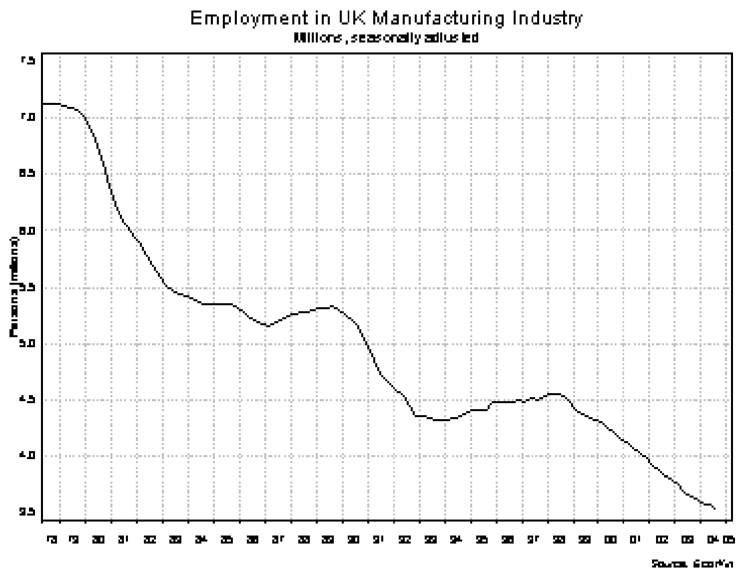
The creation of internet along with the rise of the mini and micro computers in the late 1970s and Personal Computers (PCs) in the 80s facilitated the transition from industrial era to information era and the network economy.

3.1 Changing the face of competition

Intranets and extranets allowed companies to connect their offices, plants, suppliers and customers into closed networks. This allowed them a better overview of their operations while strengthening the coupling between themselves and their customers and suppliers. Indeed implementing JIT without such networks would have been impossible. Similarly, outsourcing of many goods and services is extremely difficult without the existence of such networks.

Until a few decades ago, creating such networks required large amount of capital, specialised software, hardware and expertise; which made it a perfect tool for erecting entry barriers around industries. In addition these new technologies gave large corporations geographical independence. It allowed these corporations to relocate parts of their operations to low-cost countries, effectively reducing their operations' costs. It started with manufacturers and was followed by service companies. Some may see the advent these ICT technologies as one of the main facilitators of the globalisation. Today a large company can have its administration in London, its production facilities in Shanghai, and its accounts and billings in New Delhi.

There are many reasons given for this relocation, chief among them being the pressures of the global competition. This can partly be accepted for standardised low-value goods in the manufacturing industry; however it is rather difficult to accept this reason for service industries. For example the competition in utility such as gas or water is national or in some cases even regional. Moving British Gas customer services such as billings or customer enquiries to New Delhi does not look like the result of international competition in this sector in UK. It seems to us more the result of increasing pressure from shareholders on company's executives for higher returns.



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Whatever the case may be, the relocation or outsourcing of many services and manufacturing activities to low-cost countries has put a tremendous pressure on local SMEs; which traditionally have been the providers of many goods and services to the larger corporations.

In addition those SMEs that were directly competing with the large corporations also felt the pressure of these relocations and outsourcings. Not only they could not compete with the low-cost countries, where past of services or products were being produced, but they also lacked the distribution channels of the large companies.

> Lacking the ability to share information with others, small suppliers, distributors, and consumers were disconnected, doing business on the margins in industries dominated by large players. Economists called these unconnected spaces in an organisation, market, or industry *network holes*. Those "holes" became a prime target for Internet entrepreneurs in the late 1990s.

> While the key technological innovations of the Industrial Economy enabled economies of scale and scope in production, the technological innovations of the Network Economy are improving economies of *distribution*, especially in relation to coordination, communication, and information sharing. [14]

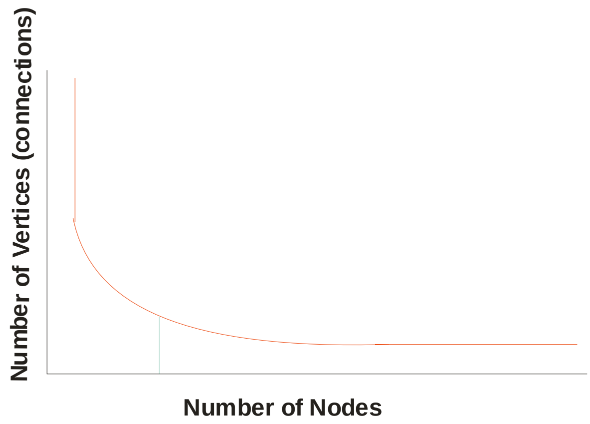
The internet was seen as a solution to many of these problems. First, the Internet itself was and is a dynamic and exciting new area (it was and is considered) where large companies don't enjoy their traditional advantage of size. Second, Internet itself was and is seen as a brand new market ripe for new products (software and hardware). And finally SMEs see in Internet, the perfect opportunity to find and establish new connections to other businesses and customers. But as we shall see Internet has its own problems.

4 First Mover Advantage and Scale-free Networks

After each technological innovation, a group of start-ups and SMEs move in to take advantage of the new opportunities. Technological evolutions usually give birth to new industries where start-ups and existing SMEs, because of their size (agility) enter first, becoming the first movers. First movers generally have the advantage of registering patents, establishing brand names, changing the economics of the market making it difficult for others to enter and compete and so on. In young industries, first movers have the ability to, in a very short time, become industry leaders or keystones. We have seen this with Microsoft and personal computer operating systems. Microsoft was one a few first movers in this segment. Microsoft managed very quickly to establish itself as the leading PC operating system provider and thereby create a quasi standard for PC operating systems, which was and is highly lucrative. To dominate and discourage others from entering the market, it bundled its operating system with the PCs, making it extremely difficult for others to compete. Even almost free operating systems such as Linux with compatible quality, and same or better functionality, have had a hard time competing with MS operating system. Using its operating system as the main platform (and a cash cow), Microsoft has tried to limit competition in other segments of the PC industry (e.g., office, internet browser, multimedia player etc.).

We have seen other first movers such as Yahoo and later Google (search engines), Adobe (readers) following the same strategy in other segments, trying hard to set standards or changing proposed standards to their advantage, although with less success than Microsoft. Nevertheless, first mover advantage has been very rewarding for these companies, especially in the Internet. First movers have managed to become strong hubs with many links, becoming almost impervious to competition from smaller actors.

Internet is a network of computers. This network has no determined structure and expands in a random fashion. New nodes (computers) constantly connect and disconnect themselves to the network via links (vertices) to other computers. Studies [15,16] have shown that the topology of this network is governed by power- law distribution; which means that often a few nodes evolve in such a way to attract a large number of links while many nodes continue to exist with only a few links. This is especially true for World Wide Web (WWW) where page links acts as links to other pages and hence internet sites. This gives those nodes (with large number of links) and companies that own them a disproportionate power in the network. First movers have managed early-on to become large hubs. SMEs in this sector have very little chance of becoming hubs. The entry barriers in this sector are getting higher and higher. If by chance or design an SME manages to acquire a number of links (e.g., Alibaba.com in China), it is bought (Alibaba was acquired by Yahoo) and integrated into the existing hub.



Power-Law Distribution in a network:
Few nodes have many connetions while many have few.

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The power of these hubs is so strong that even large companies with sufficient financial resources and know-how such as Microsoft have trouble competing effectively in these segments. Similarly, as Microsoft used its size and financial resources (derived from its operating system) to spread its wings and expand into different segments, these hubs are also trying to establish themselves as Goliaths in other areas.

As was mentioned earlier, first movers take advantage of their position and try to establish themselves as the industry leaders. As such they constantly try to either set the industry standard or change the proposed standards to their own advantage. So here we see two distinct problems: the first being the structure of the networks where hubs try to dominate and the second being the question of standards being set for the creation of applications that will be running on those networks.

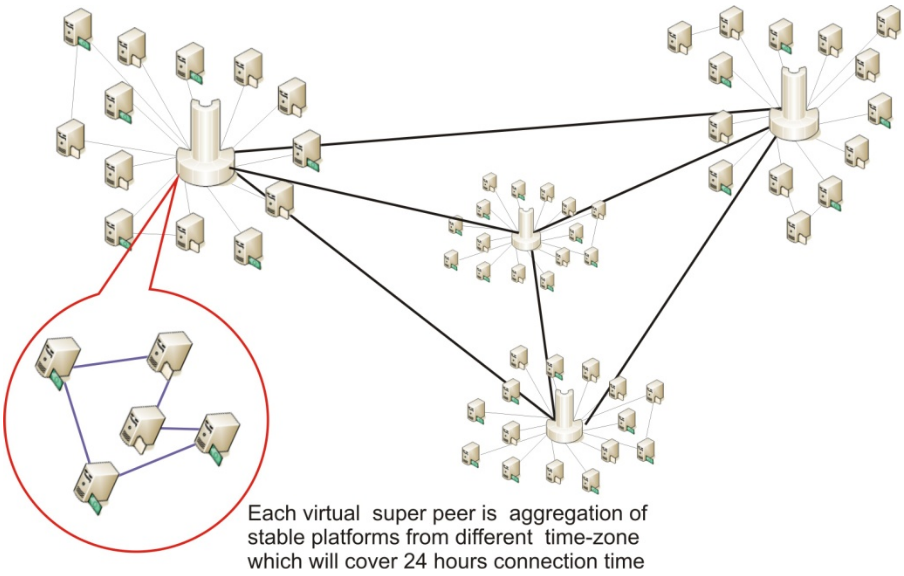
4.1 Scale-free network and Virtual Super Peers (VPS)

We have already mentioned that in free-scale networks few nodes become hubs, dominating the network. There are some arguments for the importance and thereby existence of hubs within a network: chief among them being that these hubs provide stable connections which are online all of the time.

> "Hubs, the highly connected nodes at the tail of the power law degree distribution, are known to play a key role in keeping complex networks together, playing a crucial role from the robustness of the network to the spread of viruses in scale-free networks. Our measurements indicate that the clustering coefficient characterizing the hubs decreases linearly with the degree. This implies that while the small nodes are part of highly cohesive, densely interlinked clusters, the hubs are not, as their neighbours have a small chance of linking to each other. Therefore, the hubs play the important role of bridging the many small communities of clusters into a single, integrated network." [17]

There are several problems with having these hubs. The first is that it is costly to maintain. The second is that of increasing traffic and traffic congestion during peak time. To answer the increasing traffic, one has to keep increasing the capacity of the hub, leaving substantial free capacity in the off-peak times which results in increase in the overhead costs. In addition these hubs present major targets for intentional or unintentional attacks. Any disruption at these hubs will result in major fragmentation of the network.

To solve this problem, Razavi and Moschoyiannis [18] propose a better and more egalitarian system of coordinating the networks by using Virtual Super Peers (VSPs). They propose a system where all nodes' stability is constantly monitored and graded. Based on their stability, a cluster of stable nodes are identified across different time zones (to provide 24 h stability). These clusters will then be assigned the role of network peers or Hubs (Figure 4).



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This new system offers two major advantages over the existing system of hubs. First, it reduces the danger of fragmentation. Second, it reduces the inherent power of hubs in the system; providing a more egalitarian environment where smaller nodes will have the same opportunities as the larger nodes. Having a better and more SME friendly network is the first step in addressing the problem of entry barriers in the Internet. The second problem is the problem of standards; especially the problem of influence of large enterprises or Keystones in shaping and defining standards that can be used as part of the large enterprises' competitive strategy.

5 Problem of coordination and Service-Oriented Architecture (SOA)

Having addressed the problem of scale-free networks and the emergence and influence of major players, we shall turn our attention to the problem of coordination of information systems of different enterprises over the net. The ideal solution, as has been proposed and pursued, is to establish mechanisms that allow different businesses with different practices, equipment and technologies to seamlessly and effectively communicate with each other. One of the solutions that have been warmly received by major players and other organisations has been the Service Oriented Architecture (SOA).

We must remember that architecture is more of a mind-set or a development philosophy than anything else. As such the concept has been around for a number of years and didn't become interesting for major software developers and vendors until the emergence of Web Service (WS). A WS is defined as "a software system designed to support interoperable machine-to-machine interaction over a network". [19]

The whole concept of SOA revolves around services and loose coupling. Services can be described as special functions that are accessible over standard Internet protocols and are independent from platforms and programming languages. Here the focus is on functionality not the programming languages or methods used. We can for example call the viewing of an online bank statement, a service. Services unlike the old procedures or functions have no calls to each other embedded in them. Instead protocols are defined which describe how one or more services can talk to each other. The applications are created by a business process expert or software engineer who links and sequences services, in a process known as orchestration.

> "The goal of SOA is to allow fairly large chunks of functionality to be strung together to form ad hoc applications which are built almost entirely from existing software services. The larger the chunks, the fewer the interface points required to implement any given set of functionality; however, very large chunks of functionality may not be granular enough to be easily reused. Each interface brings with it some amount of processing overhead, so there is a performance consideration in choosing the granularity of services. The great promise of SOA is that the marginal cost of creating the n-th application is zero, as all of the software required already exists to satisfy the requirements of other

applications. Only orchestration is required to produce a new application." [20]

An application is the orchestration of many services which have different dependencies on each other. They call this work flows or business processes which usually means a collection of transactions. Transactions require data consistency and recoverability. Data consistency: Regardless of transaction deployment with any rate of concurrency, the results should be consistent. Recoverability: regardless of any failure, one can roll-back the transaction to its initial estate. [21].

These two are the main responsibility of the coordinator [22]. In theory the role of coordinator can be assumed by either party to the transaction; however the current systems place a heavy demand on computational complexity [23], making it very difficult for majority of SMEs to assume this role. Therefore the current system requires that a third party with sufficient resources assume this responsibly. Here we have to mention that the coordinator enjoys many privileges [23] without the associated responsibilities (at least, the full responsibility of recovering a failure without involving participants).

The role and function of the coordinator is determined by WS-coordination protocol as defined in Windows Communication Foundation (WCF) [24]. This protocol is used by the two existing and competing industry frameworks: Business Transaction Protocol (BTP : supported by Oracle, Sun Microsystems, Choreology Ltd, Hewlett-Packard Co., IPNet, SeeBeyond Inc. Sybase, Interwoven Inc., Systinet and BEA System in term of OASIS Business Transaction Protocol [25]) and Web Services transaction (WS-Atomic Transactions[26] and WS-Business Activity [27]: supported by Microsoft, Hitachi, IBM, IONA, Arjuna Technologies and BEA Systems).

Despite all claims and advertisements, both coordination protocols for business transactions, violate loose coupling on one side and offer just one pattern behaviour (clarifying the completion protocol in a transaction and determining the recovery method in respect to that protocol [28]) for participants of transactions on the other [29].

Violating loose-coupling, not only is contrary to SOA, but also gives the coordinator the opportunity to estimate the local state of SMEs (in realistic term, this tight coupling between coordinator and participants means coordinator is aware of local state of participants at any given time during or after the transaction). For instance in a business transaction between two businesses, where PayPal is the coordinator, PayPal can in-effect during the transaction estimate the income of both parties in the transaction.

This tight-coupling results in the participants (e.g. SMEs) losing their local autonomy (their local states of businesses will be visible to coordinator). At the same time the pattern behaviour supported by coordinator framework (do-compensate [30]), forces participants to apply specific method of fault recovery during a transaction failure [30, 31, 32]. This not only enforces a specific problem solving method in event of a failure (which is known by the companies supporting the protocols) but also imposes the responsibility of sorting the failure out to participants.

The coordinator by having an overview of the participants' recovery pattern behaviour and their local state can construct or simulate the participants' business models [31, 32].

We have seen that whenever there is an innovation there are a few players that take advantage of that innovation and establish themselves as the main actors within that industry. This happened in the operating systems, office software, database and other sectors of the IT industry. Now a new opportunity is presenting itself: the coordination role.

Many large companies are already jockeying for position to take advantage of this opportunity to establish themselves as the leading companies that provide coordination services. Considering the importance of coordination and the power that a major coordinator can gather onto itself, it would be wise to revisit and re-examine the coordination process. We can ill-afford the emergence of large monopolies or oligopolies here.

4 Conclusions and further works

This paper provides a brief overview of some challenges that are facing us in the proposed and partly implemented digital ecosystem. In this paper we have pointed out two major problems that if left unanswered will tilt the scale (once again) in favour of large corporations, stunting the growth and freedom of the SMEs. Here we have warned of the real possibility of the domination of infrastructural level (scale-free networks) and tight coupling in coordination framework for service orchestration (business transactions) by the large corporations.

We acknowledge that although some technical solutions, have been provided (such as using VSPs and distributed coordination by applying local autonomy), the economical feasibilities of such solutions still remains unanswered. We will try to address these issues in our future works by analysing market conditions and determine the economic feasibility of the proposed solutions. Meanwhile the wider aspects of digital ecosystem such as B2C relationships (Businesses to Consumers) and non-commercial facets of digital ecosystem (such as social, knowledge and media networks) have not been properly researched and analysed and as such remains an exciting area for further research.

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References

[1] Moore, J.F. 1993. Predators and Prey: The New Ecology of Competition. Harvard Business Review. Vol. 71(3), pp. 75-83.

[2] Hannon, B. (1997). "The use of analogy in biology and economics: From biology to economics, and back," Structural Change and Economic Dynamics, ISSN 0954-349X, 8 (4): 471-488.

[3] Lewin, R. (1999). Complexity: Life at the edge of chaos, Chicago, IL: The University of Chicago Press, ISBN 0226476553.

[4] Iansiti, M. and Levien, R. (2004). The keystone advantage: What the new dynamics of business ecosystems mean for strategy, innovation, and sustainability, Boston, MA: Harvard Business School Press, ISBN 1591393078. pp.39

[5] Rothschild, M. (1990). Bionomics: Economy as Ecosystem. New York, Henry Holt and Company, 423p.

[6] Marco Iansiti & Roy Levien (2004). The Keystone Advantage: What the New Dynamics of Business Ecosystems Mean for Strategy, Innovation, and Sustainability, Harvard Business School Press, ISBN 1-59139-307-8

[7] Power, M. E. ; Tilman, D.; Estes J. A. ; Menge, B. A.; Bond, W. J. ; Mills, L. S.; Daily, G.; Castilla, J. C.: Lubchenco, J. ; Paine, R. T. (1996). "Challenges in the quest for keystones". Bioscience 46: 609-620

[8] Payton, I. J. ; Fenner, M. ; Lee, W. G. 2002: Keystone species: the concept and its relevance for conservation management in New ealand. Science for Conservation 203. 29p.

[9] Toynbee Arnold (1884). Lectures On The Industrial Revolution In England: Public Addresses, Notes and Other Fragments, together with a Short Memoir by B. Jowett, London, Rivington's (1884); Whitefish, Montana: Kessinger Publishing (pb 2004). ISBN 1-4191-2952-X

[10] Dillard, D. (1967). Economic Development of the North Atlantic Community. Englewood Cliffs, New Jersey, USA, Prentice Hall, Inc.

[11] Cournot, A. (1960). Research into the Mathematical Principles of the Theory of Wealth. New York, Kelly.

[12] Matthew Josephson (1962). The Robber Barons: The Great American Capitalists, 1861- 1901. Harcourt, Brace & World. New York, USA. Page 315

[13] Chandler A. D. (1990). Scale and Scope: The Dynamics of Industrial Capitalism, Harvard Business Press Cambridge, MA, USA.

[14] Appelgate, Lynda M.; Austin Robert D.; McFarlan Warren F. (2003). Corporate Information Strategy and Management: The Challenges of Management in a Network Economy, 6th Edition. McGraw Hill, ISBN 0-07-112291-5

[15] Barabási, Albert-László and Albert, Réka (1999). "Emergence of scaling in random networks". Science, 286:509-512, October 15, 1999

[16] Barabasi A.-L.; Albert R.; Jeong H. (2000) "Scale-free characteristics of random networks: the topology of the world-wide web". Physica A, Volume 281, Number 1, 15 June 2000 , pp. 69-77(9)

[17] Erzse´bet Ravasz and Albert-La´szlo´ Baraba´si. "Hierarchical organization in complex networks". PHYSICAL REVIEW E 67, 026112 (2003)

[18] Razavi, A. R., Moschoyiannis S. and Krause P., (2008). A Scale-free Business Network for Digital

Ecosystems, In Proc. of IEEE Int'l Conf. on Digital Ecosystems and Technologies (IEEE-DEST 2008), IEEE Computer Society, 2008.

[19] World Wide Web Consortium (W3C). “Web Services Architecture”, W3C Working Group Note 11 February 2004. http://www.w3.org/TR/ws-arch/

[20] Wikipedia, the free encyclopedia. “Service-oriented architecture”, Retrieved 22 July 2008 http://en.wikipedia.org/wiki/Service-oriented_architecture#Web_services_approach

[21]Singh, M. and Huhns M. (2004). Service-Oriented Computing, WileyBlackwell, (26 Nov 2004)

[22] Cabrera, L. F., Copeland, G., Cox, W., Feingold, M., Freund, T., Johnson, J., Kaler, C., Klein, J., Langworthy, D., Nadalin, A., Orchard, D., Robinson, I., Shewchuk, J., Storey, T. and Satish Thatte. (2003) Web Services Coordination Framework (WS-Coordination), September 2003.

[23]Razavi, A. R., Krause, P. J . and Moschoyiannis. S. K. (2006). DBE Report D24.5: DBE Distributed Transaction Model, University of Surrey, 2006.

[24]Cabrera, F. L., Copeland, G., Johnson, J. and Langworthy, D. (2004) Coordinating Web Services Activities with WS-Coordination, WS-AtomicTransaction, and WS-BusinessActivity. Available at: http://msdn.microsoft.com/webservices/default.aspx, January 2004

[25]Furnis, P.; Dalal, S.;Fletcher, T.; Green, A.; Ceponkus, A. and Pope, B. (2004), "Business Transaction Protocol, version 1.1.0", Committee Draft, November 2004. Available at: http://www.oasis-open.org/committees/download.php/9836/business_transaction-btp-1.1-spec-wd-04.pdf

[26] Cabrera L. F. Copeland G., Cox W., Feingold M., Freund T., Johnson J., Kaler C., Klein J. Langworthy D., Nadalin A., Orchard, D., Robinson I., Shewchuk J., Storey T. and S. Thatte. (2004). Web Services Atomic Transaction Framework(WSAtomicTransaction), January 2004.

[27] Cabrera L. F., Copeland G., Cox W., Feingold M., Freund T., Johnson J., Kaler C., Klein J., Langworthy D., Nadalin A., Orchard D.; Robinson, I., Shewchuk J., Storey T. and S. Thatte. (2004) “Web Services Business Activity Framework (WSBusinessActivity)”, January 2004

[28] Razavi, A. R., Moschoyiannis S. and Krause P. (2007). A Coordination Model for Distributed Transactions in Digital Business Ecosystems. In Proc. of IEEE Int'l Conf. on Digital Ecosystems and Technologies (IEEE-DEST 2007), IEEE Computer Society, 2007.

[29]Razavi, A. R.,Moschoyiannis S. and Krause P. (2007). Concurrency Control and Recovery Management for Open e-Business Transactions. In Proc. of Communicating Process Architectures (CPA 2007), 2007.

[30]Furnis P. & Green. A. (2005). Choreology Ltd. Contribution to the OASIS WS-TX Technical Committee relating to WS-Coordination, WSAtomicTransaction and WS-BusinessActivity. November 2005.

[31] Vogt, F.H., Zambrovski, S., Grushko B. et al. (2005). Implementing Web Service Protocols in SOA: WS-Coordination and WSBusinessActivity. In Proc. 7th IEEE Conf on E-Commerce Technology Workshops, pp. 21-26, IEEE Computer Society, 2005.

[32] Razavi A. R., Moschoyiannis S. and Krause P. J. (2007). Preliminary Architecture for Autopoietic P2P Network focusing on Hierarchical Super-Peers, Birth and Growth Models. OPAALS project Deliverable D3.1, 2007