Supply Community Network: A Taxonomy of Flow Dimensions

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Supply chain management (SCM) and its associated activities continue to evolve as new communication technologies and cooperative efforts emerge to facilitate system-wide process integration; the context within which supply chains (SCs) operate, the technologies, and performance enhancement mechanisms have all changed. Thus, linear-based SCs are increasingly being challenged as firms look towards a more networked approach to maximize performance amid growing market dynamics. This paper, however, recognizing inherent similarities between social structure of Social Internet of Things (SIoT) principles and what we term supply community networks (SCN) from literature, seeks to cross-pollinate the two in a way capable of dealing with these market dynamics. Our contribution is, therefore, a new 'setting' of social relationships between supply community agents (SCA) within SCN mirroring interactions played out in the physical world; SCAs autonomously sense each other, exchange information and interact within SCN mimicking the behavior of humans. Also, it identifies the bounds of flow, i.e. all possible dimensions within a SCN which need to be understood to support relationship management. Therefore, communications are improved, sharpening SCAs synchronization in a way responsive to customer needs.

Keywords: supply community network (SCN), supply community agents (SCA), flow dimensions

Introduction

Dating back more than a century, supply chains (SCs) are considered by many to be the backbone of any nation's economy, supporting production, commerce, and international trade. Desirable characteristics of an optimum SC include collection, analysis, and proactive use of big data; inventory optimization; adaptability; rapid order fulfillment; customization and scalability; sustainability; and compliance, visibility, and traceability. However, a combination of constantly evolving technology, increasingly flexible business processes, and shifting organizational boundaries mean SCs will always be a moving target in the crosshairs of strategists seeking to tame them.

Internet of Things (IoT) offers exponentially expanding opportunities for new functionalities and capabilities that transcend traditional product boundaries. For example, Amar Abrol, CEO of AirAsia at a Strategy Forum on Internet of Things 2017 said, in the city of Johor Bahru, (Malaysia), AirAsia don't have a single human interface in terms of baggage drop, check-in and ticket purchase. But, the IoT paradigm only allows us to connect objects/things in the environment through unique addressing schemes, allowing fixed interaction and cooperation with each other. Ideally, the objects should be capable of dynamically forming their

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own social relationships without human intervention in a way that they would be able to seek out new "friends" that can offer the things they desire. So that, with the analogy of social networking services, the Social Internet of Things (SIoT) introduced the social relationships concept among objects (Atzori, Antonio, & Giacomo, 2011). Accordingly, SIoT can be defined as socializing intelligent objects in a network, thereby signaling the inevitable fusion of IoT with social structure phenomena, enabling formation of trust-based communities among objects—herein termed supply community agents (SCAs)—similar to that one associates with social networks (SN). This fledgling paradigm centers around the concept of social relationships among objects where said objects autonomously mimic[1] human behavior using social networking principles including "friend" selection, interaction, and communication in finding desired services.

Therefore, in this paper, we propose the concept of supply community networks (SCNs) with its taxonomy of flow dimensions; a new setting of social relationships between agents within and across SCN mirroring possible interactions played out in the physical world, which we argue is capable of dealing with present day market dynamics that emphasizes creating communities (rather than chains) that assess needs and make cross references instead of the rigid (inflexible) form of SCs. So, SCAs are increasingly inclined to service their own needs and to increase value and convenience for themselves when market brutality calls for survival over congruence. As such, SCNs are better able to support the concept of "coopetition" (Pathak, Wu, & Johnston, 2014), a portmanteau of competition and cooperation describing situations where two or more organizations both compete and cooperate with one another concurrently. For example, rival carmakers Toyota, Citroen, and Peugeot previously collaborated on the research and design of a new automobile; the results of which were later produced, marketed, and sold under different names with minor modifications by each company (Karolina, 2015).

Section 2 of this paper will review related literature; Section 3 presents the conceptualization of our SCN framework and its social relationships between agents; Section 4 presents a SCN framework configuration example; and Section 5 offers our conclusions and future research agenda.

Literature Review

Traditional SCs are changing in a quest for development and low-cost sourcing (Fredriksson & Jonsson, 2009). They have become non-static phenomena, constantly evolving in shape and configuration, size, integration, control, and management (MacCarthy, Constantin, Olhager, Jagjit, & Xiande, 2016). Majeed & Rupasinghe (2017) argued that as the world is changing and evolving constantly, it has influenced many firms and their entirety of supply chain actors which in turn increases pressure to redesign business processes to a form that best accommodates their business. This contrasts markedly to traditional SCs which are typically vertical and linear, orchestrated by one dominant company mobilizing many smaller companies.

Today, SCs are totally different as companies outsource more to focus on their core competencies, often with trading partners on the other side of the globe (M. J. Schniederjans, A. M. Schniederjans, & D. G. Schniederjans, 2015). This has previously been attributed to the net effects of a "surplus society" (Ridderstråle & Kjell, 2007), where similar companies, with similar employees of similar education, generate similar ideas yielding similar products of similar quality, sold at a similar price. Furthermore, some components are interchangeable (notwithstanding quality variations), enabling manufacturers to buy from whichever supplier

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[1] This is a paradigm comparable to human social networks which the objects/devices participate in social relationships with other objects/devices but, outperform their human counterparts by for example more timely decision making.

offers the lowest prices. Other parts may not be widely available, meaning a manufacturer must seek out alternative (and affordable) suppliers. Firms are therefore challenging traditional linear-based SCs by looking towards configuring relationships with other agents as a network (rather than a rigid linear chain) for performance and flexibility reasons amid increasingly turbulent markets.

The SCN conceptualizes the above-mentioned relationships as a network of loosely coupled agents connected (in social network parlance) by strong and weak ties (Zorzi, 2019) for the transference of commodities/services, information, and remittances. A SCN example locally can be found in TCC Logistics (Thailand) who are part of the Sealite group of companies, a supply community comprising 158 different organizations based in 68 countries—including Standard International Trade Classification (SITC), the fastest growing Chinese liner in the past 20 years (*Your Reliable Partner in Thailand*, 2016).

Further afield, another example is New Zealand Farmers' Market (alternatively known as food networks) that brings together producers and consumers (Pathak, Wu, & Johnston, 2014). In this network, suppliers are the farmers while consumers are the buyers including institutional purchasers, for instance, restaurants and food service businesses. Growers and farmers convene creating a physical hub in which to sell produce, vegetables, flowers and meats. The variety of fresh products on offer attracts buyers while exuding a friendly shopping experience. Moreover, among farmers, this allows for exchange of vital information; for instance, it helps them determine what to grow next by knowing the choice and costs at neighboring stands, while also avoiding excess supplies by staggering planting and harvest times.

One further example is the Star Alliance which has 28 member airlines, each with its own distinctive culture and style of service (*About Star Alliance*, n.d.). Together, they offer easy connections to almost any destination in the world. Each airline maintains its own individual style and cultural identity, bringing a richness of diversity to the alliance (competition) while cooperating over matters of mutual interest (e.g., economy of scale in fuel purchasing).

In the introduction, we discussed the notion and meaning of coopetition; over time, new ties may be formed by firms within a supply network, while existing ones can be just as easily dissolved. There is a growing acceptance that rigid chain, like supply structures are not suited to current market dynamics and that when ties are formed, they are transitory and finite. However, when the circumstances are favorable, firms may forge new ties where mutual benefits are foreseen; i.e., interacting, sharing, and transforming resources while continuing to compete aggressively with those partner companies outside agreed bounds of cooperation (Pathak, Wu, & Johnston, 2014). Specifically, operational links in a supply network lead to relational strategies that differ from those of peer firms; a firm's position in the supply network affects how it relates and responds to other firms. Cooperation can be viewed as syncretic rent-seeking behavior of individual firms combining cooperation and competition to attain an optimal performance outcome (Gnyawali, He, & Madhavan, 2006). Coopetition takes place within lateral business networks where firms are competitors. Competitors employ complementarity technology, own a comparable market share, and possess similar capabilities. Competitors are also able to engage in competition and cooperation sequentially—they cooperate in developing the market and then compete to divide up the market.

Accordingly, technological advances have fueled the improvement of new action plans and methods of working (Johnson & Carlos, 2008) as today's business world becomes more complex and turbulent (Christopher & Matthias, 2011). Porter and Heppelmann (2014) stated that the Internet of Things (IoT)—which

they call smart connected products—changed the environment offering exponentially expanding opportunities for new functionalities and capabilities that transcend traditional product boundaries. Such changes have disrupted the value chain, forcing companies to rethink everything they do, from how they conceive, design, and source products; to how they manufacture, operate, and service them; and to how they build and secure the necessary IT infrastructure.

IoT has also raised a new set of strategic choices about how value is created and captured, how companies work with traditional and new partners, and how they secure their own competitive advantage as new capabilities reshape industry boundaries (Porter & Heppelmann, 2014). In a separate paper, (Porter & Heppelmann, 2015) described how smart, connected products are transforming companies; it focused on the impact of IoT on company operations and structural changes in terms of how business interacts with customers, reshaping functions in the value chain (new processes), and new forms of cross-functional integration and collaboration. IoT also enables improved data monitoring, remote access controls, optimization and autonomous learning.

Social Internet of Things (SIoT) is a promising paradigm that we believe can support SCAs with the possibility of discovering, selecting, and using the appropriate services found through their friend network. As we mentioned in the Introduction, SIoT signaled the inevitable fusion of IoT with social structure phenomena, enabling formation of trust-based communities among the objects (SCAs) similar to that of established social networks. Therefore, as Abhinav (2014) described, SCs can be sources of competitive advantage as their efficient management leads to cost savings and synergies between the components of the SCs and leads to greater profitability for firms. Recent comments from Intel's global Jon Stine point to global business being in the midst of "accelerated Darwinian natural selection" where supply chain innovation will be a key factor in determining whether brands survive or thrive (Feller, 2018).

Social networking has, through various enabling platforms we collectively term social media, dramatically changed the way society at large communicates. Given that communication is vital to SCM success, it follows that social media should have an equally significant role in that domain also. Assuming our proposed theory (that of a SIoT enabled SCN framework) as a form of network, the concept of network theory and its strong/weak ties has the potential to reveal interesting truths about SCs behavior (Ketchen & Hult, 2007). Firmly coupled organizations exhibit strong ties, whereas organizations with more tenuous links involve weak ties; strong ties provide more prominent unwavering quality, while weak ties enhance flexibility. Significantly, Zorzi (2019) argued that the general quality of social ties impacted how innovations course through a SN; strong ties stifle innovation by cultivating continuity, while weak ties encourage innovation by stifling continuity.

However, the next increment in evolution of the internet is already upon us; inspired by SN, SIoT proposes to share resources of smart, internet-enabled objects by assuming characteristics inherent in SN so as to mimic human engagement. Therefore, in the following section we describe the SCN concept as a combination of interconnected networks, channels, and node businesses that come together in the provision of products and services required by end customers.

Supply Community Network (SCN)

SCN is a term that refers to the management and management behavior (on a synergistic [strong

tie]/antagonistic [weak tie] continuum[2]) over the total bidirectional flow of commodities/services, information, and remittance throughout an omni-channel order fulfilment network community composed of loosely coupled agents, from supplier(s) to the ultimate consumer(s). It is argued that an SIoT enabled SCN successfully integrates SCAs allowing them to deal with present day market dynamics. A SCN autonomously orchestrates SCAs and allows them to interact directly within and across networks. SCN conceptualizes SCs as a network of SCAs connected throughout their transference of commodities/services, information, and remittances. They represent multiple organizations each with relationships or links to other organization(s). This allows SCAs to start new connections, discover new services, utilize the capabilities of each other, and exchange information. With these aforementioned capabilities and functionalities, a SCA (e.g., a manufacturer) will contain several different objects aligned to departments "inside" their business (e.g., sales, warehousing, production, logistics, etc.) that communicate with each other to fulfill the efficiency and effectiveness of that operation. These connections consist of relatively flexible and interchangeable relationships among suppliers, customers, and other SCAs.

On the other hand, bidirectional exchange can also be between SCNs of different functional specialty, from suppliers to the ultimate customers. Therefore, agents supply directly to others as they need their supplies, but if commodities are generally interchangeable, so an agent may buy from whichever SCA (supplier) offers the lowest prices. For other commodities which are not interchangeable, agents must seek out affordable SCA (suppliers). For this reason, SCN autonomously orchestrates SCA and allows them to interact directly within and across the network; SCA can be designed to link tenuously, enhancing their flexibility (see Figure 1). If there are strong stipulated relations between agents, there is only bidirectional communication between them which is not providing the flexibility to interact with the dynamic markets. But the weak ties used in this SCN allow endurance in dynamic markets and encourage advancements by allowing them (SCAs) to look to service their own needs and to increase value and convenience for themselves.
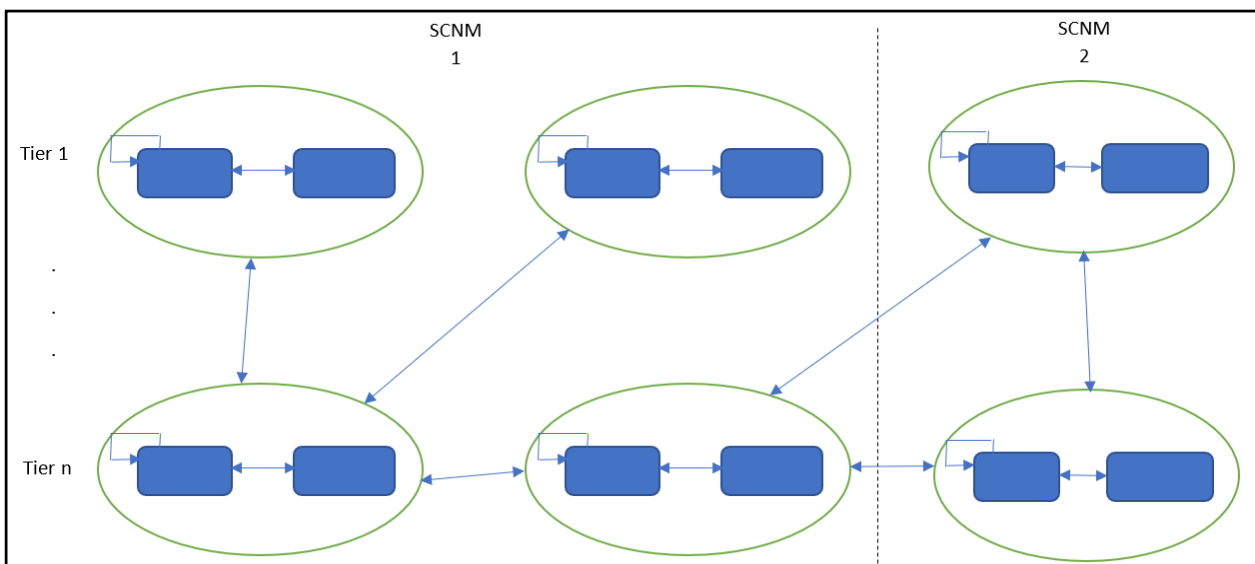

Figure 1. A generic SCN.

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[2] In this paper, we assume all programmed object (SCAs) behavior to be synergistic, implying the favoring of strong ties, but with the capacity to become self-serving whenever survival needs dictate.

Types of Relationships

Before we can support a SCN, we must first identify the bounds of flow that need to be supported. Table 1 lists types of relationship management across all possible dimensions of a SCN. This notion is based on taxonomy by Mason (2005) who defined a conceptual framework for traceability in a systems integration context in which it was argued that in order to develop effective support systems and methods for complex engineering projects (which in our present context becomes managing exchanges across SCNs), it is first necessary to ensure the problems they are intended to solve—i.e., the aims, purposes and objectives—are both scoped and clearly defined.

Table 1

Relationships of SCAs With SCN

No.	Dimensions	Within same SCN	Within same Tier	Same dept.	Diff. dept.
1	Intra-Macro-Vertical	☑	☒	☒	☒
2	Intra-Macro-Horizontal	☑	☒	☒	☑
3	Intra-Micro-Vertical	☑	☒	☑	☒
4	Intra-Micro-Horizontal	☑	☒	☑	☑
5	Intra-Nano-Vertical	☑	☑	☑	☒
6	Intra-Nano-Horizontal	☑	☑	☑	☑
7	Inter-Macro-Vertical	☒	☒	☒	☒
8	Inter-Macro-Horizontal	☒	☒	☒	☑
9	Inter-Micro-Vertical	☒	☒	☑	☒
10	Inter-Micro-Horizontal	☒	☒	☑	☑
11	Inter-Nano-Vertical	☒	☑	☑	☒
12	Inter-Nano-Horizontal	☒	☑	☑	☑

These terms are defined as follows:

• **Intra-Macro-Vertical**—The management of relationships involved in bidirectional exchange of commodities/services, information, and remittances within SCN, between tiers, between organizations, and between departments of different functional specialty, from suppliers to the ultimate customers.

• **Intra-Macro-Horizontal**—The management of relationships involved in bidirectional exchange of commodities/services, information, and remittances within SCN, between tiers, between organizations, and within departments of different functional specialty, from suppliers to the ultimate customers.

• **Intra-Micro-Vertical**—The management of relationships involved in bidirectional exchange of commodities/services, information, and remittances within a supply community Network, between supply chain tiers, within organizations, and between departments of different functional specialty, from suppliers to the ultimate customers.

• **Intra-Micro-Horizontal**—The management of relationships involved in bidirectional exchange of commodities/services, information, and remittances within SCN, between tiers, within organizations, and within departments of different functional specialty, from suppliers to the ultimate customers.

• **Intra-Nano-Vertical**—The management of relationships involved in bidirectional exchange of commodities/services, information, and remittances within SCN, within tiers, within organizations, and between departments of different functional specialty, from suppliers to the ultimate customers.

• **Intra-Nano-Horizontal**—The management of relationships involved in bidirectional exchange of commodities/services, information, and remittances within SCN, within tiers, within organizations, and within

departments of different functional specialty, from suppliers to the ultimate customers. All "Intra" relationships are shown in Figure 2.
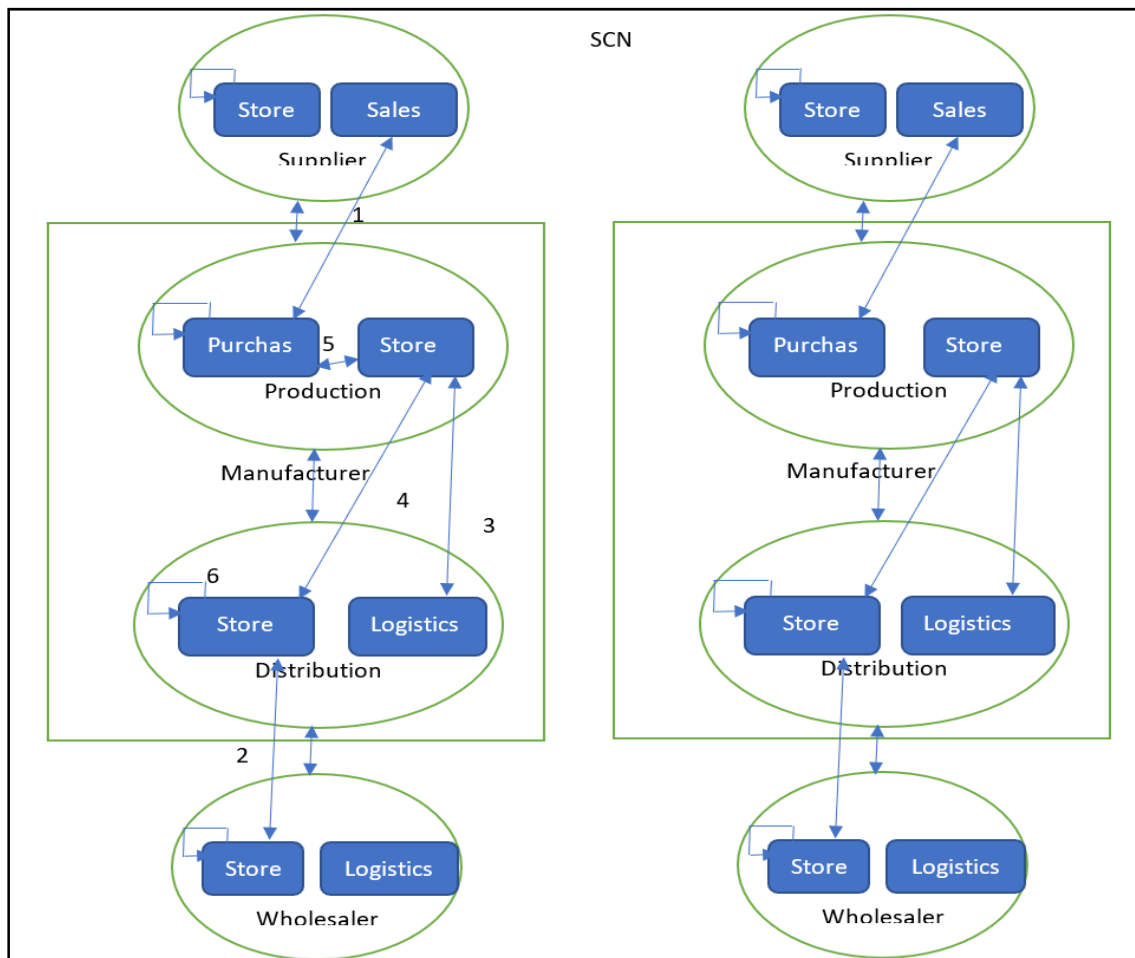

Figure 2. Intra-relationships of SCAs in SCN.

- **Inter-Macro-Vertical**—The management of relationships involved in bidirectional exchange of commodities/services, information, and remittances between supply community network, between tiers, between organizations, and between departments of different functional specialty, from suppliers to the ultimate customers.

- **Inter-Macro-Horizontal**—The management of relationships involved in bidirectional exchange of commodities/services, information, and remittances between supply community network, between tiers, between organizations, and within departments of different functional specialty, from suppliers to the ultimate customers.

- **Inter-Micro-Vertical**—The management of relationships involved in bidirectional exchange of commodities/services, information, and remittances between supply community network, between tiers, within organizations, and between departments of different functional specialty, from suppliers to the ultimate customers.

- **Inter-Micro-Horizontal**—The management of relationships involved in bidirectional exchange of commodities/services, information, and remittances between supply community network, between tiers, within

organizations, and within departments of different functional specialty, from suppliers to the ultimate customers.

• **Inter-Nano-Vertical**—The management of relationships involved in bidirectional exchange of commodities/services, information, and remittances between supply community network, within tiers, within organizations, and between departments of different functional specialty, from suppliers to the ultimate customers.

• **Inter-Nano-Horizontal**—The management of relationships involved in bidirectional exchange of commodities/services, information, and remittances between supply community network, within tiers, within organizations, and within departments of different functional specialty, from suppliers to the ultimate customers. All "Inter" relationships are shown in Figure 3.
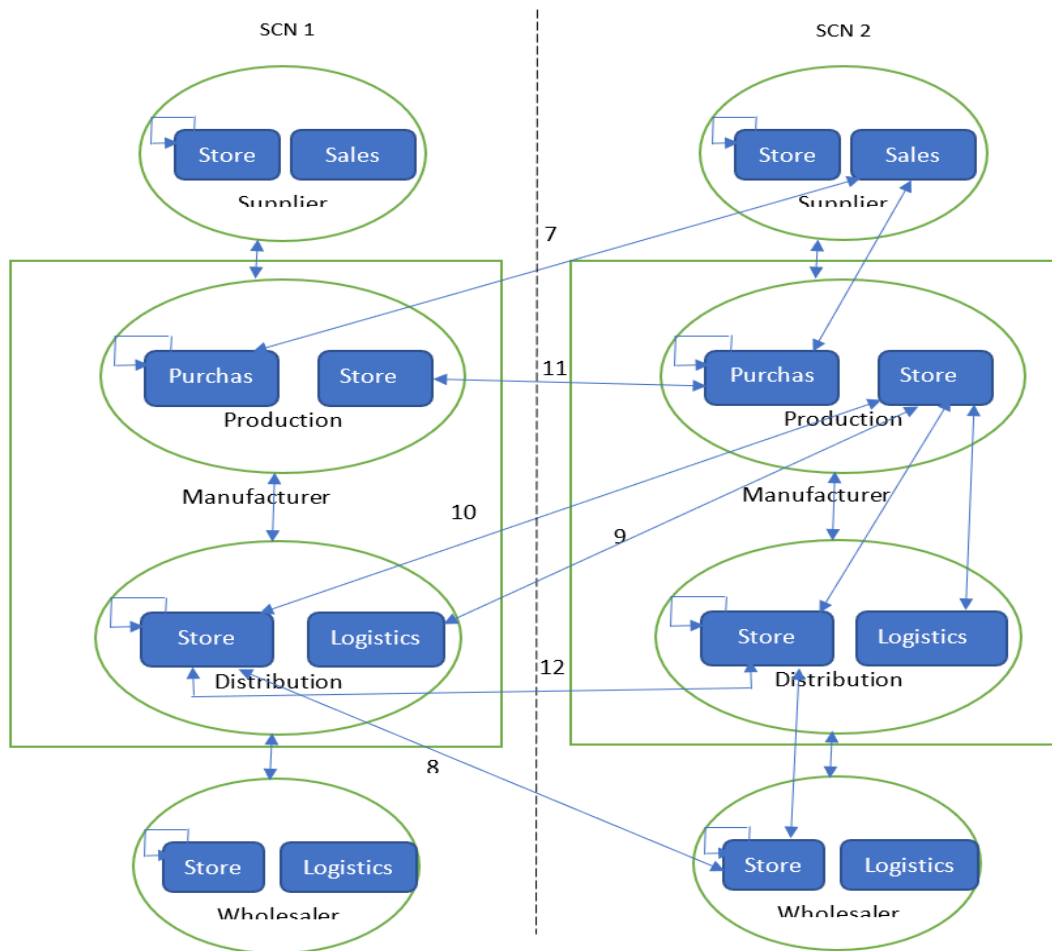

Figure 3. Inter-relationships of SCAs between SCN.

However, the bounds of flow in all possible dimensions of a SCN identified above can be illustrated below on one hand, as relationships among agents that involve bidirectional exchange of commodities/services, information, and remittances within a SCN; and on the other hand, relationships among agents that involve bidirectional exchange of commodities/services, information, and remittances between SCN. But first, we apply the theoretical concept proposed above to cases involving distinct SCN configuration.

SCN Configuration Example

In this section, we apply the theoretical concept proposed in the Section "Types of Relationships" to cases involving distinct SCN configuration. The applicability of the theory is determined by the aid of these cases and also indicates the key endeavors towards the future use and refinement of SCN configuration.

Conventional approaches to dealing with the management of relationships have focused on the vertical design of sequentially ordered relations between agents independently, for example, a tiered supplier structure orchestrated by one dominant agent mobilizing many smaller agents who are dependent on that dominant agent who can supply critical resources to other agents. However, this idea focuses on vertical and linear sequence of inter-dependencies between agents which several authors have challenged in favor of a networked approach to relationships to maximize performance (Eskandarpour, Dejax, Miemczyk, & Péton, 2015; Stevens & Johnson, 2016).

In this study, the relationships among suppliers, customers, and other agents, on the one hand, involve bidirectional exchange of commodities/services, information, and remittances within/between SCN within/between SC tiers, within/between organizations, and within/between departments of different functional specialty, from suppliers to the ultimate customers as shown in Figures 2 and 3. Similar to Toyotas supply network which illustrates intra-tier ties comprising number of ties between different types of firms within tier (Toyota, other Japanese assemblers, overseas assemblers, and other clients) and inter-tier ties that connect firms in different tiers which verify the high degree of connectivity in the Japanese automobile industry and the presence of "alpine structure[3]" (Kito, Brintrup, New, & Reed-Tsochas, 2014).

Also, considering a hypothetical SCN from (Mack, n.d.) for baked goods in which we delineate all possible end to end flows. As with any industry, a baked goods SCN is subject to numerous variations; so, that starts with suppliers of raw ingredients (materials) and ends with delivery of the product to the end consumer. Raw ingredients are often supplied directly to baked goods manufacturers from farmers or possibly agricultural cooperatives. At the manufacturing stage of a SCN, a baked goods company converts the raw ingredients into a product, such as bread, cookies, cakes, patisseries and many other items. The distribution stage involves moving products from the manufacturing production facility to wherever the consumers are. Wholesalers are merchants that buy products from manufacturers/distributor and use their expertise in shipping and distribution to re-sell the products to retail stores and/or consumers. Most consumers buy baked goods from a retail store, such as a supermarket. Based on that, if a manufacturer's warehouse is in need for replenishment, the purchasing department seeks out and then sends a purchase order for the raw materials required to a supplier's selling department which reflects the Intra-Macro-Vertical relationships; the other flows are exemplified as follows.

• Intra-Macro-Horizontal—for example, when the store's system interacts with smart shelves, equipped with a myriad of sensors to locate the ordered items.

• Intra-Micro-Vertical—for example, if a distribution center's warehouse may need to replenish and send a new production order to a manufacturer acting in two different tiers but same organization.

• Intra-Micro-Horizontal—when distribution center's warehouse sends production orders to its manufacturer, the logistics department is sent to process the order then handle the materials and control the inventories.

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[3] "An entangled system of interlinked keiretsu pyramids" (Kito et al., 2014).

- Intra-Nano-Vertical—for example, a wholesaler's store may try to respond to stock insufficiencies of another Wholesaler's store in the same SCN.
- Intra-Nano-Horizontal—as sending notification to logistics department to move products to Wholesaler's store department.
- Inter-Macro-Vertical—supplier's logistics department in one SCN trying to ship needed products in response to stock insufficiencies of manufacturer's warehouse in another SCN and transfer raw materials to manufacturer's warehouse.
- Inter-Macro-Horizontal—the warehouse of a supplier in one SCN needs to respond to stock insufficiencies of a manufacturer's warehouse in another SCN.
- Inter-Micro-Vertical—for example, if a warehouse needs replenishing with new products and its manufacturer cannot provide for whatever reasons, they may outsource with other manufacturers in a different SCN.
- Inter-Micro-Horizontal—flow the products are arranged by the logistics for shipment to the warehouse.
- Inter-Nano-Vertical—for example, Wholesaler's logistics in one SCN may try to respond stock insufficiencies of Wholesaler's store in another SCN and move products to Wholesaler's store department.
- Inter-Nano-Horizontal—as the communications between two Wholesaler agents in different SCN responding to stock insufficiencies of one another.

Overall, the SCN member firms are independent from each other with strong and/or tenuous linkages. The primary objectives of the SCN are to effectively help SCAs deal with present day market dynamics by autonomously mimicking human behavior. This improves communications and benefits SCA, sharpening agent synchronization in a responsive way to customer needs dealing with present day market dynamics and enables full integration of agents.

Conclusions

Literature suggests that firms are challenging the linear-based SCs in favor of a networked approach to convey predominant performance and reorganize their operations as a network of relationships rather than a sequence (chain). SCs have to be much more flexible and capable of changing rapidly as conditions change. Practical applications are not prevalent in the literature, so in this paper, we proposed an SIoT enabled SCN capable of dealing with present day market dynamics. A new setting of social relationships between supply agents within such a network accounted for the possible interactions in the physical world. The notion of agents assuming humanoid social networking behaviors, together with the SIoT components necessary to realize that aspiration provided the essential elements of our framework.

The SCN renders SCs as interconnected networks, channels, and node businesses that combine in the provision of products and services required by end customers. This improves communication allowing agents to rigorously manage the flow of commodities/services, information, and remittance (in quasi-real-time) across the SCN; the net benefit is to sharpen agent synchronization in a way that is responsive to customer needs and hence has potential to deal with present day market dynamics enabling full integration of supply agents. This potentially opens the door to absolute tracking of purchase orders, and improved monitoring of stock levels; e.g., an agent may autonomously trigger replenishment or production of commodities if warehouse store reaches a minimum threshold. In addition, the SCN agents' behavior intentionally balances strong and weak ties and hence reliability and flexibility.

Our contribution is, therefore, this new setting of social relationships between agents within SCN that reflects possible interactions between supply agents played out in the physical world. It exploits the applicability that supply agent autonomously sense each other, exchange information, and interact within the SCN mimicking the behavior of humans. It connects supply agents to one another over the total bidirectional flow of commodities/services, information, and remittance throughout omni-channel order fulfilment process in the SCN. It should be stressed the approach we are proposing is best-suited to loosely coupled communities that consist of relatively flexible and interchangeable relationships among suppliers, customers, and other agents. Interchangeable because the final product has a modular architecture; think cars or computers for example, or baked goods and other food/beverage produce.

Our research focused on proposing a framework that balances strong and weak ties and hence reliability and flexibility. Ongoing work demonstrates the working practices of our SIoT orchestrated SC agents in SCN via simulation assuming a scenario-based narrative of SCN and evaluates how SIoT orchestrated SC agents in SCN work both individually and collectively.

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