Supplier Network Intelligence Collection Framework

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Abstract

This paper proposes the use of an integrated information retrieval framework (IIRF) to facilitate the collection of critical information of a manufacturer's supply network. It explores the requirements for a sustainable survival of manufacturers by aligning information among the entities within a supply network. It proposes that manufacturers must have accurate and current information and data of their prime suppliers of critical components. Current research and literature search indicates there are very little publications investigating supplier intelligence in the context of the supply network like suppliers' supplier's financial health in terms of capital investment, debt, market performance, financial reporting, accounting practices, corporate governance, competitive factors and operating environment. This paper proposes a data gathering model for collating supplier intelligence from the internet and commonly available online sources. The impetus for such information is becoming more critical in a supply network. Supplier intelligence enables long term procurement strategies with greater certainty.

Keywords: data mining, supplier intelligence, information retrieval, model

INTRODUCTION

Supply chain networks consist of numerous entities at different stages of transforming raw materials into finished products. This paper focuses on the entities in a product manufacturing supply network. Each of these entities would be manufacturers of components and sub-assemblies or finished products. They also supply products and goods to several other entities within that network who may be competitors with each other. This supply network would consist of several tiers of manufacturers/suppliers along the supply chain. The onus of ensuring the continuous supply of components and sub-assemblies falls on the manufacturer of the finished product as this final manufacturer/assembler knows the characteristics and demand of the consumer market.

The final manufacturer/assembler may also have contractual obligations with many different suppliers. If one of these suppliers is unable to supply the components and sub-assemblies, the manufacturing process of the finished product will be greatly constricted. The cause of this supply risk could be that the immediate supplier of higher order suppliers along the supply chain is unable to produce or source parts and components. Other causes of supply risk may be changes in strategic directions of the suppliers in the supply network, pricing or a major catastrophe in their plant. The challenging question facing the final manufacturer/assembler is - will the current suppliers be able to continue supplying parts, sub-assemblies and components at a competitive level? The answer will be the ability to ascertain the future strategic plans as well as provide a high level of certainty in managing supply risk.

Similar to the ‘bullwhip effect’ any constraints in the upstream side of the supply chain will have a domino effect on the entities in the downstream side. This chain reaction may be defined as the ‘stock whip effect’. The ‘stock whip effect’ may be defined as “any constraint or supply disruption in the upstream side of the supply chain will increase the disruption in the subsequent entities along the supply chain”. Entities along the supply chain must ensure that such constraints are eliminated immediately or find new sources of supply. Therefore supplier intelligence will assist in the informed decision making process of existing suppliers or new suppliers in terms of new product development, purchasing strategy, sourcing strategy, long term supply contracts and other critical factors in sustaining long term operations.

In order to manage supply risk and ensure a continuous supply of parts, sub-assemblies and components, supplier intelligence (SI) is necessary. Supplier intelligence is defined as “the up to date knowledge base of critical suppliers incorporating the suppliers’ market intelligence, business intelligence, competitive capability, financial stability including their suppliers’ suppliers’ supplier intelligence” (Jeeva 2008). This definition includes both the internal and external factors that would make that entity’s operations sustainable. It also means that manufacturers of finished products need to have very good knowledge of all the upstream entities along a supply chain. Supplier intelligence could ensure that there is no disruption of supplies by tier 1 or tier 2 suppliers (see Figure 1).

Supplier intelligence could also comprise of ethical practices, like workers’ work conditions, quality of work environment, salary and wages. Such information may be sourced from publicly available databases.

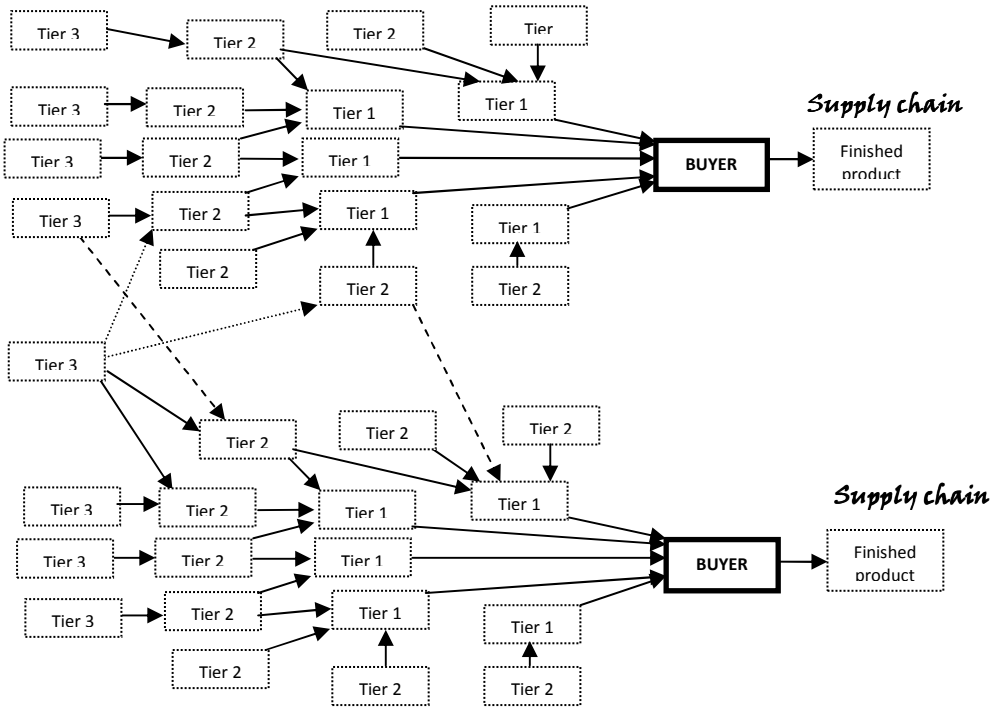

Figure 1 Upstream Supplier Network

NEED FOR SUPPLIER INTELLIGENCE

Humphreys (2001) notes that purchasing has undergone significant changes, more importantly towards competitive and strategic aspects. SI would be able to identify an excellent sustainable supplier from a mediocre supplier. SI would also be very useful in innovating processes, products and services. This is supported by Ellram (1992) who advocates that in a world of rapidly advancing technology, escalating costs, converging consumer tastes and growing protectionism close cooperation with suppliers are critical.

Close cooperation requires buyer to know their suppliers intimately. This intimate supplier relationship is non-productive if that supplier's supplier goes bankrupt or does not have the technological capability or production capacity or is financial not viable. Therefore intimate knowledge of the supplier's supplier is also critical to ensure the sustainability of supplies and sustain the supply chain's viability.

Supplier attributes are a major part of that supplier's intelligence profile. Odgen (2006) states that suppliers must meet the needs of the buyer in terms of capacity, quality, technology, price, service and flexibility. In terms of competitive pricing total cost approach is necessary (McIvor et al.1997). Figure 1 shows a typical upstream supplier network. Tier 2 suppliers supply raw materials and components to several tier 1 suppliers which end up as substitute or competitive finished products. The buyer must have knowledge or intelligence of to whom is the tier 2 supplier selling their product to. This provides the knowledge of possible future substitute supplier as well as which competitor is using that product. This intelligence becomes more critical and intense in high technology markets and where there is limited finished product model/range in the consumer market.

SI plays a major part in total cost approach. Ellram (1992) and Easton, Murphy and Pearson (2002) suggest that on an average about 50% of the cost of the finished product is on purchased raw materials. Hence the opportunity to lower selling price is in the cost savings in

procurement activities. In a price competitive marketplace SI data would assist in evaluating which supplier has the capability to lower their procurement price and production costs. SI would also be able to identify and predict which suppliers are possible current or future risks. SI can also help manufacturers in other challenges like competitive and leading edge; and 'first to market'.

Manufacturers are also facing greater challenges to compete and succeed. Some researchers (Kannan and Tan 2002, Kocabasoglu and Suresh 2006, Talluri and Sarkis 2002) suggests that strategic sourcing is becoming a significant aspect of purchasing as manufacturers out source more non core activities which creates a greater reliance on long term relationships with suppliers. They are also forced to behave as entrepreneurs and innovators. They have to use effective solutions and strategies to reduce costs, improve efficiency and performance. Manufacturers are also faced with increased complexity in sourcing due to new sources of supply, uncertainties in the environment, quality and capability of suppliers, supply configuration, corporate social responsibility and green supply chains.

This increase in complexity of the supply chain is making it less visible, therefore less manageable. Further complications are shorter product life cycle, demand spikes, changing customer expectations and new entrants in the supply market. SI is not about sharing of daily information about demand and supply, neither is it understanding the supplier/buyer co-operative activities. It goes beyond sharing of information and operational interactions. It sets the basis for long term sustainable manufacturing supply chain strategy.

The standardised information sharing is about demand and forecasting data but it is critical that manufacturers have a steady supply of all raw materials and components to sustain their production run in the short and long term. It includes the wider collection of data about the supplier network. SI is about creating a profile of the supply market including the suppliers' suppliers. It is about establishing the profile of the supplier network. It is predictive profiling to be able to predict constraints and possible risks caused by certain suppliers, or their suppliers, that may disrupt production operations and the continuance of supplies and take pre-emptive strategies. This predictive profiling would provide the intelligence if any entity in the upstream side of the supply chain would create a risky constraint. It is similar to collating data from Porter's Five Force (1998) analysis.

Porter (1980) originally provided an overview of the five forces that affect every company. The five forces are threat of new entrants to an industry which erodes market share and SI needs to collate data on how the supplier reacts to this new entrant, what and how high is the entry barrier, how serious is the threat and what is the risk to that supplier and the rest of the supply chain network. The second force is the bargaining power of suppliers directly dictated pricing, quality and service levels. The third force is the bargaining power of buyers. Powerful suppliers and buyers can demand high and low prices respectively thereby lowering profits of the seller and buyer. Similarly quality and service levels can be raised or lowered. The fourth force is the threat of substitute products. SI needs to collate data on substitute products' trends, pricing and performance. SI should also consider if the substitute product is a good value exchange if the current supplier is constricted in any way. The four forces directly impact the fifth force in terms of competitor rivalry. This manoeuvres the organisation into a jockeying or competitive position. The wider the SI information, the greater the jockeying ability.

However, Porter (2008) provides a deeper view of the five forces for strategy that strategist need to understand the underlying structure of the industry in terms of the five forces. This differentiates short term blips from long term structural changes. Understanding the industry

and market structure would make an organisation less vulnerable to constrictions. Hence, SI should include market structural data for all entities in the supplier network.

Understanding the industry and market structures in terms of substitute products and its supplier's supplier intelligence, buyers are able to have sufficient knowledge to switch suppliers easily when necessary. Baily et al. (2006) suggest that ensuring a continuity of supply with existing sources or alternate suppliers to meet emerging or planned demand should be the main purchasing objective. SI would assist in identifying possible alternate supplier readily and quickly, instead of going through the long tedious process of supplier selection.

Using SI to select suppliers can lead to quality improvements and ultimately higher customer satisfaction and organisational performance (Hsu et al. 2006). The correct supplier will also reduce product flaws and improve work processes. SI also has the capability to reduce bullwhip effect exacerbated by uncertainties (McCullen and Towill 2002). SI is necessary to know that the supplier will provide the support for competitive advantage. Selecting the right supplier who will provide the required materials in a timely and effective manner will help maintain the competitive advantage.

Since SI provides the knowledge of the supplier's environment. This environment includes the supplier's economic, political, legal, cultural, social and technological circumstances. Supplier intelligence should also include the financial stability of the supplier. This is an extension of supplier selection attributes.

Financial data should include capital investments, debt, share market performance, financial report methods, auditing, corporate governance, accounts receivable details, accounts payable details, etc. These data provide the financial intelligence whether that supplier can survive the next few years in a financial capacity. This financial intelligence and stability must be transparent whether the supplier is a public listed company or privately owned.

Downstream entities along a supply chain also need to know the internal and external environmental situation of their supply network in the upstream side. This provides sufficient long term strategy formulation with contingency plans.

SUPPLIER ATTRIBUTES EVALUATION

Supplier selection literature (Choy et al. 2005, Ellram 1990, Kannan and Tan 2002, Hsu et al. 2006) propose the following traditional selection criteria – price, quality, quantity and delivery timing. Other publications (Paulraj and Chen 2005) include quality assurance standards, design competence, resources and workplace health and safety. But these criteria do not provide any supplier attributes data or information as to the long term implications of the survival ability and capability of that supplier or their products like product life cycle.

Other criteria should include supplier management attributes like suppliers' long range planning practices, technological expertise, commitment to continuous improvement and total quality management, training and development, personnel capabilities, vision, experience, workforce flexibility, employee morale, corporate culture, information systems capability and performance. High level criteria would include supplier sourcing strategies and policies, e-business capability, financial capability and stability, long term relationship potential, advanced manufacturing technological capabilities, research and design capabilities, knowledge of suppliers cost structure,

All the above supplier selection criteria and attributes must be a compulsory part of SI. Some multinational companies have auditing programs to improve data on their suppliers especially factors concerning the environment. DuPont and Canon evaluate their supplier selection criteria in a systematic manner through regular site visits (Dobilas and MacPherson 1997). With the growing concept of the green revolution, a future criterion could be environmentally friendly or green manufacturing with corporate social responsibility, carbon foot printing, environmental regulation compliance, green house gas emission reduction policies, etc. SI could be used to predict and forecast which entities in the supply network are more ready than others.

SI provides the basis for the promotion of buyers' innovative collaboration with suppliers. Geffen and Rothenberg (2000) discuss how closer relationships with supplier has contributed to the development of new non-toxic paint compounds resulting in a higher competitive advantage in pollution control and waste disposal. Zsidisin and Smith (2005) state that one of the main determinants of a supplier's innovativeness is their previous history of new product development coupled with their knowledge and expertise within their industry. SI would provide this knowledge and buyers can choose with which supplier to begin collaborative relationships. Choi and Krause (2006) further suggest that interactions of suppliers with other suppliers in the industry leads to greater innovative capabilities, as well as their reputation, experience and capabilities.

Zsidisin and Smith (2005) also state an example where Rolls-Royce aerospace division without any previous relationship applied supplier selection criteria based on the suppliers reputation and engineering expertise. Over a period of time this new relationship collect more intelligence in terms of staff experience, IT capabilities, laboratory facilities, company philosophy, management commitment, sustainability and future willingness to participate in collaborative projects. This intelligence provides an informed decision on developing future innovative concepts with selected suppliers.

CONSTRAINTS IN COLLECTING SUPPLIER INTELLIGENCE

However there are several constraints in collecting supplier intelligence as well as updating this intelligence. The supplier network may be distributed in several global locations. Some of these locations may be low cost countries where it may be very difficult to source and collect corporate data of companies. The purchasing environment within the supplier network is a complex quagmire. The supply network is influenced by different external and internal environmental situation which are controlled and restricted by geographical, political, legal, social, cultural, economic and technological factors. Other factors that affect the operations and production processes of the entities in the supply network are skill, financial resources, expertise, capability, etc.

APPLICATION OF IIRF

To alleviate the constraints discussed in the previous section, an Integrated Text Retrieval Framework (IIRF) suggested by Zhu and Dreher (2007) is employed in this research to collect relevant information of a manufacturer's prime suppliers. IIRF is an enterprise-oriented integrated information retrieval system which combines Web information retrieval techniques and traditional database search technologies to provide comprehensive and dynamic information.

In an IIRF as show in Figure 2, information is collected from various sources including the Web, intranet of an enterprise, commercial databases, meta-search engines, desktop computers, and databases in a Digital Ecosystem, which is "a self-organising digital infrastructure aimed at creating a digital environment for networked organisations that supports the cooperation, the knowledge sharing, the development of open and adaptive technologies and evolutionary business models" (www.digital-ecosystems.org).

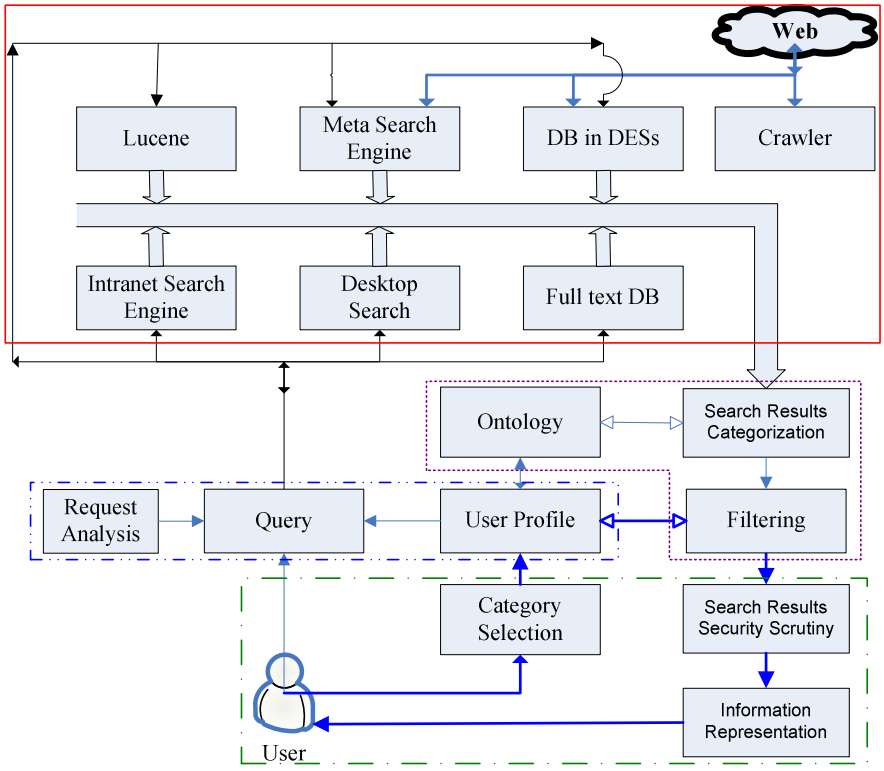

Figure 2: A search framework in an enterprise (Zhu & Dreher 2007)

When a query is submitted, IIRF utilizes Lucene (Gospodnetic and Hatcher 2005) to conduct a search from a database of indexed information extracted from the different sources described above. The retrieved information is further refined based on a user profile which depicts search preferences of the user.

IIRF can easily gear to the application of supplier intelligence information collection by 1) adjusting the initial queue of the crawler designed in IIRF; 2) modifying user profile to limit the search preferences related to the target suppliers. The intelligence information of supplier includes as suggested by Jeeva (2008) Key Performance Indicator (KPI), spend, demand, performance, finance, quality. Market intelligence data of a target enterprise such as markets, industries, good and commodities, finance, suppliers, competitors, and technologies is also relevant to support business decisions.

Supplier intelligence data crawler

"A crawler is an automated script, which independently browses the World Wide Web" (Cho & Garcia-Molina 2001). Many challenges are facing crawlers due to the huge size, complexity and rapid growth of the World Wide Web - page selection, importance, recency, and refresh issues. In addition to regular page refresh, crawlers should concentrate on the effectiveness of crawling when intelligence information of a supplier is to collected. Generally, a crawler starts off with an initial set of URLs that are placed in a queue where

they may be prioritized. A URL is selected based on some ordering strategies. Crawlers download Web-pages, extract URLs from the downloaded pages, and put the new URLs in the queue for expanding into (crawling) possibly relevant Websites. This process is repeated until crawlers decide to stop (Cho & Garcia-Molina 2001). Prioritizing the URLs in the queue and setting the stop conditions are both related to estimating, or measuring the relevance of the URL content to the need of intelligence information collection. However, the relevance *per se* is an arguable topic (Hjørland 2010).

The proposed novel solution to supplier's intelligence information collection is to divide the crawling process into five stages, as demonstrated in Figure 3. The five-stage algorithm is discussed in detail as follows.

The first stage is to keep an active URLs list that contains all necessary relevant Websites links as determined by a manufacturer who is collecting supplier's information. Dependent on newly found relevant URLs, the list may be adjusted and changed at any time. A typical example of such list of links including the supplier's homepage, the supplier's prime suppliers' home page, Webpages contain the supplier's market data, and other pages that may include relevant information of the supplier.

The second stage is to use the URL list to initialize a crawling queue Q^0, download all the Web-pages pointed to by the URLs in Q^0 to form a Web-page collection R0. All the Web-pages in R0 are treated as documents. Stop words are removed; other words are stemmed and indexed. Then the Web-pages in R0 generate a relevant document set RD0 that are stored by the IIRF. The URLs in the downloaded Web-pages in R0 are then extracted to form a new extended crawling queue Q^{E1}. The Web-pages pointed to by the URLs in Q^{E1} are also downloaded to form an extended Web-page set EP1.

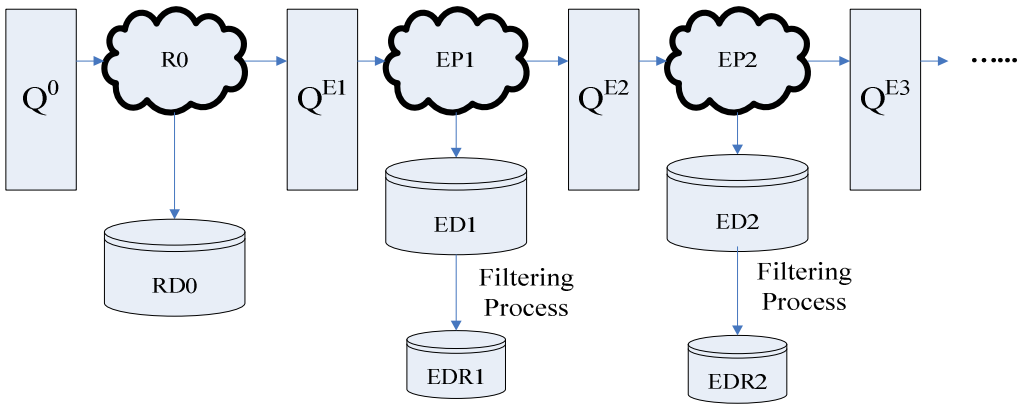

Figure 3: A search framework in an enterprise (Zhu & Dreher 2007)

The third stage uses Web-pages in EP1 to build an extended document set ED1, as explained in the second stage for RD0. That is, all downloaded Web-pages in EP1 are treated as documents. Stop words are removed, other words are stemmed, indexed, and then stored in the retrieval framework.

The fourth stage filters out irrelevant Web-pages from ED1 to generate a relevant document set EDR1. At stage two described above, Web-pages pointed to by links in Q^{E1} were downloaded by using the extracted URLs from the Web-pages in R0 from which EP1 is derived; however, it is highly possible not all the downloaded Web-pages in EP1 are relevant to the intelligence information of supplier. For example, a mining corporation in resource rich Western Australia may have a link to Curtin University because graduates from Curtin University are working there. Web-pages of Curtin University School of Mines are no doubt

relevant to the mining industry. However, it is obvious that not all Web-pages of Curtin University are about mining industry. Therefore, similarities between documents in ED1 and documents in RD0 are compared, if the similarity scores are higher than a predefined threshold, the page is considered relevant and to be put into relevant document set EDR1; otherwise, the document is considered irrelevant to the intelligence data of the supplier and thus discarded. URLs in the corresponding relevant Web-pages are then extracted to form a new crawling queue Q^{E2}.

As pointed out by Belkin and Croft (1992), information filtering and information retrieval are actually two sides of the same coin. Several existing information modeling methods, such the Vector Space Model, Probabilistic Model (Manning et al. 2008), and text categorization techniques (Sebastiani 2002) can be used to filter the crawled Web-pages.

The fifth stage uses URLs in Q^{E2} to download Web-pages to construct a new Web-page set EP2. Substituting EP1 by EP2 and then jumping back to stage four, this stage then selects relevant Web-pages from EP2 to form another relevant document set EPR2. Repeat this process until the query list Q^{Ei} (i may be limited to some arbitrary positive integer) is empty; or stop the crawling procedure after a predefined cycle, say after five times (i=5).

Refinement of intelligence data

The intelligence information collected from different sources by IIRF can then be refined by means of text categorization based on users search preferences. First, an ontology that represents the categories of intelligence information of suppliers is to be created. For example, KPI is a category of intelligence data of suppliers, and KPI can be further categorized into a list of sub-categories such as quantitative indicators, practical indicators, and finial indicators according to an enterprise's real needs. For each of the categories in the created ontology, features of a category are assigned, and these features can then be used to expand a query and then re-rank the search results according to the features in the user profile. In other words, a user profile in this scenario is a collection of features for a specific type of intelligence data, such as KPI, and can be referred to as category profile. When KPI data of a supplier is needed, the term KPI and the name of the supplier can be submitted to IIRF to obtain a list of search results from different sources. The retrieved results are then categorized into sub-categorizes of KPI. IIRF thus facilitates users to acquire intelligent data of a supplier effectively and efficiently.

CONCLUSION

This paper has outlined the need for current and relevant supplier intelligence within a supply network. This is critical in the current volatile economic environment. The manufacturer who has the most profound intelligence will be able to sustain their long term survival. The IIRF framework provides a logical method of collecting on-line data to form an intelligence profile of the supply network as well as individual entities in a supply network. This framework can be finetuned to have the lesser amount of human resources dedicated to scanning the environment for repetitive work and it can update the information automatically.

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