SUPPLY CHAIN VISIBILITY

Supply chain visibility is an outcome of alignment between corporate strategy, supply chain strategy, business processes, and information systems. The degree of visibility depends on the degree of alignment and integration. Supply chain visibility enables enterprise to capture and store data, derive intelligence, and alter decisions based on product, cash and information flows along with other environmental details.

Supply chain visibility enables enterprise to identify and remove blockages in cash, inventory (material/WIP/FG) and information flows. The pre-requisite for supply chain visibility is "integration capability "toreduce degree of uncertainty in supply chain. The relationship between information systems, integration and supply chain visibility is illustrated in figure 10. Supply chain visibility involves automatic identification and data capture systems for data collection, wireless communication networks for data transfer and data analytics for planning and decision making.

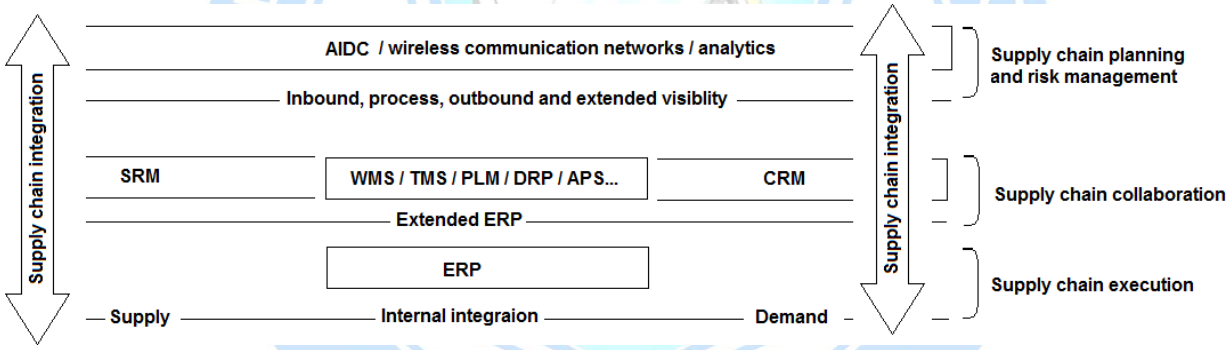

Figure 10: Integration, visibility and information systems

Scope of supply chain visibility

The scope of supply chain visibility is from end-to-end as illustrated in figure 11. It could be limited to internal supply chain or extended to total supply chain based on the business needs.

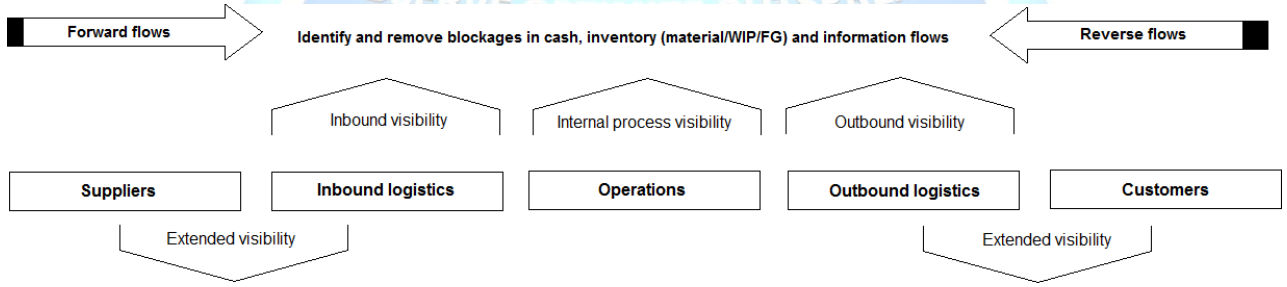

Figure 11: Scope of supply chain visibility

Inbound visibility

The inbound visibility is accomplished through *procure to pay* process integration. The process involves four entities:

1. The customers who release purchase orders to suppliers
2. The suppliers shipping material as per released purchase orders
3. The freight carriers moving the material from supplier locations to focal enterprise locations
4. Regulatory authorities screening the contents for compliance

In this process, the material ownership is transferred from supplier through freight forwarder to the customer. Since each of the entities maintains independent information systems, the challenge is in keeping track in-transit shipment. Suppliers send **advanced shipping notice (ASN) and bill of lading (in case international delivery)** to the customers through EDI that includes the freight forwarders details. Figure 12 illustrates sample ASN. On receiving the ASN the customer creates an inbound delivery note with details of expected delivery date. The freight forwarder upon taking custody of the shipment updates his information system with shipment details. The shipment might travel through various jurisdictions and is intercepted for compliance requirements. The freight forwarder is responsible for updating the status of shipments in transit in information systems. Customer on receipt of shipment reconciles with ASN, PO and proceeds with inspection and unloading activities. On completion of process the buyer sends a goods receipt note (GRN) also called as proof of delivery (POD) to supplier via freight forwarder and releases payment (through mutually agreed payment methods).

Advance Shipping Notice

To:	Ship To:	Ship From:	From:
Buyer Inc 1212 Las Vegas Boulevard Las Vegas, Nevada 89109 tel: 808 555 5555 fax: 877 555 1002 purchasing@demobuyer.com	Buyer Inc - LA Warehouse 1111 S. Figueroa Street Los Angeles, California 90015 United States tel: 1 800 555 5555	Supplier Inc. - San Pedro 555 Channel Street San Pedro, California 90731 United States tel: 310 121 1234	Supplier Inc. 555 Channel Street San Pedro, California 90731 tel: 310 555 1002 fax: 310 121 1237 fulfill@demosupplier.com

Buyer Name:	Chris Adams	Page:	1 of 2
Buyer PO:	111306CAA	Shipper:	QUEBECOR - FedEx Freight West
System PO#:	66	Ship Date:	07/16/2007
Project:		Custom Shipper:	
Required Delivery Date:	02/14/2008	Supplier Name:	Kelly Smith
Product for Resale:	Yes		

Line	Buyer Part#	Product Description	Service	Supplier Part#	Manuf. Part#	QTY ordered	QTY shipping	Date available	Dimensions	Weight	BULK	Unit Price	Tax and Tariffs	Ext. price
1	111306CAA	deluxe thermo dispenser with gauge glass, 2.5 liter, 6 pack	No			10	10	11/23/2006	20 Inch x 10 Inch x 15 Inch	15 Pound	No	$799.00 per	$0.00	$15,980.00

Commodity	Class	Special Instructions
	250	

Hazardous	Hazardous Code	UNNO	Schedule H Code	Freight Terms	Evente Service	Transportation Service Level	Type of shipment	Domestic/Intl/Air	Equipment Grade
No				Domestic - FOB Origin	Inbound Freight	UPS Ground	LTL (less than truck load)	Door to Door	No Special Reqs.

Equipment Attribute 1	Equipment Attribute 2	Equipment Attribute 3	Ready To Ship	Special Equipment	Routing Preferences
Standard Trailer			11/28/2006		

Evente Services			
	Transload		CFS Bonded
	Warehousing		Cranage
	Cross Dock		Distribution
	Mutliple Stops		

Figure 12: Sample ASN

Internal process visibility

Materials received are treated directed in two ways at production facilities:

1. Put away in allocated storage location after updating WMS or Inventory management system (IMS)
2. Directly routed to production line in case of JIT inventory policy

The information about material received (components or sub-assemblies) are subjected to few more activities in warehouse– sorting, kitting including packaging and labeling. This activity is very important for three reasons:

a. For identifying component or sub-assembly is associated with their finished product labels
b. For ease of picking and packaging for customer order fulfillment
c. For work in progress inventory tracking
d. For enabling e-kanban system

Customers provide guidelines (on labeling) to suppliers for reducing the process time. Either the supplier or the freight forwarder performs labeling activity. For materials flowing through JIT process follow kanban system for replenishment. In such cases, the supplier performs sorting, kitting including packaging and labeling (refer figure 13).

Outbound visibility

The outbound visibility is accomplished through *order to cash* process integration. The process involves four entities:

1. The customer who releases purchase orders (or indents) to suppliers
2. The supplier shipping material as per received purchase orders (or indents)
3. The freight forwarders moving the material from supplier locations to customer locations
4. Regulatory authorities screening the contents for compliance

In this process, the supplier creates an outbound delivery in ERP that is attached to customer PO. The information is then passed on to WMS or IMS to enable pick-pack-load (PPL) process. The PPL process efficiency depends on the warehouse infrastructure (pick to light, AS/RS) and *inbound / internal process visibility*. In case of supplier manages transportation network the TMS is posted with load details. Automatic identification and data control (AIDC) enables customer to improve the efficiency of outbound logistics. AIDC involves barcode labeling and RFID tagging at container, pallet, case and item levels. The AIDC enabled process allows supplier to quickly track finished goods that are loaded in transporter vehicles. After loading suppliers send advanced shipping notice (ASN) and bill of lading (in case international delivery) to the customers through EDI that includes the freight forwarders details. Tracking of in transit shipment is enabled by following ISO/IEC 15416 (linear) and ISO/IEC 15415 (2D) for barcodes and EPC global or GS1 international standards in RDFID tagging.

Extended visibility (supplier - customer)

The extended visibility is accomplished through collaborative planning, forecasting and replenishment (CPFR) initiatives. It requires customer and supplier to mutually agree on high degree of information integration through information systems. The CPFR initiative includes

supplier managed inventory or co-managed inventory programmes. In an ideal scenario, the end of point of sales information is processed by supplier and customer in real time. It involves customer and supplier teams to work together on demand planning, forecasting and replenishment areas to reduce out of stock situations, reduce replenishment costs, improve customer service and increase sales by analyzing end customer behavior.

The extended visibility process includes inbound, internal process and outbound visibility. In addition, it requires high degree of information integration along with data analytical capabilities to understand and predict end customer behavior (SKU level) for joint actions to improve customer satisfaction.

The scope of visibility extends to tracking enterprise assets inside and outside the facilities.

Supply chain integration, visibility and resilience

In a global sourcing, manufacturing and distribution scenarios, supply chain integration and visibility critical to create supply chain resilience. For example, Nokia relies on its strategic supplier Philips for semi-conductors used in mobile phones. Nokia's supply chain visibility capability allows it to track major shipments from its suppliers. The visibility capability alerts Nokia sourcing team in case of any exceptional incidents to activate contingency plans. It is this capability that rescued Nokia's production during an accident in Phillips factory the year 2000. Acting on the alerts through inbound visibility system, Nokia's top management leveraged its strategic relationship with Philips not only to rerouted major Philips production capacities for its supplies, but also improved Philips production capabilities through technical resource sharing. Nokia maintains relationship with three contingency suppliers for semi-conductors sourcing. Nokia's integration, visibility systems capabilities and risk management initiatives made its supply chain resilient.

Automatic identification and data capture (AIDC) systems

AIDC refers to the methods of automatically identifying business objects (like materials, products, packages, machines, people), collecting data about them, and input that data directly into enterprise information systems. Barcode, Radio Frequency Identification (RFID), Sensor, Magnetic Strip, Smart card, Optic Character Recognition (OCR), Voice Recognition, Fingerprint and Optical Strip are some AIDC technologies being used in enterprises in various contexts. For example, Barcodes application is widely seen in retail stores, magnetic strip cards applications are seen in banking transactions, smart cards applications are seen in enterprise security scenarios, OCR applications are seen in entrance examinations, finger print applications are seen in driving license acquisition process.

In supply chain management context, *barcode* is the widely used AIDC technologies. RFID technology is gaining importance in the global context with its unique capabilities that overcome limitations of barcode technologies.

Barcode technology: The history of barcode points to 1948 as year of development well ahead of

retail industry adoption during 1970s. The barcodes come in two forms: one dimensional (1D) and two dimensional (2D) barcodes. The 1D barcodes contain *bars and gaps* to encode identification information such as serial numbers. This is the most widely used form of barcodes. The 2D barcodes comprise of more complicated *patterns* and may encode up to 4K bytes of data (customized data). This is becoming more popular as it can encode more information than 1D bar code. Figure 15 and 16 illustrate two forms of bar codes. Figure 17 illustrates composite barcodes that combines 1D and 2D barcodes.

Figure 15: 1D barcode

Figure 16: 2D barcode

Figure 17: GS1 / RSS composite barcodes

The basic barcode system comprises of three key components: Bar code printer, reader or scanner (optical technology), and a computer with software to process encoded data / information. Figure 18, illustrates a simple barcode system. In automation scenarios typically found in production and storage facilities, programmable logic controllers (PLC) are used to control the scanner.

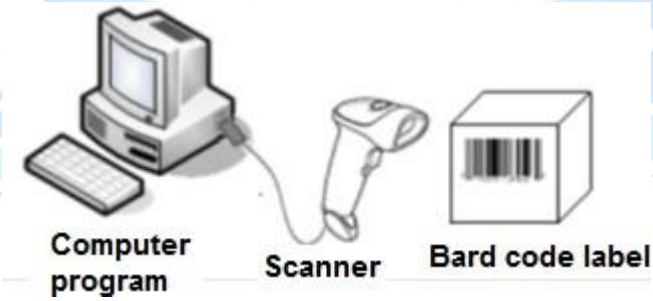

Figure 18: Bar code system

The coding scheme used to encode and decode data is called “symbologies”. Table 2 describes symbologies used in different application contexts.

RFID technology: The first applications of Radio frequency identification (RFID) technology can be traced back to World War II in 1940s. Transmitters and interrogators were used to identify ally's aircraft from enemy's aircraft. Later it was used in processing hazardous materials and livestock tracking (1980s). In 2005 mandates from Department of Defense (DOD), USA, Wal-Mart followed by other retailers such as Target, Metro…have given triggered rapid adoption of the technology by many suppliers.

The RFID system is composed of following elements: RFID tag, a small silicon chip attached with a small antenna; Reader or interrogator, a device that communicates with RFID tags through radio frequencies. Reader antenna, generally attached to readers is used to transmit and receive signals between reader and tag; a computer server with program (middleware known as Edge servers) connected to RFID reader to process data. RFID technologies are classified into three categories: Passive RFID, Semi passive RFID and Active RFID. Figure 19 illustrates basic RFID system.

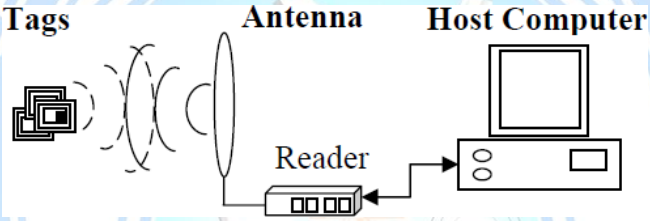

Figure 19: Basic RFID system

Based on the radio frequency, the passive RFID technologies are sub classified into Low frequency RFID (LF), high frequency RFID (HF), ultrahigh frequency RFID (UHF) and microwave RFID. While the LF and HF RFID systems use magnetic field to establish communication link between RFID tag and Reader, the UHF RFID systems use electromagnetic field. Figure 20 illustrates RFID system components.

The semi-passive and active RFID systems have RFID tags powered by batteries to assist in collecting environmental parameters such as temperature or humidity. However, the communication link is established through reader and its antenna. Apart from the battery power, the key characteristics which differentiate passive, semi-passive and active RFID are reading range, data storage space, read/write speed (passive RFID: low, semi-passive RFID: moderate; active RFID: high). Table 3 describes characteristics and applications of various RFID categories.

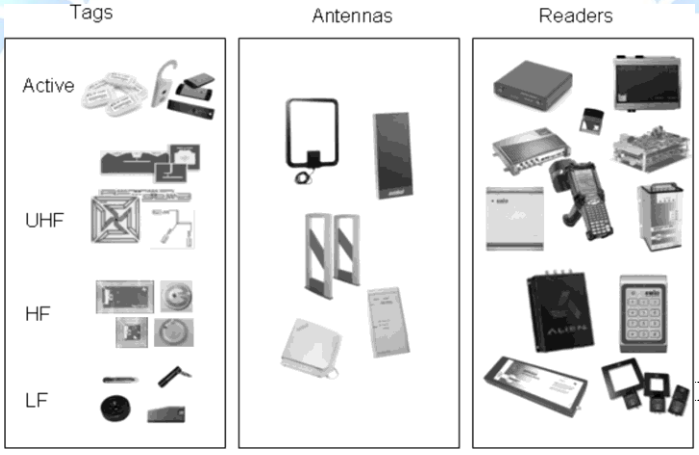

Figure 20: RFID components

Examples of AIDC usage in supply chain

Sterlite Industries (India) Limited

The company's Tuticorin facility manages major task in handling inbound and outbound logistics with an average traffic of 800 to 1000 trucks. RFID technology was used to identify vehicle movement, placement and loading. The logistics and security departments leveraged technology for managing inbound, outbound logistics including entry and exit security verifications.

Bhima & Brothers Jewellers, Mysore

The jewellery store implemented RFID technology to deal with the need for quick and efficient daily stock management. It enabled the product information to be available on handheld PDA readers and point-of-sale billing mechanisms that automate the billing activity. The result was reduced effort in stock reconciliation activities with 100 percent accuracy.

State bank of India, Mumbai

The bank wanted to recognize and attend high net worth individuals (HNI) account holders as soon as they enter bank premises. RFID enabled privilege cards were provided to key customers that helped customer relationship executives to attend them as soon as they entered premises.

Other examples

1. **Manufacturing:** Kimberly-Clark, General Motors, Procter & Gamble, DePuy Orthopedics, Amcor Fibre Packaging, Colourpoint, MidAmerican Growers, Boeing, Chrysler, Gillette, Pierrel-Ospedali
2. **Logistics:** FedEx, United Postal Service (UPS), Collex, Online Express Parcels, Delta Airlines, San Francisco International, Airport, TrenStar, HPCL, Adani grain logistics, Shree Cement, Ranbaxy
3. **Retail:** Wal-Mart, Benetton, David Jones, Target, Albertsons, ITC Lifesytle, Pantaloons

SUPPLY CHAIN EVENT MANAGEMENT

Supply chain processes spread beyond enterprise boundaries to trade partners and end customers. The process view of supply chain introduces a systematic methodology to define expected and unexpected events, activities, rules, status notifications and metrics. The process definitions reflect enterprise boundaries, hierarchy and role limitations to maintain information confidence. Figure 21 illustrates the relationship between process, events, activities, metrics, rules and status notifications. It is important to note that in the context of complex systems, definition of all possible events is not possible. The event management systems evolve over a period of time. Unexpected events are recorded and are reported to process improvement teams for analysis and solutions.

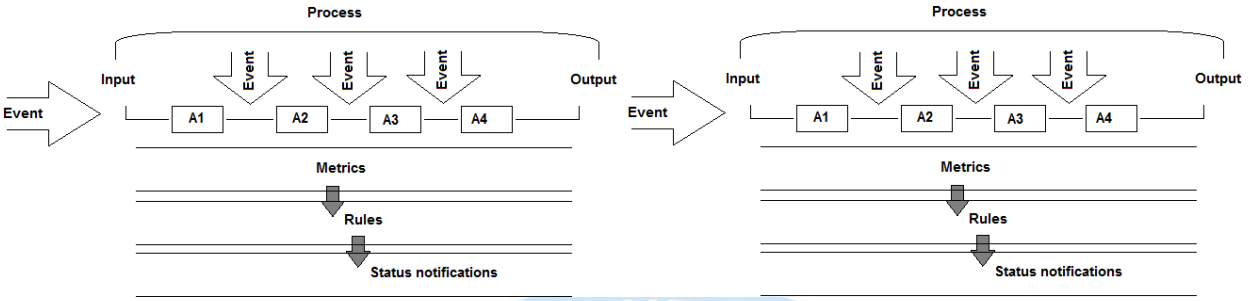

Figure 21: Relationship between process, events, activities, metrics, rules and status notifications

Following are few examples of supply chain events:

- a customer's order or a container tracking
- production orders, stocks in an enterprise or in a supply chain
- late start of a production if it occurs before or after the planned point of time
- machine breakdown, traffic jam that occur as a result of an unplanned, unpredicted process
- not confirming the handing over of goods to the customer by a freight forwarder as agreed
- punctual arrival of materials

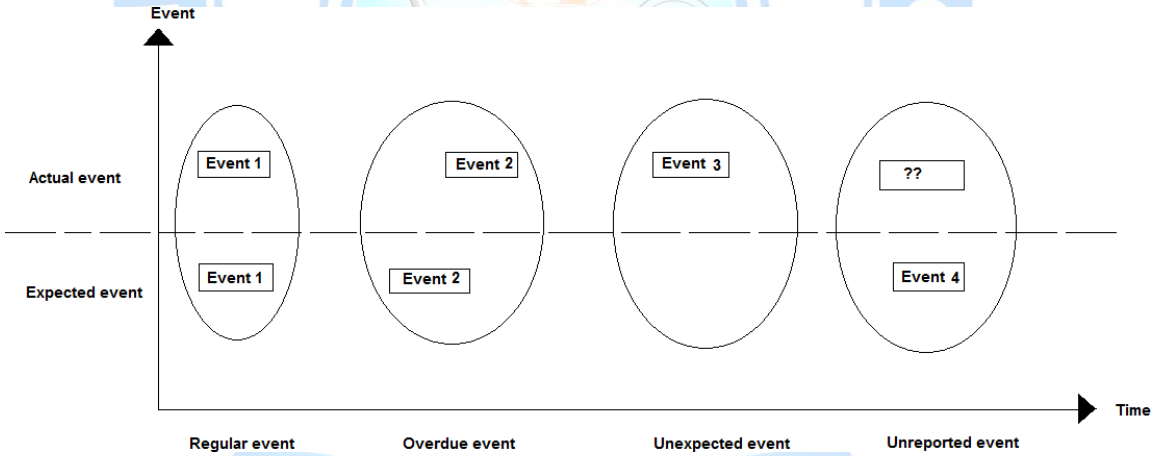

Figure 22: Types of events in time dimension

The supply chain event management systems support decision making by providing standard responses to pre-defined event occurrences in the form of alerts. For example, an alert sent to procurement manager regarding the delay of materials receipts suggesting immediate action. In some cases, the event management systems trigger automatic contingency action based on pre-defined rules. For example, trigger automatic production of an order if the inventory falls below a certain threshold.

SUPPLY CHAIN PERFORMANCE

Enterprises measure supply chains in which they are partners to gain monitor, control and improve not only their enterprise performance but also overall supply chain performance. The performance measures evolve as the enterprise supply chain matures from functional focus (stage 2) to internal integration (stage 3) and to external integration (stage 4) phases. The Supply chain council operations reference model (SCOR) provides multiples levels of performance measures. The level 1 metrics provide internal and external facing measures grouped in to fivebroad perspectives or dimensions:

- External facing
    a. Delivery reliability (perfect order fulfillment)
    b. Responsiveness (order fulfillment cycle time)
    c. Flexibility (upside supply chain flexibility, adaptability, downside supply chain adaptability)
- Internal facing
    a. Costs (total supply chain cost, cost of goods sold)
    b. Assets (cash to cash cycle time, return on supply chain fixed assets, return on working capital)

The above metrics are further decomposed for micro level measurement and control of supply chains.

The performance management systems are grouped under any of the four models[19]:

1. **Balanced models:** They consider both financial and non-financial measures to balance diverse perspectives in business. Three key models in this category are performance measurement matrix, balanced scorecard and performance prism.
2. **Quality models:** They are focused predominantly on quality. EFQM (European Foundation for Quality Management) is quality model for business excellence.
3. **Questionnaire-based models:** These are based on questionnaires for performance measurement. Performance management questionnaire (PMQ) and TOPP (Norwegian manufacturing industry) are two known models in this category.
4. **Hierarchical models:** These are models that are characterized by cost and non-cost performance on different levels of aggregation. Performance pyramid, Advanced Manufacturing Business Implementation Tool for Europe (AMBITE), The European Network for Advanced Performance Study (ENAPS) approach and Integrated Dynamic Performance are different hierarchical models.
5. **Support models:** They do not build a performance measurement system but help in the identification of the factors that influence performance indicator. Key models in this category are Quantitative Model for Performance Measurement System (QMPMS) and Model for Predictive Performance Measurement System (MPPMS).

[19]Cagnazzo, Taticchi, and Brun, A; The role of performance measurement systems to support quality improvement initiatives at supply chain level. International Journal of Productivity and Performance Management, 2010

Supply chain managers have to carefully select measures to ensure that conflicting supply chain functional goals do not hinder overall enterprise goals or supply chain goals. Following table illustrates conflicting measures that lead to tensions between functional organizations:

Source / Purchase	Make/ Production	Deliver/ Warehouse	Sell/ Customer
• Stable volume requirements • Large quantities • Flexible delivery times • Little variation in mix • Low purchase price • Multiple vendors	• Few changeovers • Stable schedules • Long run lengths • High quality • High productivity • Low production cost	• Low inventories • Low transportation costs • Quick replenishment capabilities	• Short order lead times • High inventories • Wide variety of products • High service levels • Regional stocks • Low prices

Table 6: Conflicting functional goals

Information technology enables enterprise and supply chain wide performance management systems. Based on the business needs, enterprises choose appropriate performance measurement model for deployment. Figure 23 illustrates the information systems stack in the context of supply chains in multiple stages of integration.

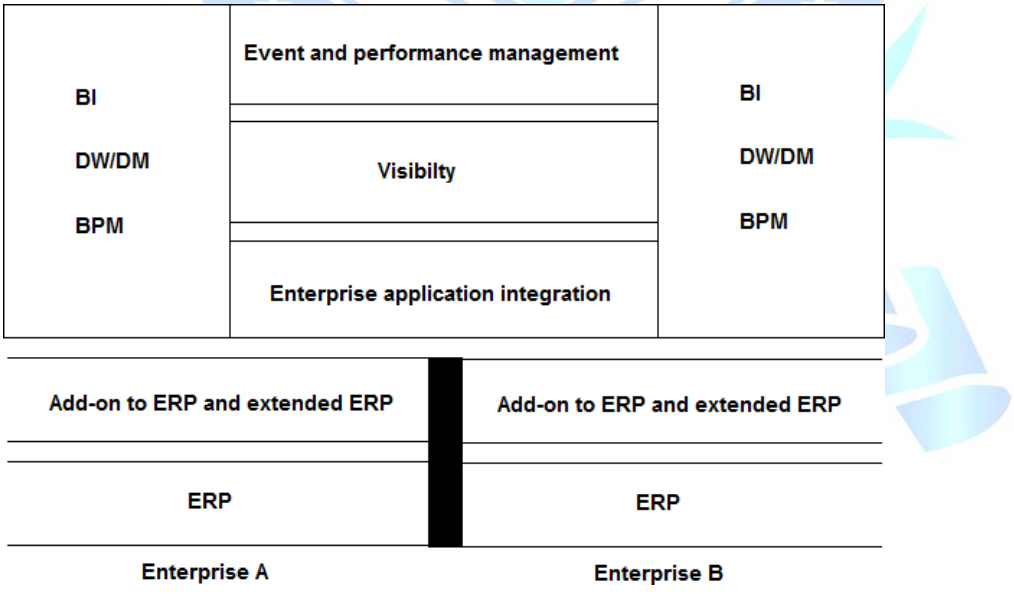

Figure 23: Information systems applications stack

The information technology concepts that are widely used in building performance measurement

systems are data warehousing and mining. Information systems built on these concepts allow users to extract, transform and load relevant data from multiple sources (systems) to perform multi-dimensional analysis as per select supply chain performance measurement model. Many ERP vendors provide such capabilities as a specialty offering to enterprises.

SELF-ASSESSMENT QUESTIONS

1. Write a note on EAI architectures.
2. Describe EAI system and its components.
3. What is the purpose of supply chain visibility practice? How does it improve customer service?
4. Write a note on applications of AIDC in supply chain management.
5. Why are supply chain event management systems required? Describe SCEM characteristics.
6. Describe supply chain information systems application stack.