

## Turning signals into profits in the RFID-enabled supply chain

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*Abstract:* Auto-ID/RFID provides real-time material flow data. Distinguishing noise from relevant data signals, using these signals to identify supply chain bottlenecks and taking operational advantage of optimization opportunities, will be major prerequisites to supply chain improvement.

Supply chains are value networks made up by network nodes (i.e. distribution centers, stores, etc.) which collaborate around material movement events and according to defined service levels and rules. In a real-time world, success depends on both central and local decision making. Whereas supply chains may be centrally governed, distributed control and execution of events are equally important as it is the only practical way to cope with the complexity of a real-time value network.

### ***1. The promise of RFID***

If supply chain data was accurate, current, and complete,

Then:

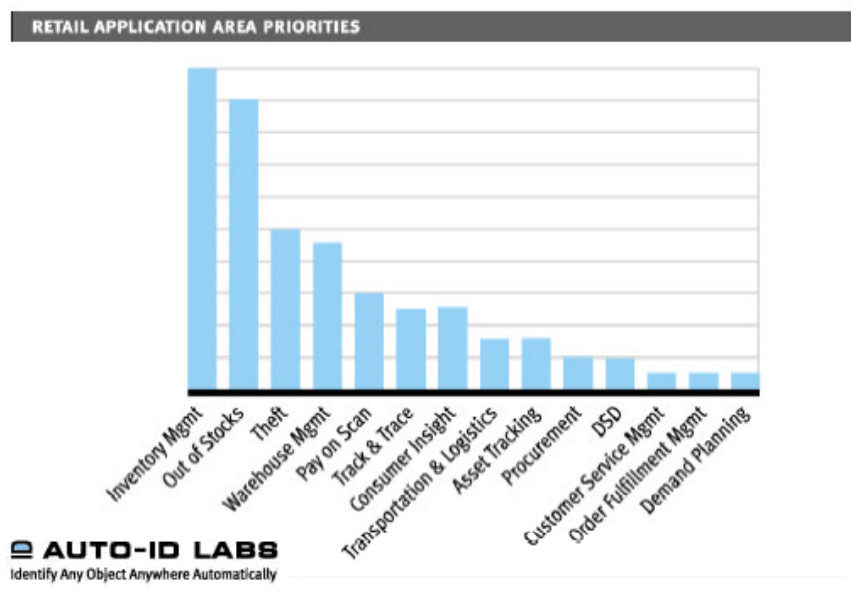
- Efficiency could be measured in real-time
- Analysis could be done ad hoc, and
- Optimized action be taken at once.

Consequently, profits will increase significantly.

The promise of RFID is to make this dream a reality. RFID will increase transparency of the flow of mobile assets at affordable cost levels. Higher transparency will result in cost savings - if exploited appropriately. Simply put, RFID-enabled companies will make more money. These days, this simple statement is broadly accepted within logistics-focused industries, such as CPG/retail. Consequently, Wal-Mart, Tesco, Metro, Carrefour and others have been pushing the adoption of RFID. Manufacturing sectors will follow suit and logistics industries will deliver RFID-enabled services. Indeed, RFID has all the ingredients to deliver benefits for a range of reasons:

- RFID is maturing. RFID technology has been around for decades and successful RFID projects in logistics have been implemented since the early 90's.
- RFID greatly facilitates and automates labor-intensive work and is therefore a perfect tool for rationalization.
- RFID is non-intrusive. So, the flow of assets is not being disrupted and therefore the number of reads, i.e. the level of transparency, will not become a limiting factor.

The Auto-ID Center (ACN AUTOID BC 007; 2003) identified the following value drivers and retail application priorities:



GMA (Grocery Manufacturers of America) confirm the high priorities assigned to inventory and out-of-stock management and control. GMA emphasize the need for synchronization, flow-through distribution and overall improvements on supply chain efficiency.

GMA quantifies the losses incurred through inefficient supply chain visibility and execution as follows:

- Out-of-stocks = 4% loss of sales; approximately \$17.5 billion to retailers. \*
- Loss to manufacturers = \$7.5 billion; primarily due to customer substitution choices. \*
- The cost of Unsaleables = \$2.5 billion, or 1.14% of sales.\*\*

\* Source: Retail Out-of-Stocks; CIES; FMI; GMA

\*\* Source: 2002 Unsaleables Benchmark Report; Anne Lightburn; FDI; FMI; GMA

An RFID-enabled supply would considerably reduce these losses.

## ***2. Open RFID Questions in 2004***

While RFID is widely believed to have significant impact, questions remain about the evolution towards full adoption throughout industries. For fast proliferation to happen, manufacturers, retailers and logistics companies will have to be given satisfying answers to the following strategic questions:

- The early adopter question:
  - Do I really gain a competitive advantage or am I simply sponsoring the learning curve of my industry, i.e. my competitors, with my investment into RFID?
  - How can I leverage successful pilots for roll-out?
  - How do I generate and profit from economies of scale?

- The risk of emerging standards:
  - How can I reduce financial and operational risk exposure in a field in which standards are still volatile?
  - Are there ways to reduce fixed cost, thereby limiting my investment?
- The “benefit versus investment” question:
  - Who in the value network (e.g. supply network) benefits at which level and how big will my return be?
- The “RFID readiness” question:
  - What minimum investment will I have to make to be “RFID ready”?

Not all of these questions can be sufficiently answered at present. Therefore, an investment dilemma will continue to exist. While all stakeholders in value networks will have to be “RFID-ready” to be viable business partners, they will at the same time try to avoid committing funds to sunk-cost investments.

Still, the adoption rate of RFID has accelerated. The year 2004 has not only confirmed the viability of the RFID technology in a range of pilots, such as Metro’s future store. 2004 is also the year for the start of full rollouts throughout supply chains. Metro’s decision to start with 10 distribution centers, 250 stores and their Top100 suppliers by yearend 2004 is being matched by similar plans from Wal-Mart and Tesco to rollout RFID in 2005. Consequently, all major suppliers in CPG (consumer packaged goods) industries will have to adopt RFID in this period.

While standards for the capture and exchange of RFID information are being drafted and refined, it will take some time before widespread adoption. Moreover, companies are keen to leverage their existing signal capture capabilities, so it is highly likely that RFID implementations over the next few years will actually be a hybrid of legacy barcode systems working in concert with RFID equipment. In addition, these implementations are likely to include a mix of standards-based coding conventions like the EPCGlobal Electronic Product Code (EPC) and proprietary coding schemes working in ‘closed communities’ of trading partners. The MIT/Auto-ID vision of a ubiquitous, global, Auto-ID information infrastructure (sometimes referred to as the ‘Internet Of Things’) requires

that the all the technology deployed operate to 'Open Standards' that will ensure interoperability of readers, tags, coding schemes and information access. These standards will take several years to develop and will, no doubt, go through several iterations before global acceptance (concerns over corporate and consumer privacy will drive much of the discussion). However, companies will move ahead with hybrid solutions in 'closed communities' to gain first-mover advantage. Those large organizations that move first will in a position to shape and drive standards (as has already been demonstrated by Wal-Mart).

### **3. RFID Vision 2010**

The penetration of RFID in supply chains is not only driven by CPG/retail. Other industries, such as pharmaceutical or automotive will follow suit. In addition, security-related industries will adopt RFID. Most notably, the US Department of Defense requires their suppliers to ship products with RFID tags from 2005 onwards. Therefore, the broad adoption of RFID is on its way. In 2010, RFID will be ubiquitous throughout industries.

RFID will enable value networks, i.e. organizations and their suppliers and/or customers, to permanently synchronize their businesses in the most efficient manner alongside the three dimensions of supply and distribution chains:

1. the physical flow of goods throughout a value network
2. the flow of information about these goods
3. the financial flows

Demand-driven organizations will have an edge in the world of micro-segmentation and fine-grained customer profiling. Forecasting alone will no longer be sufficient but has to be complemented by demand signals which may automatically be generated when a customer takes a product from the shelf. Distribution centers will receive these replenishment signals and will have to determine whether to replenish immediately or wait until more replenishment requests have been collected and a more efficient delivery to store level can be made. Trucks will be loaded according to local store requirements.

Capacity utilization will no longer be the only dimension for optimization. Loading at distribution center level will take into account the conditions at the receiving store, i.e. plan-o-gram of the local store and free space in its backroom, in order to also consider cost at the receiving desk. Likewise, replenishment of distribution centers through manufacturers will be driven by demand signals. Manufacturers and the other entities in such a value network will have to make individual decisions in order to optimize their business, while at the same time delivering according to a global service level. Shelf-availability for customers in a store may be such a service level indicator.

The “demand to order network” is an example for a KPI-driven value network. RFID will generate a precise picture of the physical world at any given moment as an input to optimizing and synchronizing value networks. Furthermore, financial flows will be automatically generated by RFID-based information about physical flows. Cumbersome reconciliation of financial obligations will be history.

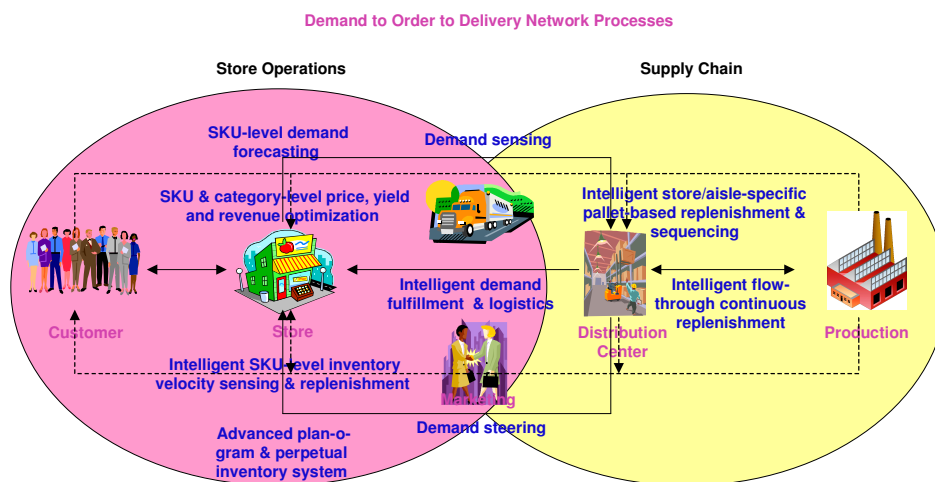


Figure: Demand-driven CPG/retail value network

Even consumers will use RFID and read RFID tags with their personal readers which may be embedded in their mobile phones. Data privacy issues will be resolved and consumers will be able to leverage the information on RFID tags to identify the origin of food products, to receive information about an electronic product which they want to dispose of, and to ensure that they take their medication according to the prescription. Furthermore, consumers will be able to tell a counterfeit from a genuine product. RFID will empower them as consumers while concerns about data privacy will be addressed. For companies which understand and respect these concerns and behave as good corporate citizens, RFID will pay off.

#### ***4. Delivering on the Vision***

This section describes what needs to be in place to deliver the 2010 vision. It requires a range of market-led capabilities be understood and developed incrementally:

- Market Requirements
- Value Network Management
- Mastery of data overload and complexity
- Right-time Event Intelligence in RFID-enabled Value Networks
- Data Privacy
- Auto-ID Managed Services and International Supply Chains
- Commoditization

##### **4.1. Market Requirements**

Most logistics-focused industries are working on the adoption of RFID and, as is demonstrated by the table below, the range of business processes being targeted is broad, however, today there is a predominant focus on product visibility and operational process automation. These are seen as the foundational capabilities that will be developed further to cover the entire landscape of requirements identified.

The table below presents what RFID is expected to deliver in different industries.

Market Space RFID Requirements Matrix										
Value and Supply Chain Requirements and Benefits Matrix										
	FMCG	Fashion (Brands)	High-Tech Electronics	Manufacturing	Life Sciences	U.S. DoD	Transportation and Logistics	Security	Secure Deliveries	Financial Documents and Securities
<b>Value and Supply Chain Visibility</b>										
Tracking & Tracing	X	X	X	X	X	X	X	X	X	X
Automated Inventory Counts	X	X	X	X	X	X	X	X	X	X
Auto-replenishment	X	X	X		X					
Dynamic event disruption management & optimization	X	X	X	X	X	X	X			
Targeted recalls			X	X	X					
Level of visibility										
Item-level	X	X	X	X	X	X	X	X		
case, pallet, tote, pouch	X	X	X	X	X	X	X	X	X	X
container, trailer	X	X	X	X	X	X	X	X	X	X
truck, ship	X	X	X	X	X	X	X	X	X	X
<b>Operational Process Automation</b>										
Data Synchronization	X	X	X	X	X	X	X	X	X	X
Purchase Order Processing linkages	X	X	X	X	X	X	X			
Value Network Analytics and KPIs	X	X	X	X			X			
Ad hoc situational analysis and optimization	X	X	X	X		X	X			
Automatic results achievement	X	X	X	X		X	X			
Decision Support	X	X	X	X		X	X			
Invoice reconciliation and discrepancies	X	X	X	X		X	X			
Automated invoicing & payment	X	X	X			X	X			
Shipping and receiving automation	X	X	X	X		X	X		X	X
Shipping and receiving auditing	X	X	X			X	X		X	X
Proof-of-delivery at final destination	X	X	X	X	X	X	X			
Pick & pack, sorting, break-bulk	X	X	X				X			
Cross-docking automation	X	X	X	X			X			
Dynamic warehouse material handling automation	X	X	X	X			X			
Intelligent Object self-responsibility	X	X	X	X			X			X
Dynamic object routing	X	X	X	X			X			
Real-time shipment routing and re-routing	X	X	X	X		X	X		X	X
Real-time flow analysis and identification	X	X	X				X	X		
Advanced scheduling, bottoms-up	X	X	X	X		X	X		X	X
Dynamic order allocation, multi-variable	X		X	X		X				
<b>Planning</b>										
Demand-driven replenishment planning	X	X	X	X	X					
Advanced plan-o-grams	X	X	X		X					
Demand and supply planning	X	X	X	X	X	X	X			
Inventory optimization	X	X	X	X	X		X			
Process simulation and optimization	X	X	X				X	X	X	X
<b>Reverse Logistics and Warranties</b>										
Returns management			X	X			X			
Recycling & end-of-life disposal			X				X			
Spare parts inventory management			X	X		X	X			
Field-level equipment configuration analysis			X			X				
Manufacturer retail allowance management	X	X								
<b>Illicit Activities Tracing and Deterrence</b>										
Anti-counterfeiting and authentication	X	X	X			X	X	X		
Gray-market goods tracing	X	X	X	X		X	X	X		
Theft prevention and deterrence	X	X	X	X		X	X	X	X	X
Secure International Transports	X	X	X	X		X	X	X	X	X
<b>Condition Monitoring</b>										
Temperature	X				X					
Humidity	X		X		X					
Expiration Date	X				X					
Shock and Vibration			X	X						
Tampering	X	X	X	X	X				X	X

## **4.2. Value Network Management**

A Value Network is an information sharing community that jointly delivers goods or services. The most common example of a value network is a supply chain where many different organizations collaborate together around the common goal of expediting the movement of goods at the lowest cost with the terms of agreed service levels. However, other examples of value networks include (but are not limited to):

- Airline Code sharing Networks
- Franchised Operations
- Collaborating domestic Government Authorities
- Seaport Security Communities
- International Customs Authorities.

A value network is a community of interest that is focused on a common set of goals and objectives with the express purpose of sharing selected operational data in a secure manner.

Value networks have existed for a long time and so has the exchange of information between members of such a value network in order to enable collaboration. With RFID, value networks and its members will have an exact picture about inventory on all levels of the network. Misallocation of inventory and bullwhip effects will more easily be detected and mismatches of fulfillment and actual demand be resolved or avoided altogether.

In a CPG/retail value network, the retailer assumes the role of the value network master. In this capacity, the retailer determines the global service levels which all entities of the value network have to comply with. These entities comprise his distribution centers and stores and his suppliers. A value network therefore organizes value creation across companies. Hence, some data will be shared and other data will be considered private. Value Networks handle complex business relationships. Across CPG/retail value networks, relationships are even getting more complex. A CPG manufacturer, such as Procter&Gamble has relationships with all big retailers, and so have all retailers relationships with most CPG manufacturers.

Still, these many-to-many relationships work to date. Companies simply share information by exchanging documents. This loose, document-based, integration and co-operation has proven to be the right approach to managing these complex relationships. Tightly-coupled, point-to-point information exchange solutions would fail for reasons of cost and complexities of integration.

Standard electronic business documents such as waybills, purchase orders, bills of material, picking lists, advanced shipping notices, etc. are being accepted as input to a value network and will generate electronic documents for consumption by other systems and participants. RFID will not change these relationships but improve processes through finer granularity and higher accuracy. More fruitful collaboration will be enabled by RFID signals, their translation into business events and the subsequent combining of electronic documents with more event information.

The graphic below illustrates a CPG/retail value network with its flows of goods and information.

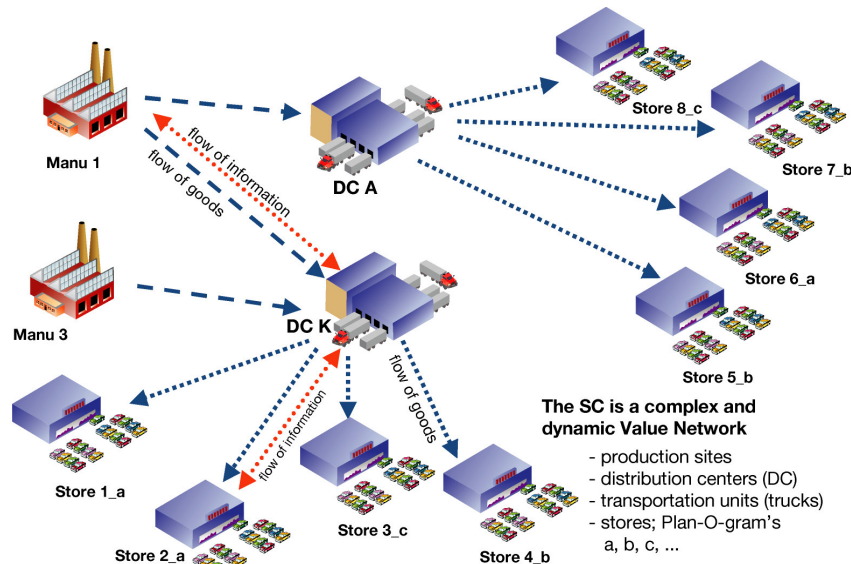


Figure: Manufacturer-DC Store Value Network SC\*: supply chain

Through RFID, value networks will become transparent and Key Performance Indicators (KPI) can automatically be measured. This will allow supply chain members to permanently monitor performance of individual entities of the value network (store and distribution center (DC)) and the performance of the value network as a whole. Network process metrics, such as consolidated SKU-level network inventory, will give a permanent picture about network performance.

Furthermore, such metrics can be used to actively manage the behavior of parts of or the whole value network. Instantaneous analysis on business events, e.g. total network SKU margin analysis, will suggest appropriate action to exploit such business events.

The vision of a CPG/retail Yield-Management-System becomes real once SKU-level profit/cubic foot analysis can be conducted and appropriate action be taken in real-time.

The subsequent table is a compilation of store-, DC- and network-level metrics, which will be critical for a Yield-Management system for CPG/retail value network.

<b>Store Process Metrics</b>	<b>DC Process Metrics</b>	<b>Network Process Metrics</b>
SKU-level profit/cubic foot analysis	% SKUs cross-dock	Consolidated SKU-level Network Inventory
SKU-level SLA	% SKUs inventoried staple stock	Total network SKU margin analysis
SKU Out-of-Stock Index	\$ SKUs DSD	Total network SKU cost allocation index
Store-Specific Network EOQ Modeling	Cartons/hour/DC headcount	SKU-level distribution cost performance index
SKU Process Responsiveness Index	Trailer cube capacity utilization	Private and common fleet cost / mile index
Store-level labor productivity index	DC-level labor productivity index	% of vendors with full demand and SC visibility
SKU-level velocity analysis	SKU-level replenishment SLA	Pallets reuse index
SKU-level forecast to actual sales index	Inventory investment/RDC applied revenue	SKU-specific transportation cost index
	% of conveyable SKUs	Private fleet round-trip utilization / cubic foot
	% of flow-through no-touch pallets	Trailer utilization 24x7 index
	% of flow-through no-touch cartons	
	% of store/aisle specific pallets	

### **4.3. Mastery of data overload and complexity**

RFID data signals and the transformation into business events require the value network to be event-sensitive. The question remains how such events can be exploited once they occur. The traditional operations research approach of applying a central optimization paradigm must fail given the decentralized nature of events and their resolution. Also, the interdependencies between nodes of a value network (store, DC, manufacturing site) and the fact that they may have different goals given that a value network comprises entities of separate companies, does not bode well for a central approach.

Instead, it is worthwhile adopting a distributed control paradigm. Distributed control will help master complexity. The farther the decision competence is away from an event, the more data and brainpower will be needed to process an event and the fewer local constraints can be considered. As an example, let's imagine a data noise at the receiving gate of a warehouse, e.g. resulting from a reading error, which could easily be filtered out locally as the local context is known rather than passing it on to a central 'problem resolution' engine where it is difficult at best to determine whether or not this is

a relevant event or simply a noise. Distributed control mechanisms will result into more robust solutions.

Distributed control is vital to RFID-enabled asset intelligence on two levels.

- (a) Local capturing of signals and local pre-processing
- (b) process execution determined and executed by individual entities, i.e. contributors

RFID tags will put more information into mobile assets than ever before. Previously dumb items will deliver information which can be exploited in a local context only. Hence, central control systems like traditional warehouse management systems (WMS) will become less important over time and render authority to local decision making components. These can be local process controlling units and in the future, RFID tags themselves will be equipped with processing power and will be able to make own decisions on a local level, e.g. a tagged product could notify its environment, when it is time to being shipped upon certain conditions. In fact, the first RFID tags of this kind are tags which process state information like humidity and temperature. Rather than being governed top down, these products have bottom-up capabilities. In the future, these products are expected to pro-actively manage their destiny.

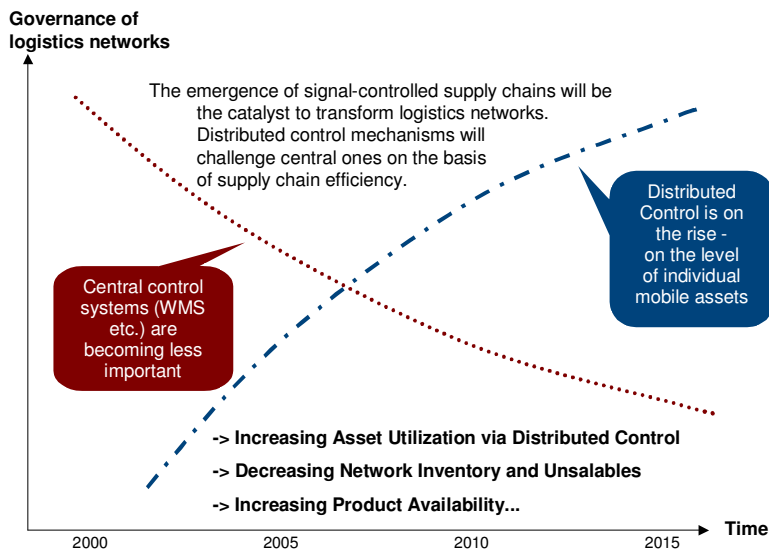


Figure: Distributed control to increase supply chain efficiency.

An example of a “bottom-up” organizational model is Kanban. Kanban has been widely adopted due to its flexibility, efficiency and adaptive event resolution. Local decision making by context-savvy entities (work groups) is a key advantage of Kanban. Toyota and many other organizations have proven, that local decision making and event resolution helps master complexity and run a more efficient business. Kanban’s local control helps cope with uncertainty and external events and complements forecasting and planning. Its pull-based behavior makes it demand-driven and enables the customer-driven organization.

The IT equivalent of a distributed control system which can manage a complex value network, is an agent-based event-driven system. Such an agent-based system will sense, analyze and act locally while maintaining global service levels.

#### ***4.4. Right-time Event Intelligence in RFID-enabled Value Networks***

IT and business people alike support the notion of real-time business. “Real-time” suggests that any event shall be spotted, analyzed and processed in nanoseconds, including its implications for back-end systems. While this desire is valid and its fulfillment would greatly facilitate the world in which we live, we must determine what “real-time” really means in the context of a sophisticated value network and its processes. Fortunately, business processes tend to have a duration which is not measured in nanoseconds but in days and hours. Also, value network members may determine whether an event is relevant for all other members (i.e. sent to systems of other members) or whether this event can be dealt with locally without jeopardizing expected service levels. In the latter case, notification to other partners is not necessary as action can be taken autonomously. In the case where events must be resolved in collaboration with others, “real-time” must be looked at in the context of actual process requirements. So, “real-time” in a procurement process may be a 24-hour period in which a bottleneck situation has to be resolved. Hence, “right-time” is more appropriate a concept in this context. Most business processes comprise asynchronous elements which have to be coordinated, and acted upon in concert with a broad spectrum of

information sources – the objective is therefore to ensure that this information is accurate, relevant and timely.

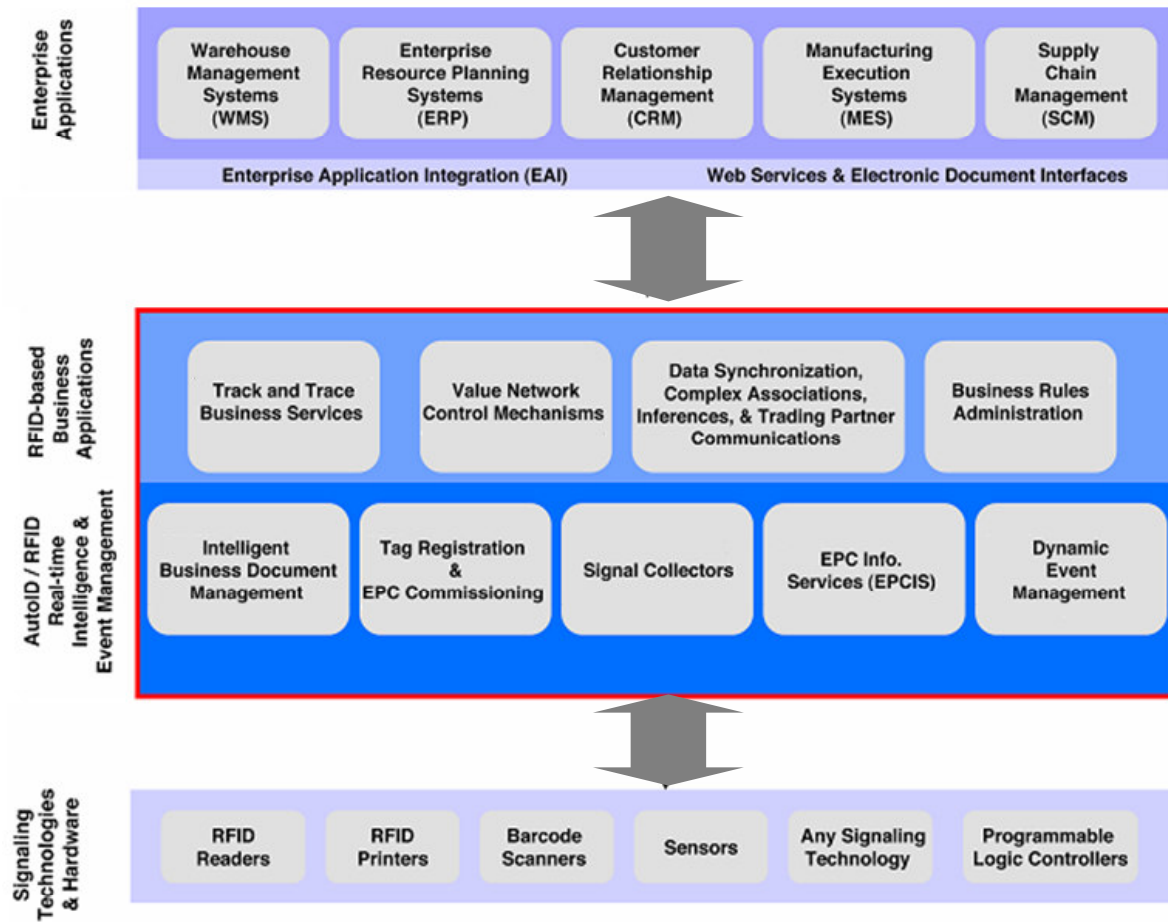
As mentioned earlier, a value network comprises heterogeneous entities and goes beyond companies' boundaries. Systems will never be connected in point-to-point solutions for reasons of complexity and flexibility and as a consequence, for reasons of cost. Network collaboration will therefore continue to be document-based. Still, RFID-based collaboration will require a Business Systems Infrastructure upon which a range of processes be synchronized.

The definition of this 'Business Systems Infrastructure' is:

- A globally applicable software layer,
- That sits above signal capture,
- That provides horizontal business application functionality that both supports and augments enterprise applications,
- That integrates business events into heterogeneous business processes and legacy systems environments.

The figure below illustrates such a business systems infrastructure with its application functionality.

Figure: Business Systems Infrastructure for RFID-enabled Value Networks



#### **4.5. Data Privacy**

Data privacy has to be looked at on the level of inter-company information exchange in value networks and on consumer level.

Introducing the notion of access categories for information exchanged between companies greatly facilitates integration issues. There is private data which a company will not reveal, shared data which companies are willing to share with business partners only, and public data which is non-sensitive and available for broader audiences. Given the sensitivity of flow information, access to data will be classified as

- (a) private
- (b) shared (accessible for individual partners)
- (c) public (broad access)

The value network master will control access rights. Beyond an agreed shared base data, members of the value network may determine which data they are willing to share and which data shall remain private.

If RFID is to become ubiquitous, all stakeholders in the RFID business must find answers to the concerns of consumers which fear that RFID may help intrude their privacy. Arguments of consumer advocate groups, such as C.A.S.P.I.A.N (Consumers against Supermarket Privacy Invasion and Numbering), must be taken seriously and data privacy issues resolved.

#### **4.6. Auto-ID Managed Services and International Supply Chains**

For value networks to be successful in leveraging RFID, the value network master and the members need a cost-effective solution to conduct their value networks operations. In an emerging market like RFID, many companies are reluctant to invest into infrastructure given that product offerings are volatile and standards are just emerging.

An alternative is to use a managed service.

- A managed service allows the vast majority of network participants to leverage a common networked Auto-ID/RFID service allowing value networks to be immediately enabled and cost-effectively organized into clusters that can migrate to open networks as Auto-ID/RFID standards mature.
- A managed service will realize critical mass quicker providing the support and maintenance of central and distributed Auto-ID/RFID equipment and software at a lower total effective cost and with materially more effective field support of hardware and software systems
- A managed service allows the cost of learning and leveraging Auto-ID/RFID technologies to be amortized over a large population of companies and users providing a lower total cost of ownership
- Managed service providers have a critical mass of influence in which to help enable a more rapid maturation of Auto-ID/RFID standards
- Companies that deploy Auto-ID/RFID hardware and software systems using a managed service provider experience lower total cash flow requirements
- The managed service can be leveraged as a stand-alone or loosely 'light-touch' integrated solution that doesn't require costly integration and customization expenses
- The managed service provider can provide a more secure high performance environment that customers can trust
- As an 'edge service' with significant value network characteristics across multiple participants, it logically makes sense to outsource part or all of the service to a shared managed service provider
- Network service providers have existing networks that they can leverage at bundled service prices

Supply chains increasingly become international in scope. Event-based end-to-end supply chain monitoring and optimization will therefore require end-to-end RFID networks. Affiliate managed service providers will enable end-to-end value chains to cost-effectively tag items in remote manufacturing facilities and provide the network visibility, track, and trace services worldwide.

#### **4.7. Commoditization**

Today's RFID pilots still lack the key characteristics for full-scale rollout, that of significant economies of scale when rolled out throughout a value network. Standardization is key to achieving economies of scale. This scalability and standardization requirement applies to all components of RFID delivery:

1. Hardware
2. Software
3. Professional Services

Both, hardware and software will have to be commoditized before large-scale rollouts throughout value networks, i.e. 1,000s of RFID reading locations, will become economically viable. Vendors must understand that current architectures, products and solutions will have to become simpler and cheaper before RFID will proliferate. The industry consortium created by major retailers Carrefour, Metro and Tesco and the chip company Intel gives an indication for the need of accelerated standardization and commoditization.

In the emerging more commoditized RFID world, professional services will be required not for integration of software systems but for value-added business services directly related to the specific business.

## **5. Conclusions**

While the market for RFID-based services in logistics and IT will grow substantially in the years to come, companies will be reluctant to commit significant resources upfront. Companies have to find out what is in it for them before investments will be made. They will therefore try to source basic capabilities of their RFID services and only build what really differentiates their services in the perception of their customers.

This sourcing strategy will be adopted throughout the different phases of RFID projects:

- Design and build
- Pilot
- Rollout
- Operation and Maintenance.

By leveraging existing RFID services and capabilities, companies will be in a position to reap benefits from economies of scale and achieve decreasing incremental cost as soon as the market takes off.

A major example for this delivery model is a managed service. Managed services providers, e.g. logistics companies or telecom providers like British Telecom, will offer basic RFID services such as tracking and tracing for their customers. Customer-specific extensions will complement reusable basic capabilities and result into customer-specific solutions at minimum cost. Providers of the basic capabilities (hardware and software) will tackle issues such as adoption of the newest standards, integration with ERP and other legacy systems and support of existing technologies, such as barcode. This way, all applications deployed on such a managed service will be up-to-date as only the lower level layers need to be updated or upgraded in case standards change. Also, leveraging operational RFID capabilities throughout entire value networks is best being achieved through a managed service with standardized operations.

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