Building
Tomorrow's Enterprise

View Point

Infosys®

Impact of RFID/EPC-based Information Visibility

A quantitative analysis and technology architecture vision

Omer Farooque

Abstract

The 'disruptive' Radio Frequency Identification (RFID) technology can significantly impact the information infrastructure of trading partners – retailers as well as suppliers. Leading analyst firms including AMR, Forrester and Gartner believe this impact could be the weak spot of any RFID implementation. Quantifying and managing it are aspects that remain unaddressed.

With large retailers adopting RFID, there has been a knee-jerk response from consumer packaged goods (CPG) manufacturers under pressure to comply. However, there is immense value to be derived from RFID through timely sharing of accurate information between trading partners.

This Infosys paper provides insights into how this value can be realized by understanding the nature of RFID information, sharing and quantifying its impact.

Nov 2006

Distribution Center Operations

Information sharing between suppliers and retailers based on Radio Frequency Identification/Electronic Product Code (RFID/EPC) technology introduces significant cost and time efficiencies in the execution of critical programs. The path to harvesting the benefits associated with this technology is, however, mined with challenges.

To understand these challenges, it is important to consider the processes and infrastructure involved in a typical distribution center (DC) both pre-and post-RFID deployment. A DC could be a warehouse or a specialized building with refrigeration or air-conditioning supplied with goods by air, road, rail or ship. The goods are then re-distributed from the DC to retailers or wholesalers.

The key functions of a distribution center considered for the purpose of this analysis are:

- Receive product (in the form of cases and pallets)
- inventory product
- Ship product

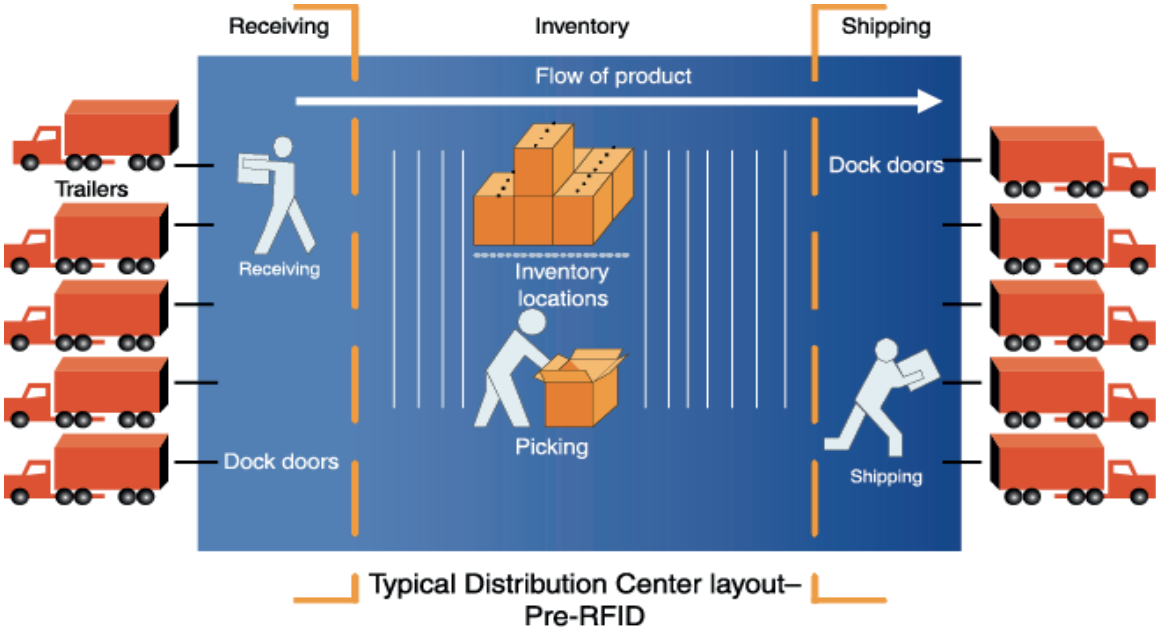

Fig 1.0 - Pre-RFID DC layout

As a quantitative basis for this analysis, the following assumptions take a typical Distribution Center serving 350 stores as the reference.

Process-related assumptions

- Cases, pallets and items are the operative units of work
- The product moves from receiving to inventory and then to the shipping area. Specifically:
  - Receivers unload the product from supplier trailers against a Purchase Order (PO) or Advanced Shipping Notice (ASN) through one of the receiving dock doors
  - It is then taken to the inventory area to replenish depleted inventory slots
  - The product is picked by selectors against a pick list for an outbound shipment
- Periodic audits ensure inventory accuracy. This may result in adjustments to or reconciliation of the inventory available on the warehouse management system (WMS) or the physical quantity available
- The product is identified by barcodes and human readable information labeled on cases and pallets

Infrastructure-related assumptions

- 50,000 cases of the product move through this DC each day
- The DC operates in two 8-hour shifts (not accounting for peak season)
- There are 20 active dock doors each for receiving and shipping
- This DC supplies the product to 300 stores with 2 or 3 deliveries per week

Changes Required for RFID

Several process and infrastructure-related changes are required to handle RFID tagged products (cases and pallets). (See fig. 2.0)

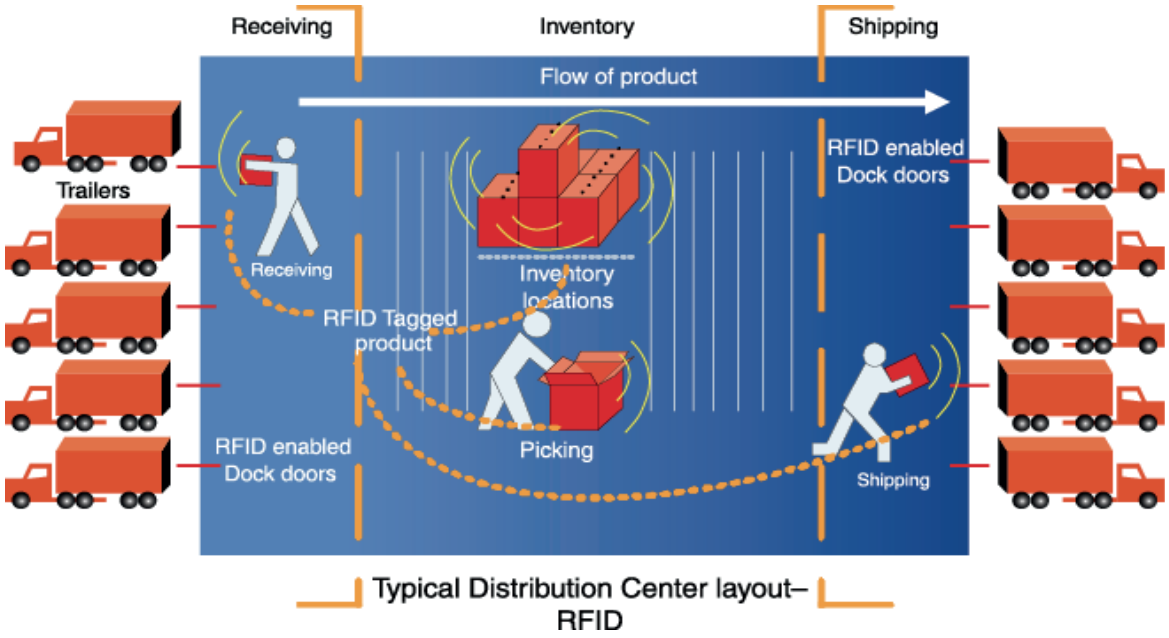

Fig. 2.0 - Distribution center layout post-RFID

Process-related changes

- Product identification via RFID tags eliminates the need for line of sight visibility of cases and pallets
- Product identification is stored on the RFID tag as serialized GTIN or serialized SCC
- Receiving, inventory and shipping are RFID-enabled

Infrastructure-related changes

- Product cases and pallets are RFID tagged using UHF EPC Class 1 compliant RFID tags
- The active receiving and shipping dock doors have RFID readers with antennae

Physical changes

- Cartons and pallets are RFID tagged and carry the EPC equivalent of the product identification information (SGTIN & SSCC). This identification information could be serialized.
- All 40 dock doors are equipped with RFID readers and antennae to capture data at receiving and shipping nodes.
- 10 portable readers are used during inventory and picking operations to accurately update inventory

Impact of RFID data

The Infosys RFID EPC Event Information Model

The nature of information available from an RFID-enabled process is fundamentally different from that of traditional processes. Infosys has developed an RFID EPC event information model to articulate the nature of information and its relevance. Based on Infosys' experience across industry verticals, this model defines three levels for events that retailers can exchange with their suppliers. These are:

- Level 1 Events or logical RFID Events – The result of basic filtering and elimination of noise
- Level 2 Events or RFID Business Events – Business/application context-based event processing at the edge. These events are essentially refinements of Level 1 events
- Level 3 Events or Business Transactions – The result of execution of business processes by enterprise applications like WMS. These events essentially aggregate Level 2 events with business context enrichment as per the consuming application

To illustrate how the RFID EPC Event Information model works, it is applied to the RFID-enabled DC scenario discussed above. Fig. 3.0 illustrates a situation where RFID readers are directly linked to the WMS.

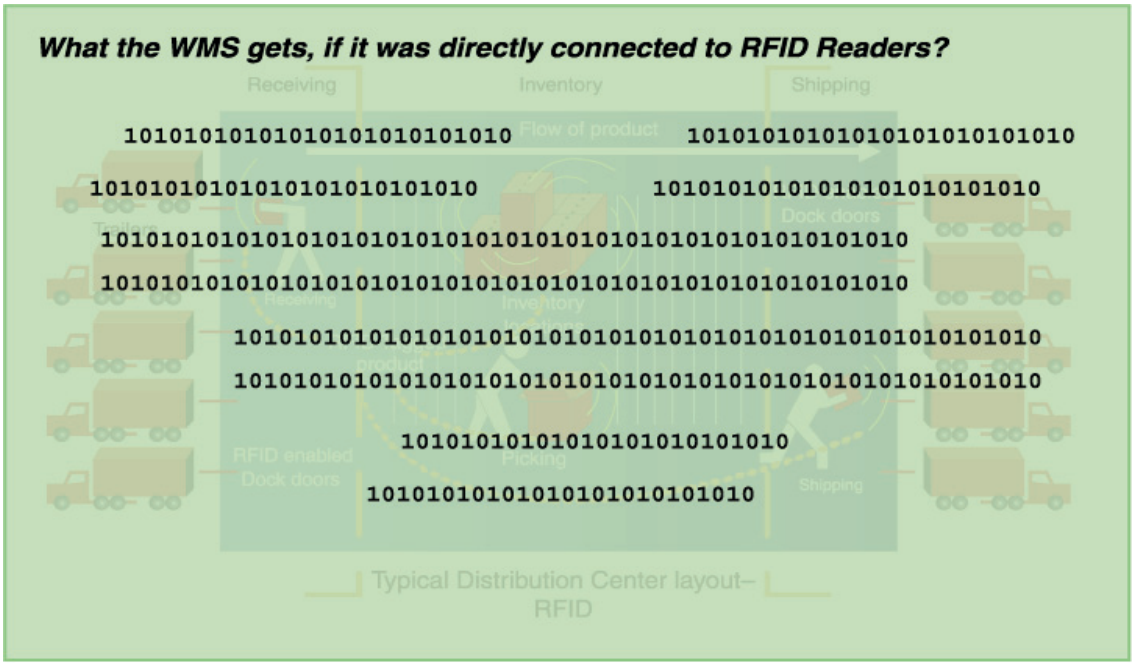

Fig. 3.0 - Number jumble: When RFID talks to WMS without middleware

The incoherent bits of binary data above represent RFID read events sent by RFID readers to the WMS. Clearly the level of abstraction at the event generators doesn't match with what the WMS expects. This calls for RFID middle ware to act as an information broker between the event generating devices and consumers like WMS (See fig. 4.0).

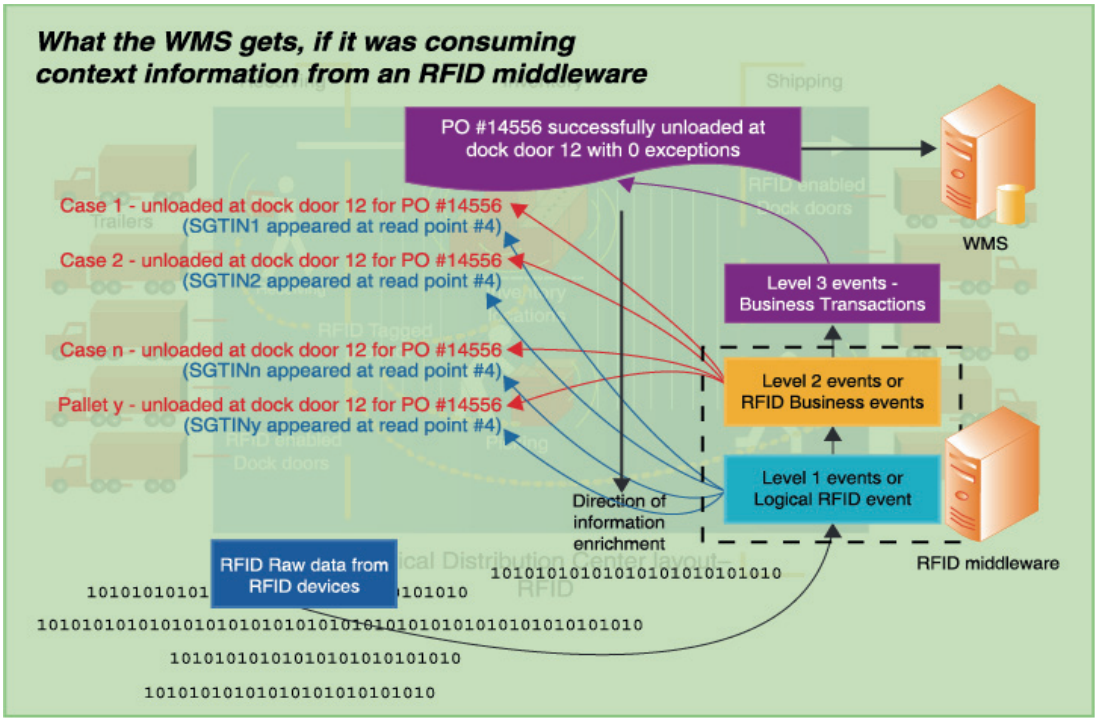

Fig. 4.0 - Middleware facilitates information clarity

While Level 1 and Level 2 events are processed real time in the RFID middle ware locally in the DC (edge), Level 3 events may occur locally or centrally at the enterprise level depending on where the consuming application is located.

Volume

To quantify the volume impact of RFID on enterprise information systems, Infosys has developed a calculator based on its experience with RFID and non-RFID projects. While it helps quantify the volume impact in the following scenarios (please see appendix for details), the calculator works in a variety of scenarios and KPIs specific to a CPG supplier or retailer:

#	Scenario	Description
1	Retailer – Single DC	Assess volume impact due to RFID on a single RFID-enabled DC of a retailer
2	Retailer – All DCs	Assess volume impact due to RFID on all DCs of a retailer
3	CPG supplier – All DCs to all DCs of a retailer	Assess volume impact due to RFID/EPC based supply chain visibility data received by a CPG supplier from one of his top 5 retail customers.
4	CPG supplier – All DCs to all DCs of top 5 retailers	Assess volume impact due to RFID based supply chain visibility data received by a CPG supplier from his top 5 retail customers.

Findings from the analysis

The table below summarizes the number of events and total size per event level:

Scenarios — Number of events	Level 1	Level 2	Level 3
1- Retailer single DC	420,000	385,000	52,500
2- Retailer all DCs	10,500,000	9,625,000	1,312,500
Retailer single store	4,800	4,800	550
Retailer all stores	4,800,000	4,800,000	550,000
Supplier - single DC	384,000	377,000	44,111
3 -Supplier - all DCs to a retailer (all DCs)	11,700,439	15,625,000	1,984,722
4 -Supplier - all DCs to top 5 retailers	58,502,197	78,125,000	9,923,611

Scenarios — Total MB occupied	Level 1	Level 2	Level 3
1 - Retailer single DC	38	70	20,764
Retailer all DCs	961	2	519,104
Retailer single store	0	1	15
Retailer all stores	439	879	15,400
Supplier - single DC	35	69	5,094
3 -Supplier - all DCs to a retailer (all DCs)	1,071	2,861	537,926
4 - Supplier - all DCs to top 5 retailers	5,356	14,305	2,689,631

The key findings that emerge from the scenarios:

- Level 1 and Level 2 events didn't exist pre-RFID and hence there is no benchmark data for comparison.
- The transaction volumes and throughput remains the same in the scenarios described. This may not be true - both will probably increase with an RFID implementation.
- Level 3 events will be serialized in the post-RFID scenario. This means the same business transactions compared to the pre-RFID scenario may account for each tagged product uniquely.

For L3 events there is a 105% - 369% increase over the current number of business transactions, but more importantly there is a staggering 422% - 437% increase in the size of each transaction. This is due to:

- Serialization
- Additions due to exceptions/alerts
- Context-specific transactions (locations, use cases, etc.)

To put this into perspective, where the WMS had about 5GB of data per day for 50,000 cases – now it would have about 20GB of data per day for the same number of cases for one DC. The situation is far more challenging for the CPG supplier who is expected to leverage the data sent by retail trading partners. Before a supplier can make any decisions on this data, it needs to be formatted as per the enterprise information system requirements. Fig. 5.0 is a graphical comparison of the volume of data currently being handled by retailers and suppliers, vis-à-vis RFID-enabled scenarios.

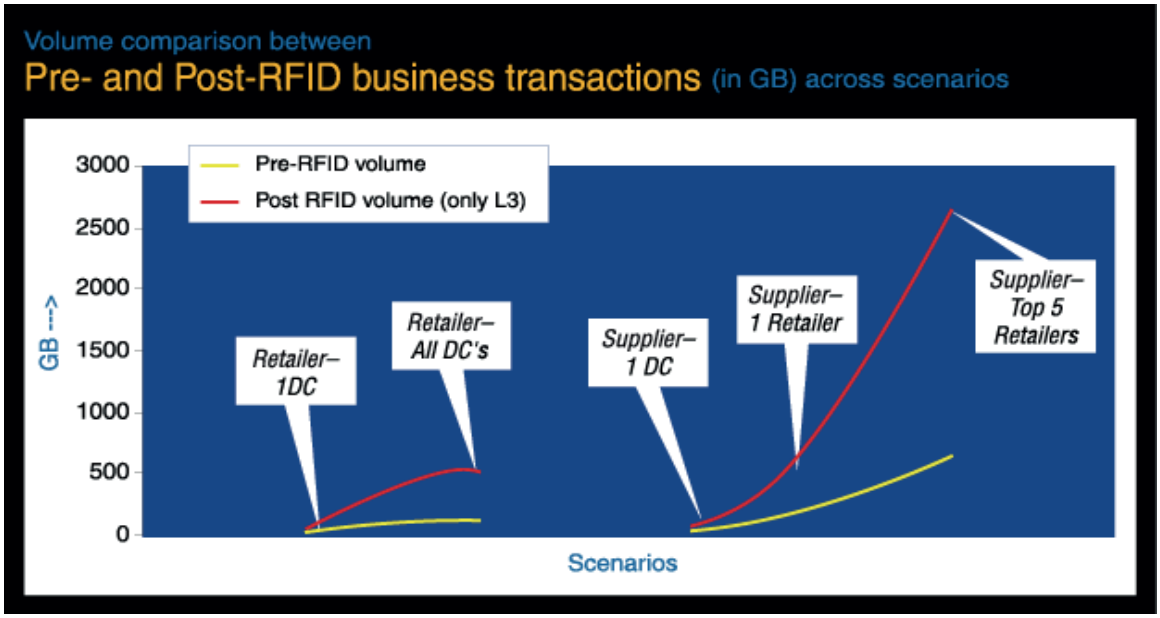

Fig. 5.0: Volume of data: Pre- and post-RFID implementation

Data Throughput

The following aspects are significant from a data throughput perspective:

- The nature of events at Level 1 and Level 2 is transactional and without the context of time has no value.
- The nature of Level 3 events as described in the previous section now has serialized product information
- The rate at which events are generated is now aligned to their process specific operations, i.e., in near real time.
- The value of being able to make decisions based on these events is highest at the point of occurrence. Consequently, the ROI derived out of an RFID implementation is directly proportional to the agility of the enterprise.

The existing systems and infrastructure of both retailers and CPG suppliers may not be geared to handle such high volume data throughput. Further, the CPG supplier must first channel the data to his enterprise in a timely manner, harmonize it and then make decisions based on it.

Information Management

Serialization, existence of lower level near real time data, the need for near real time decision making, and the overall increase in the sheer volume of information being handled by the enterprise – all emphasize the need for information management. The following are the key components of effective information management:

- Product serialization policy
- Event management
- Capacity management
- Network and CPU management
- Rules orchestration and management

The next section reviews existing technologies that can be leveraged, the technology capabilities essential and the Infosys Framework for RFID EPC information visibility and sharing.

Technology Architecture Future State Vision

The Infosys Framework for RFID EPC information visibility and sharing enables understanding of the impact and development of a viable future state. In the context of this DC scenario, it articulates the current state, identifies the missing links and depicts the future state technology architecture.

Pre-RFID Information and Systems Landscape of a Distribution Center

A DC from the perspective of physical objects comprises of barcode scanners, data terminals, desktops, printers, cartons, and pallets with inventory locations labeled using barcode labels.

From an operational perspective, information is gathered or generated manually by entering it into a system (like WMS) or by scanning a barcode label. Data gathering can also be automated using barcode portals, label applicators, etc. (Fig. 6.0)

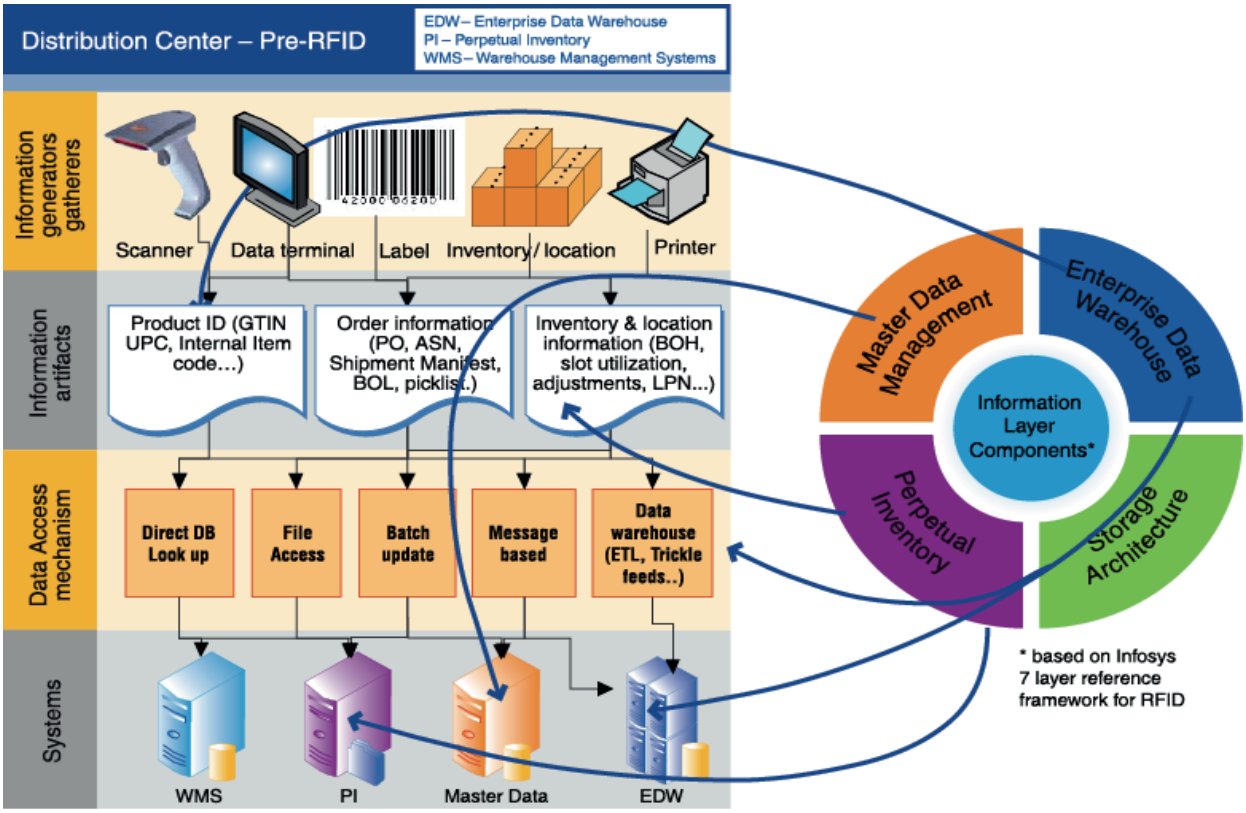

Fig. 6.0 - Existing systems landscape of a typical DC and information layer components

Information Layer Components

The key information layer components in the pre-RFID scenario are (Fig. 6.0):

1. Master Data Management – Owner of all product, location, and supplier information with the ability to manage their respective life cycles. WMS, PI & EDW all reference master data from here.
2. Perpetual Inventory (PI) - Inventory balance that is automatically updated at any point of time. Organizations typically maintain PI for actual visibility into their inventory data levels.
3. Enterprise Data Warehouse (EDW) – A collection of data that can be defined and shared across the whole enterprise along common dimensions for analysis. From a DC perspective this data warehouse stores information on purchase orders, inventory levels, adjustments, shipments, etc.
4. Storage Architecture – Addresses storage needs at the Distribution Center locally, and centrally at the organization level. The storage needs of the WMS, PI, EDW and Master Data are addressed by the storage architecture. Storage can range from RAID disk configurations and serial storage architecture to SAN.

RFID Information and Systems Landscape

The varying levels of abstraction described in the Infosys RFID EPC Event Information Model have potential visibility-based applications that can be harnessed. Connecting the existing WMS systems directly to the RFID devices will not work as the information is not at the level of abstraction required by the WMS. Key functions and capabilities of the RFID-enabled DC include:

- Context – Where did the event occur? Was it because of unloading trailer 123 at dock door 12 or because of picking at inventory slot location AB1234? Does 111001010101011 mean case or pallet and of what GTIN/SCC/UPC/LPN?
- Filtering – As opposed to scanning the barcode label until you get a good scan, it is important to separate redundant repeats from valid events. When should a new read for the same tag be sent?
- Aggregation and association – Which cases are associated with which pallet? What PO is this associated with? Which pick list is this for?
- Ability to take action on exceptions, generate alerts in real time – As events are no longer user initiated, they are triggered by response to a network of things. The event occurs for what is taking place physically at that place and time. For example, pallets with 40 cases are being unloaded from a trailer at 12:10 pm from dock door 12. If only 39 cases were counted, then a red light flashes or an alert is sent. In the barcode scenario, such exceptions can be captured only post facto.

RFID Information Layer Components

RFID-enabled DCs need new information layer components such as:

- RFID middleware for event acquisitions, filtering and forwarding between consuming applications and event generators (RFID readers, printers tags, motion sensors, light stacks)
- Hierarchical approach to realizing information that makes sense for consumer applications like the WMS, EDW, etc.
- Real time event repositories – To keep the “what”, “where”, “when” and “why” an event occurred
- Real time agents – To analyze events in real time and generate actionable alerts and exceptions
- Device configuration and management – To manage and monitor the myriad devices enabling the DC to operate effectively

Fig. 7.0 shows the RFID-enabled information and systems landscape using the Infosys Framework for RFID EPC information visibility and sharing.

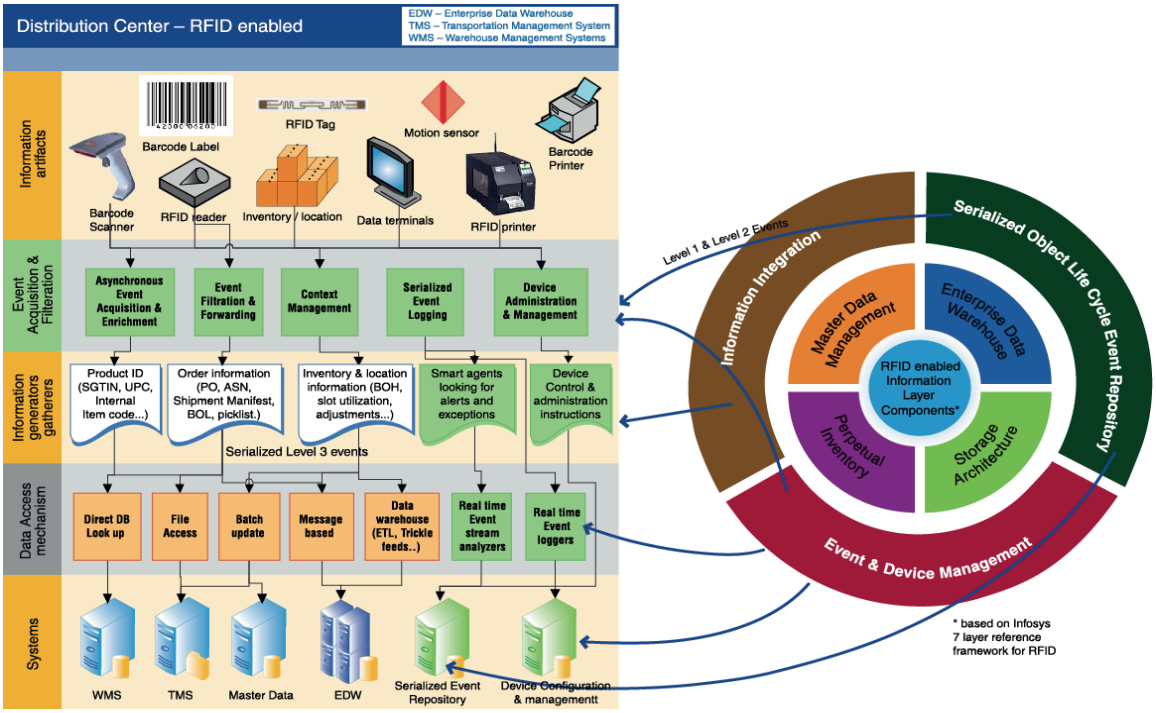

Fig. 7.0: RFID-enabled DC information and systems landscape

As the figure shows, new dimensions are added to the information layer to ease the transition for existing systems and achieve agility in operations or real time interactivity.

Existing systems are incapable of handling such activity. Enterprises that attempt to reengineer or force fit current systems to consume RFID data and control devices risk incurring excessive capital costs in addition to high maintenance overheads.

Limitations of Current Architecture and "Must Have new Capabilities

In order to leverage existing systems and infrastructure effectively, certain capabilities are essential for the RFID environment. These capabilities must be driven by a robust information architecture strategy.

Limitations of Existing Architecture

- Can understand only Level 3 events
- Cannot handle real time interactivity or multimodal interactivity
- Cannot handle serialized product identification, except in case of LPNs
- Lack of real time data repository between information generation and information consumption leads to lack of resolution

New Capabilities

- Serialized object life cycle event repository
- Event management
- Device control and administration
- Real time agents to identify and log exceptions or alerts

Conclusion

Infosys recommends that retailers as well as CPG manufacturers develop a strategic road map and future state vision for RFID-enabled operations. Understanding the challenges involved in RFID information sharing and the quantum of the impact on the data infrastructure will be critical to a successful implementation.

About the Author

Orner Farooque is a Technical Architect with the Retail Architecture Group, the technology arm of Infosys' Retail practice. With 7 years' software architecture and technology consulting experience in the Retail and Insurance verticals, he is currently the Lead RFID architect with the Infosys RFID Solutions team in Plano, Texas. Omer is an electronics and telecommunications engineer from Madras University, India.

APPENDIX I

Scenario 1: Retailer - Single DC (Majority of products flowing through are RFID-tagged)

Pre-RFID (all figures are per day)

Case Throughput = 50,000

Amount of data on WMS because of of this = 4.8GB

Post RFID (all figures are per day)

Sub location	# of Read Points	Level 1 Events	in GB	Level 2 Events	in GB	Level 3 Events	in GB
Receiving	2	120,000	0.0107	110,000	0.0197	17500	6.7592
Inventory	3	180,000	0.0161	165,000	0.0295	17500	6.7592
Shipping	2	120,000	0.0107	110,000	0.0197	17500	6.7592
Total	7	420,000	0.0376	385,000	0.0688	52500	20.2775
% Increase		NA	NA	NA	NA	105	422

NA - Not applicable

Total size of L1 & L2 events combined = 106.4 MB

Scenario 2: Retailer – All DCs (Majority of products flowing through are RFID-tagged)

Pre-RFID (all figures are per day)

Case Throughput / DC= 50,000

# of DC's and warehouses =25

Amount of data on WMS because of this / DC = 4.8GB

Post RFID (all figures are per day)

Sub location	# of Read Points	Level 1 Events	in GB	Level 2 Events	in GB	Level 3 Events	in GB
Per DC	7	420,000	0.0376	385,000	0.0688	52,500	20.2775
Total for 25	175	10,500,000	0.94	9,625,000	1.72	1,312,500	506.94
% Increase		NA	NA	NA	NA	105	422

Scenario 3: CPG supplier – All DCs to all DCs of a retailer (assumes retailer shares his supply chain data via an EPC-IS framework)

Pre-RFID (all figures are per day)

Supplier DC

Case Throughput across 10 DC's = 50,000 cases

Amount of data on WMS because of this = 4.8 GB or 4915.2 MB

Retailers DC's

Case throughput across 25 DC's= 1250000 cases

Amount of data on WMS because of this = 120 GB or 122880 MB

Store

Cases Received / day= 500 cases

Total data on store inventory system = 700 MB

Total data on store inventory system due to cases recv per day = 3.5 MB

Data on store inventory systems due to cases rcv / day for 1000 stores= 3500 MB

Post RFID (all figures are per day)

Location	Sub location	# of Read Points	Level 1 Events	in MB	Level 2 Events	in MB	Level 3 Events	in MB
25 Retailer DC's*	All	175	10,500,000	961.30	9,625,000	1,762.39	1312500	519,104.00
1000 Stores**	All recv ops	8000	439	0.04	4,800,000	878.91	550000	15,400.00
1000 Stores**	Customer Service	1000	600,000	54.93	600,000	109.86	61111	1,711.11
1000 Stores**	Disposal	1000	600,000	54.93	600,000	109.86	61111	1,711.11
Total across 10 DC's		10175	11700439	1071.207	15625000	2861.02	1984722.22	537926.23
% Increase			NA	NA	NA	NA	113	426

NA - Not applicable

Level 1 & 2 events are observational EPC-IS events

Level 3 events are business transaction EPC IS events

Total size of L1 & L2 events combined = 3,932.23 MB/day

* - Number of events account for Receiving, Inventory and Shipping in each DC of the retailer

** - Numberof events account for all receiving, customer service and disposal operations at the retail store

Scenario 4: CPG supplier – All DCs to all DCs of top 5 retailers (assumes retailer shares his supply chain data via an EPC-IS framework)

Pre-RFID (all figures are per day)

per retailer

Total supply chain transactions per retailer = 537926.23

Total supply chain transactions for 5 retailers = 2689631.13

Total supply chain visibility data volume = 126380 MB

Amount of data due to 5 such retailers = 631900 MB

Post RFID (all figures are per day)

Location	Sub location	# of Read Points	Level 1 Events	in MB	Level 2 Events	in MB	Level 3 Events	in MB
per retailer	All through SC	5014	384,000	1071.21	15625000.00	2861.02	1984722.22	537926.23
Total(for 5)		25070	1920000	5356.04	78125000	14305.11	9923611.111	2689631.13
% Increase			NA	NA	NA	NA	369	426

NA - Not applicable

Level 1 & 2 events are observational EPC-IS events

Level 3 events are business transaction EPC IS events

Total size of L1 & L2 events combined = 19,661.15 MB/day

* - Number of events account for Receiving, Inventory and Shipping in each DC of the retailer

** - Numberof events account for all receiving, customer service and disposal operations at the retail store