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Transitioning to a Modular Enterprise Architecture: Drivers, Constraints, and Actions

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Transitioning to a Modular Enterprise Architecture: Drivers, Constraints, and Actions[1]

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Executive Summary

Best practice suggests that a modular enterprise architecture, where interfaces between and among business processes and services are standardized, is a key IT capability for firms to achieve profitable growth. But few firms have successfully designed, implemented, and maintained such an architecture. This article presents findings on the drivers, constraints, and actions taken by two companies that transitioned to a modular enterprise architecture in response to competitive pressures from their business partners or customers. One company implemented an industry standard and the other developed custom partner interface processes (PIPs) to achieve business modularity. The lessons from these two case studies show how companies can smoothly transition to a modular enterprise architecture.

THE INCREASING NEED FOR A MODULAR ENTERPRISE ARCHITECTURE

At most companies, IT support for business processes has been cobbled together in a series of unrelated IT projects. Some projects build application silos; others link them together. The result is a highly inflexible IT architecture. Most IT and business executives agree that a more modular architecture—where IT-enabled business processes are plug-and-play components that can be used to meet changing business demands—provides far more capability for companies to grow rapidly and profitably. But inflexible legacy systems and processes are impeding progress in building modular IT and business capabilities. Firms wanting to move toward a modular enterprise architecture face a multi-year evolutionary process.[2] Building modular capabilities is a gradual process and is often slowed down by the tendency to invest in immediate business needs rather than long-term capabilities. As a consequence, few companies have achieved a modular IT and business environment.

In the meantime, the need for modular capabilities has been increasing. While many architecture efforts focused initially on leveraging a firm's internal resources, many companies today are focusing on expanding their vertical and horizontal partnerships and extending operations globally. Thus it is important to understand how a modular enterprise architecture can enable firms to leverage resources across supply chains and distribution channels.

Two major technological innovations are helping firms to interface flexibly with partners:

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1 Jeanne Ross is the accepting Senior Editor for this article.

2 See Ross, J. W., Weill, P., and Robertson, D. C. *Enterprise Architecture as Strategy: Creating a Foundation for Business Execution,* Harvard Business School Press, 2006, for a description of the stages that most companies go through as they work toward more modular architectures.

Figure 1: Two Companies Moving to a Modular Enterprise Architecture		
	Delivery Corp.	**Electronics Corp.**
Industry Positioning	Integrated logistics solution provider	Electronics component manufacturer
Company Size	Large	Medium
Process Standards	Negotiated and proprietary	Public
Key Challenge	Loose coupling among services offered to customers	Loose coupling with suppliers and customers

1. Process standards in vertical industries
2. Service-oriented architecture (SOA) technologies, which have created the tools for building modularity. In an SOA, functionality is encapsulated,[3] and standardized interfaces and service levels are exposed.[4]

This article describes the experiences of two companies as they transitioned to a modular enterprise architecture (Appendix A describes our research methodology). We have been studying these companies for several years, and we describe their major drivers for a modular architecture, the key constraints faced, and the actions taken to overcome the constraints.

The first company, which we call Delivery Corp., provides supply chain services and is a large subsidiary of one of the global leaders in logistics and transportation. Its revenues in 2006 were about $10 billion. The markets for its diversified offerings are turbulent, and it faces significant and growing competition. As well as establishing a platform of standardized technology and optimized business processes, Delivery Corp. has been developing proprietary standards to integrate services across business units and with the business processes of customers. Delivery Corp. intends to establish standardized interfaces across complementary services so as to achieve profitable growth.

The second company, which we call Electronics Corp., is a small-to-medium enterprise, with low product diversification. It has transitioned to a modular enterprise architecture by adopting RosettaNet's industry standards for electronic business-to-business integration. This enterprise architecture enables loose coupling with suppliers and customers, and balances efficiency and flexibility in extended enterprise processes.

These and other contextual differences between the two firms provide rich contrasts for identifying practical guidelines for transitioning to a modular enterprise architecture (see Figure 1). Delivery Corp. is standardizing interfaces among its complementary services, while Electronics Corp. is using industry-established interfaces to coordinate with its suppliers and customers. In the next sections, we present the cases of these two companies, discuss their journey toward business modularity, the constraints they encountered in this journey, and actions they took to address these constraints. We conclude with a discussion of lessons learned from the two cases.

CASE 1: DELIVERY CORP.

Delivery Corp. was established in the early 1990s as a subsidiary of a global logistics and transportation leader in response to rapidly growing demand for supply chain solutions. Its parent company is positioned in a mature market for transportation solutions and has a strong culture rooted in six-sigma capabilities for continuous improvement. In contrast, Delivery Corp. is positioned to operate in an innovative market for supply chain solutions, where assumptions of homogeneous customer requirements are invalid.

In addition to core offerings, such as freight-forwarding and customs brokerage, Delivery Corp. has pursued a differentiation strategy by developing a wide variety of specialty services, such as service parts logistics, technical repair and configuration, and supply chain design and planning.

Delivery Corp. has grown rapidly in the past 15 years by following a strategy of aggressively acquiring specialized logistics firms. Although adding to the overall portfolio of offerings, the early acquisitions resulted in disparate business units that deployed

3 Encapsulation is a principle of information systems development that allows developers to hide the actual implementation (and associated design decisions) of procedural logic behind a standardized interface. This interface is made available to clients (e.g., other systems or interfaces) that need to access and use the procedural logic to perform a function.

4 See Hirschheim, R., Welke, R., and Schwarz, A. "Service-Oriented Architecture: Myths, Realities, and a Maturity Model," *MIS Quarterly Executive* (9:1), 2010, pp. 37-48.

IT for local improvements and did not coordinate IT investments. Moreover, in the formative acquisition years, there were no IT standards to integrate technology "islands."

In the 1990s, Delivery Corp. attempted to alleviate the high costs and risks of its technology islands with initiatives that defined shared data, platforms and resources, and integrated applications through protocol interfaces. These initiatives helped the firm improve its cost structures by enabling the integration of applications and processes. As Delivery Corp.'s CIO explained, "We built standards; we built enterprise hardware standards, software standards, architecture standards, security standards, and implementation standards." IT management also established significant discipline to measure costs for IT projects to assess return on investment.

In 2002–2003, Delivery Corp. moved to optimize its core business processes. Around this time, in an effort to streamline processes across business units, the firm established an enterprise view of data and applications. This view was a consequence of a major shift in IT strategy, away from improving local applications continuously to developing a shared infrastructure.

One example of a shared capability was the creation of an enterprise data warehouse that extracted data from previously disparate transaction systems used by the business units. By aggregating data from different business units into a central repository, managers were able to obtain a comprehensive view of the entire breadth of services Delivery Corp. was providing to its customers. The shared capabilities helped the firm show "one face" to its customers. They also allowed sales managers to delve into a particular customer account to see how revenues related to service offerings, geographic territories, sales personnel, and other previously segregated entities.

During this time, integrated processes for customer relationships, sales management, and IT management were also established.

Drivers of a Modular Enterprise Architecture

Although data standardization and application rationalization improved operational efficiencies, Delivery Corp. continued to evaluate an alternate operating model that would allow it to meet differentiated customer needs more profitably. As the COO of Delivery Corp. explained, "Our goal is to combine standardized services efficiently for customers so that they perceive the solution as customized."

To pursue growth in the competitive supply chain outsourcing industry, Delivery Corp. had to service customers that required a complex portfolio of differentiated solutions. These customers were not profitable for Delivery Corp. as meeting their requirements required significant IT customization. The process of integrating services across business units to meet customer requirements too often resulted in one-off initiatives with long lead times and high costs. It was taking between 8 and 12 months to integrate the processes required to deliver customized solutions, which harmed customer satisfaction, pushed up costs, and constrained growth. To address these performance issues, Delivery Corp. decided to standardize interfaces and develop "plug-and-play" capabilities for services offered to customers.

Developing a modular enterprise architecture became especially important for three reasons. First, standardized interfaces would help Delivery Corp. leverage its heterogeneous IT environment that comprised many interrelated applications for services—such as brokerage, freight-forwarding, and warehousing—that together support an end-to-end supply chain solution. These applications were patched together with application program interfaces (APIs) that enabled data to flow between them. Second, the standardized interfaces and plug-and-play capabilities would help Delivery Corp. develop efficient collaborative relationships with customers because it would not have to customize the integration of processes to meet their requirements. Finally, a modular enterprise architecture would help Delivery Corp. thrive in a highly competitive business environment where low-cost competitors pose significant challenges.

Constraints Encountered

We identified four key challenges faced by Delivery Corp. in transitioning to a modular enterprise architecture: non-modular business services, incompatible process interfaces, limited executive knowledge, and short-term decision criteria for IT investment.

1. Non-Modular Business Services. Delivery Corp.'s portfolio of capabilities has evolved through organic growth and external acquisitions, which made the development of a robust and agile enterprise architecture especially challenging. The firm faced

significant challenges as each acquired company, and in many cases individual functional units within that company, had legacy systems, including ERP systems. Because Delivery Corp. grew so rapidly and had disparate IT systems that lacked standardized interfaces, developing enterprise solutions that pooled services across business units proved particularly challenging.

2. Incompatible Process Interfaces. In an effort to be responsive to customers in the early years of its evolution, Delivery Corp. spent large amounts of money integrating customer processes with its core operations. As interfaces for services were ill-defined, customers asked for unique APIs to integrate processes and exchange data. For example, they requested customized interfaces for advanced shipping notification or tracking the movement of goods across the supply chain. This IT customization pushed up costs and hampered the economies of scale needed for profitability.

3. Limited Executive Knowledge of Enterprise Architecture. Some of Delivery Corp.'s senior executives had previously spent several years at the parent company, which operates in a different environment than Delivery Corp. As a consequence, these executives have a limited understanding of the role of enterprise architecture and do not appreciate its potential to standardize interfaces and dynamically integrate processes.

4. Short-Term Decision Criteria for IT Investment. Net Present Value (NPV) techniques were used to evaluate IT investment proposals and to prioritize projects. Given this short-term focus, projects that contribute to and enhance long-term architecture capabilities received short shrift. For example, initial proposals to invest in encapsulating business services and standardizing their interfaces were not given the go-ahead, because they could not be justified in terms of generating revenue from meeting a current customer's solution needs.

Actions Taken to Overcome the Constraints

Delivery Corp. undertook six major initiatives to overcome the constraints and transition to a modular enterprise architecture.

1. Developing a Standardized Operating Model. Delivery Corp. is transitioning from a multidivisional model, where there was no coordination among services, to a standardized operating model, where the portfolio of services is being centrally defined and interfaces standardized. In the process, the firm's managers are developing a shared understanding about complementarities of services and why the lack of standardized interfaces is inhibiting profitable growth.

2. Developing Partner Interface Processes. Delivery Corp. is promoting the development of partner interface processes (PIPs) for high-volume services (see Figure 2). PIPs are self-contained process specifications that offer a loosely coupled architecture with standardized interfaces while enabling local differences. In fact, PIPs are designed to make business units agile by standardizing interfaces that encapsulate trading partners' core data and business processes.

Figure 2: Partner Interface Processes

- Create a loosely coupled architecture that enhances the interoperability of services and business.
- Specify activities, decisions, and roles for each partner in a B2B activity.
- Standardize interfaces and encapsulate data and processes.

Delivery Corp. is taking steps to accelerate the adoption of PIPs by key stakeholders, including customers. The high-volume services targeted include advanced shipping notification, in-transit visibility, customs clearance, and warehouse activities. To learn about best practices and influence the industry-wide development of PIPs, Delivery Corp. is participating in standard-setting boards for logistics and transportation and for vertical industries, such as the RosettaNet consortium,[5] which develops industry-wide, open business process standards for supply chain collaboration in the high-tech industry. By investing in and influencing the development of PIPs, Delivery Corp. is standardizing interfaces and reducing complexity not only among its internal routine processes, but those of its customers too.

3. Encapsulating Business Services. Delivery Corp. has been encapsulating services from legacy applications by reengineering those applications using the principles of component-based architectures. According to the firm's CIO, "We're getting to components. We have a subsystem that handles brokerage, we have a subsystem that handles forwarding, and we have a subsystem that handles

5 For more information about RosettaNet, see www.rosettanet.org.

warehousing. … What we're now doing is taking those core applications and putting APIs or other data flows out of them so you can actually build a workflow around those components." These interfaces are being standardized, making it easier to maintain loose coupling among services so that they can be combined efficiently. Such a plug-and-play capability helps Delivery Corp. combine service offerings and be versatile in service delivery.

4. Deploying Cross-Functional Teams. Delivery Corp. is using cross-functional teams to improve coordination between marketing and sales, and IT. In the past, marketing and sales personnel sold a suite of supply chain services (e.g., shipping, brokerage, freight-forwarding, customs) without adequately factoring in the IT investments that would be required for their integration. This led to slow responsiveness and increased costs in the delivery of solutions. Moreover, by bringing IT personnel into the RFQ/solutions process at the front end of a customer engagement, the sales process is becoming more effective at promoting the proprietary standards that are supported by Delivery Corp. for its services. In addition, the IT personnel who interface with marketing and sales regularly provide IT architects with customer feedback on the standardized interfaces for services.

These initiatives are improving the standards and gradually reducing the specialized learning and costs required to interface with a customer's proprietary systems. According to Delivery Corp.'s CIO, "We're working with marketing to put some real tight definition around our service portfolio so that our standard offerings can encompass 85% of what we can do."

5. Modifying Decision Criteria for IT Investments. Delivery Corp. is modifying the decision criteria for IT investments projects to include how standardized interfaces, if developed, can reduce costs and improve the time needed to respond to customer needs in the future. Using the modified criteria, a project that does not appear profitable based on NPV analysis may still be authorized if it enhances the standardization of interfaces and creates significant options for future growth. In addition, the decision criteria would now recognize that a short cut with a good NPV, but which hinders the move to a modular architecture, may actually restrict future growth options.

6. Exploiting Best Practice Knowledge. Delivery Corp. participates in standard-setting organizations, such as RosettaNet and HL7 for healthcare,[6] not only to influence the evolution of public domain PIPs, but also to be informed about best practice. In addition, ongoing interactions with customers are a rich source of information on best practice. This learning informs Delivery Corp. on how to design proprietary PIPs and leverage them for business value.

Figure 3 summarizes the constraints encountered at Delivery Corp. in transitioning to a modular enterprise architecture and the actions taken to address them.

CASE 2: ELECTRONICS CORP.

Like Delivery Corp., Electronics Corp. operates in an innovative and highly competitive market. Electronics Corp. is a U.S.-based company that manufactures electronic components for computers and other electronic devices. Success in this dynamic environment depends on quick responses to customer demands and the ability to innovate. At the time of our initial contact with Electronics Corp., it had about 1,000 employees, and its annual sales revenue was under $1 billion. It had a fairly flat organizational structure with a majority of employees being engineers and designers.

Operating in the high-tech industry, Electronics Corp. has always been keen to deploy state-of-the-art IT solutions. In the late 1990s, the firm's executives adopted ERP systems and business process reengineering as these systems and techniques gained prominence. Electronics Corp.'s IT department, with the help of a major consulting firm, implemented an ERP system to support internal business functions, such as finance, marketing and sales, and human resources.

During the ERP implementation, the firm underwent a substantial process change initiative that helped it streamline several major business processes. The firm's executives referred to this process as "optimization" or "standardization" of internal processes. Senior executives who were responsible for product design and development processes took initiatives to standardize new product development and manufacturing processes. The ERP system also forced Electronics Corp. to standardize its data architecture.

Standardization of IT platforms and business processes helped Electronics Corp. improve operational efficiency and achieve the economies

6 For more information on the HL7 standards, see www.h17.org.

Figure 3: Summary of Constraints and Actions to Overcome Them at Delivery Corp.

Constraints	Actions
Non-modular Business Services	• Developing a standardized operating model to centrally define the portfolio of business services across business units.
Incompatible Process Interfaces	• Encapsulating business services by reengineering legacy applications using the principles of component-based architectures. • Developing proprietary PIPs to improve integration among services and across firm boundaries. • Deploying cross-functional teams to improve coordination between marketing and sales, and IT, especially with respect to promoting standardized interfaces.
Limited Executive Knowledge of Enterprise Architecture	• Generating shared understanding of the economic implications of PIPs in the process of developing the standardized operating model. • Deploying cross-functional teams to increase knowledge about relative costs of developing customized interfaces and deploying standards. • Exploiting best practices learned from process standards consortia and business partners.
Modified Decision Criteria for IT Investments	• Modifying IT investment decision criteria to consider future benefits from developing proprietary standards.

of scale that were essential to survive in a highly competitive industry.[7] These efforts prepared the firm for implementing modular systems and processes.

Drivers of a Modular Enterprise Architecture

While standardizing internal IT capabilities and business processes helped improve operational efficiency, top management realized that the current IT platform and business processes were not delivering much customer value. Firms in the highly competitive electronics component industry need to respond constantly to changes in the market. Further, interorganizational relationships are very important as businesses like Electronics Corp. depend on other firms (i.e., trading partners) for the design and development of key components. There are several dominant firms in this industry that compete intensely with each other. Non-dominant firms also face tremendous competition in developing relationships with dominant firms to gain market share.

Electronics Corp.'s senior executives realized that, while internal processes had peaked in efficiency, strategic external processes, such as those for order and supply chain management, were inefficient. To their surprise, senior executives found that the firm received customer orders via various communication modes—website, fax, e-mail, telephone, and a proprietary electronic data interchange (EDI) system. Moreover, the transactions were handled through an EDI system that was not fully integrated with the ERP system. Data received from customers were not compatible with the standardized data architecture that Electronics Corp. had created. As a result, employees had to manually enter the data into the ERP system. Electronics Corp. executives realized that manual data entry introduced errors in order management and other customer-focused processes, thus increasing response and cycle times.

Further, Electronics Corp. had to hold high inventory levels to ensure orders were filled. Several mid-level managers, who had more experience with trading partners' internal IT platforms and business processes, noted that the firm's IT platform and processes were not compatible with many of its partners' IT platforms and business processes.

The inefficiency of interorganizational processes and lack of responsiveness of the IT department to meet customer demands forced top management to seek solutions. During their quest, top management became aware of RosettaNet. An initial assessment report by

7 Ross and Beath note that to prepare for a modular architecture, companies adopt disciplined business processes, often implementing enterprise systems, such as ERP. See Ross, J. W. and Beath, C. M. "Sustainable IT Outsourcing Success: Let Enterprise Architecture be Your Guide," *MIS Quarterly Executive* (5:4), 2006, pp. 181-192.

Figure 4: The Two RosettaNet PIPs Initially Implemented by Electronics Corp.

PIP	Description
PIP 3A4: Request Purchase Order	Enables a buyer to issue a purchase order and obtain an immediate response from the supplier that acknowledges the status of the order (e.g., which purchase order product line items are accepted, rejected, or pending).
PIP 3B2: Notifying Advance Shipment	Allows a shipper to notify a receiver that a shipment has been assigned. This notification contains detailed product level information about a shipment (e.g., when a shipment is expected to arrive).

a senior executive suggested that implementation of RosettaNet's standardized business processes—i.e., partner interface processes (PIPs)—could solve many of the problems facing the firm. Top management decided to implement RosettaNet PIPs and integrate them with the ERP system and internal business processes to develop seamless interorganizational business processes (see Appendix B for an overview of RosettaNet PIPs[8]).

The vision of Electronics Corp.'s top management when it decided to implement RosettaNet PIPs was to be more responsive to customer and/or market needs and to become agile. While standardizing internal processes had optimized back-office processes, RosettaNet PIPs offered a unique opportunity to create a modular enterprise architecture.

RosettaNet PIPs provide a plug-and-play capability and/or interface that enable a firm to reuse processes across interorganizational relationships.[9] Electronics Corp. management decided initially to implement two PIPs related to order management processes (see Figure 4). Their implementation required substantial changes to Electronics Corp.'s overall order management process. Management was hoping that these two PIPs would help the firm eliminate redundant steps and inefficiencies from supply chain management processes.

After the successful deployment of these two PIPs, Electronics Corp. management decided that four additional RosettaNet PIPs[10] related to order management processes would be deployed. Together, these six PIPs would help the firm automate a substantial portion of its order management value chain. They would enable reusable process modules for Electronics Corp. that would provide capabilities for dynamic integration with trading partners.

Constraints Encountered

Electronics Corp. faced several constraints during and after the implementation of the first two PIPs.

1. Deficient PIP Specification. Although RosettaNet PIPs specify how organizations should exchange business documents (that contain data) and choreograph activities, they do not provide detailed guidance on how to integrate these process standards with internal IT platform and processes. Electronics Corp.'s IT department struggled to integrate the XML-based data formats generated by the PIPs with the internal data architecture. Consequently, it was difficult to process this data using the ERP system that the firm used for much of its internal processes. Moreover, Electronics Corp. was not able to find any reliable middleware solutions to resolve the integration problem.

2. Incompatible Process Interfaces. As noted earlier, Electronics Corp. optimized and standardized its internal business processes during the implementation of ERP. When implementing RosettaNet PIPs, the IT project team found that the process specifications suggested in the PIPs were, in many cases, not compatible with the firm's internal processes. This was a major setback, as the internal processes were configured to fit with the ERP system and to provide operational efficiency. Reconfiguring these processes to align with RosettaNet PIPs required substantial changes to the internal processes and ERP system.

3. Lack of IT and Business Process Expertise. Implementing RosettaNet PIPs is complex and resource intensive, requiring not only competent IT specialists, but also cross-functional business process experts. Furthermore, given that PIPs are standards for interorganizational processes, the implementation team needs members who have experience with and knowledge of trading partners' internal IT platforms and processes. While Electronics Corp.'s

8 More details on RosettaNet PIPs can be found at www.rosettanet.org.

9 See Gosain, S., Malhotra, A., El Sawy, O. A., and Chehade, F. "Towards Frictionless E-Business: The Impact of Common Electronic Business Interfaces," *Communications of the ACM* (46:12), 2003, pp. 186-195.

10 The four additional PIPs were PIP 3A6 (Distribute Order Status), PIP 3A7 (Notify Purchase Order Update), PIP 3A8 (Request Purchase Order Change), and PIP 3C3 (Notification of Invoice).

IT department was highly competent, implementing RosettaNet PIPs was a challenge due to the rigid PIP specifications and the need to come to grips with new standards.

4. Declining Performance. Following the implementation of the PIPs, Electronics Corp. management was very surprised to find that operational efficiency decreased and cycle time increased for transactions with the three trading partners that used the new PIPs for placing orders. This was a major disappointment for those who had championed the RosettaNet project. The implementation team blamed the lack of integration and compatibility as the major reasons for the performance degradation.

Actions Taken to Overcome the Constraints

Despite the constraints, top management at Electronics Corp. pressed forward with several remedial actions and continued using RosettaNet PIPs in business transactions with trading partners. To ensure success, the implementation team took steps to address the constraints they encountered while implementing the initial two PIPs.

1. Formation of Cross-Functional Teams. A team was formed with members from different business units to support transactions that used RosettaNet PIPs. The team ensured that customers who used the PIPs were able to interact with the standardized interfaces regardless of Electronics Corp.'s internal integration and compatibility issues. The members of the team had extensive training on RosettaNet vocabulary and business process orchestration. If necessary, the members manually entered the data received from RosettaNet PIPs to the ERP system to ensure high responsiveness and agility. A second team was formed to identify sources of process incompatibility and to develop long-term solutions to address them. This team examined and documented workflows, information flows, and data and document requirements for each internal process to be integrated with RosettaNet PIPs. Top management believed that this process understanding would help Electronics Corp. modularize more of its interorganizational processes using standardized interfaces, which would improve its responsiveness and agility.

2. Fault-Tolerant Assimilation. The implementation team maintained the old processes in parallel with RosettaNet PIPs to ensure that customer orders were processed without delay or mistakes. This approach ensured the success of the modular approach because it allowed for local differences. In effect, employees were allowed to use traditional processes or RosettaNet PIPs depending on the importance of an order and a customer, which ensured loose-coupling of standard processes. The implementation team then decided to develop middleware that gradually took on the role of the cross-functional RosettaNet team. The middleware was designed to translate PIP data into a compatible format supported by Electronics Corp.'s standardized data architecture. Further, it developed workflows and transported these workflows to the ERP system so that employees responsible for an order performed the necessary actions.

3. Exploiting Best Practices. Electronics Corp. decided to seek implementation help from its major trading partners that had already implemented RosettaNet PIPs. Senior IT executives and several managers from related business units visited trading partners that had successfully implemented RosettaNet PIPs. The firm also sought help from the RosettaNet consortium for internal integration activities. Several middle-level IT executives attended RosettaNet training and educational workshops. The knowledge gained by the members who visited trading partners and attended training programs was later documented and shared with other team members. Exploiting this knowledge helped Electronics Corp. develop necessary modules and associated interfaces for back-end integration so that it did not have to go through extensive reconfiguration of internal processes and the ERP system.

Figure 5 summarizes the constraints encountered by Electronics Corp. as it used RosettaNet PIPs to transition to a modular enterprise architecture and the actions that were taken to address them.

LESSONS LEARNED ON TRANSITIONING TO A MODULAR ENTERPRISE ARCHITECTURE

Both Delivery Corp. and Electronics Corp. initially developed their respective enterprise architecture capabilities to optimize processes and streamline data exchange. For both firms, this level of capability enhanced alignment between IT and the business within and across processes, and accelerated their responsiveness to shifts in markets. However, Electronics Corp. was confronted with inefficient coordination with suppliers, while Delivery Corp. was challenged to configure solutions efficiently for customers from its portfolio of business services.

Figure 5: Summary of Constraints and Actions to Overcome Them at Electronics Corp.

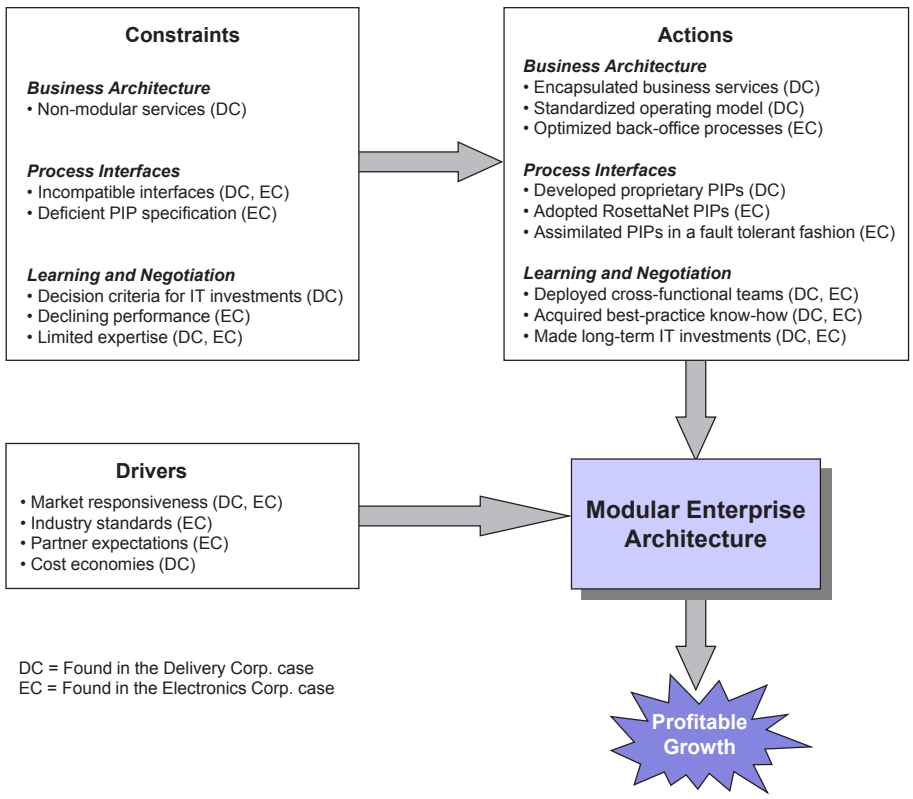
Constraints	Actions
Deficient PIP Specification	• Addressed integration challenges by using best practice knowledge from major trading partners and RosettaNet consortium.
Incompatible Process Interfaces	• Formed cross-functional teams to document internal processes and identify sources of process incompatibility. • Exploited best practices from major trading partners and RosettaNet consortium to address integration challenges.
Lack of IT and Business Process Expertise	• Used best practices developed from visiting major trading partners and attending training and workshops run by RosettaNet consortium.
Declining Performance	• Assimilated RosettaNet PIPs in a fault tolerant fashion through the parallel use of old processes. • Used cross-functional teams and middleware to map PIP data into formats compatible with internal systems.

Accordingly, each firm pursued initiatives to move toward a modular enterprise architecture.

Based on these two case studies, we have identified the drivers, constraints and actions taken to establish a modular architecture, which are represented in Figure 6. The actions and constraints span three broad categories: business architecture, process interfaces, and learning and negotiation. This suggests that the constraints must be viewed holistically and should not be narrowly perceived as a single category. Similarly, the actions should be designed to address the constraints across these categories.

The findings from these two cases lead to the following five major lessons.

Figure 6: Transitioning to a Modular Enterprise Architecture



Lesson 1: Optimize the Enterprise Architecture by Implementing Business Process Standards Where Appropriate

Delivery Corp.'s business model requires that services offered by business units be dynamically integrated to offer customers total solutions. It is transitioning from hardwired linkages between applications across business units to process standards. Accordingly, legacy applications are being reengineered to encapsulate services and standardize interfaces. Electronics Corp. optimized its back-office processes, which enabled interfaces to RosettaNet PIPs. Efforts to provide disciplined, standard processes on a solid IT infrastructure are critical to enabling business modularity.[11]

Lesson 2: Match the Interface Approach to Business Requirements

The cases reveal two distinct approaches to standardizing interfaces and achieving business modularity. Electronics Corp. deployed RosettaNet PIPs to achieve loose coupling with suppliers and to expand partnering options. Being a small-to-medium enterprise, this approach enabled it to focus resources and managerial attention on evaluating PIPs, prioritizing the ones to be initially adopted, and assimilating them. In contrast, Delivery Corp. established standardized interfaces among some of its services, through negotiation among internal stakeholders and with customers, to distinguish itself from competitors.

Lesson 3: Understand Process Dependencies and Negotiate Standardized Process Interfaces

Establishing interface standards entails negotiating global constraints among stakeholders to coordinate local actions. In both firms, PIP standards conflicted with established data architectures and process configurations. Electronics Corp.'s challenge related to the conflict between the XML specifications of RosettaNet PIPs for order management and its data architecture. Delivery Corp.'s challenge centered on the tension between negotiated interfaces and APIs across systems in business units and customer organizations.

Electronics Corp. applied public domain PIPs to coordinate actions with suppliers, which required the implementation team to become knowledgeable not only about RosettaNet PIPs, but also about trading partners' internal IT platforms and processes. This understanding enabled the team to meaningfully negotiate data flows with partners. In the case of Delivery Corp., proprietary PIPs were used to integrate services across business units. These standards had to be negotiated among business units. In both cases, cross-functional teams helped the companies understand process dependencies and to negotiate interfaces that enabled loose coupling.

Lesson 4: Educate Key Stakeholders on the Economic Benefits of Standardized Process Interfaces

Establishing a modular enterprise architecture requires support and commitment from senior managers, which means they have to be well versed on the economic implications. In the case of Delivery Corp., senior management was unaware of the economic implications of standardizing the interfaces of business services. Similarly Electronics Corp.'s management was unaware of the business potential of different RosettaNet PIPs in terms of coordination with the firm's suppliers.

To address gaps in managerial understanding, Delivery Corp. invested significant resources to communicate the economic value of standardizing interfaces to its executives, especially those in marketing and sales. Similarly, Electronics Corp. acquired and shared knowledge about the economic implications of RosettaNet PIPs from visiting major trading partners and by attending training and workshops run by the RosettaNet consortium. Likewise, Delivery Corp. participated in standard-setting organizations for public domain PIPs and interacted regularly with its best practice customers.

Lesson 5: Align Decision Criteria for IT Investments with a Modular Enterprise Architecture Strategy

Investments to develop a modular enterprise architecture should be rationalized in terms of capabilities for agility and profitable growth. Consider the transition that Delivery Corp. had to make to adjust its IT investment decision criteria. Historically, personnel in marketing and sales focused

11 These findings are consistent with those reported by Ross, who claimed companies could not move to a modular enterprise architecture without first building a standard technology and disciplined process platform. See Ross, J. W. "Creating a Strategic IT Architecture Competency: Learning in Stages," *MIS Quarterly Executive* (2:1), 2003, pp. 31-43; and Ross, J. W., Weill, P., and Robertson, D. C. *Enterprise Architecture as Strategy: Creating A Foundation for Business Execution*, Harvard Business School Press, 2006.

on revenue growth, not profit. As a result, they were not concerned about the cost of implementing process interfaces with customers and often sold them solutions that required idiosyncratic and customized interfaces. Now, not only are they fully conversant with standardized interfaces, but IT personnel are involved in front-end discussions on customer solutions. Decisions on IT investment for a particular solution or interface are increasingly evaluated on potential for profitable growth, rather than just on NPV. Similarly, Electronics Corp. examines PIP implementation costs against the future benefits from partnering flexibility and market responsiveness for its major product lines.

CONCLUDING COMMENTS

A modular enterprise architecture provides a platform for profitable business growth. Transitioning to such an architecture requires a solid base of technology and data platforms, and processes. The transition can be gradual, allowing a company to absorb and build on changes resulting from each new module. Once implemented, a modular enterprise architecture will provide growing opportunities to deliver new connections to partners and customers or to add new products and services to core customer offerings.

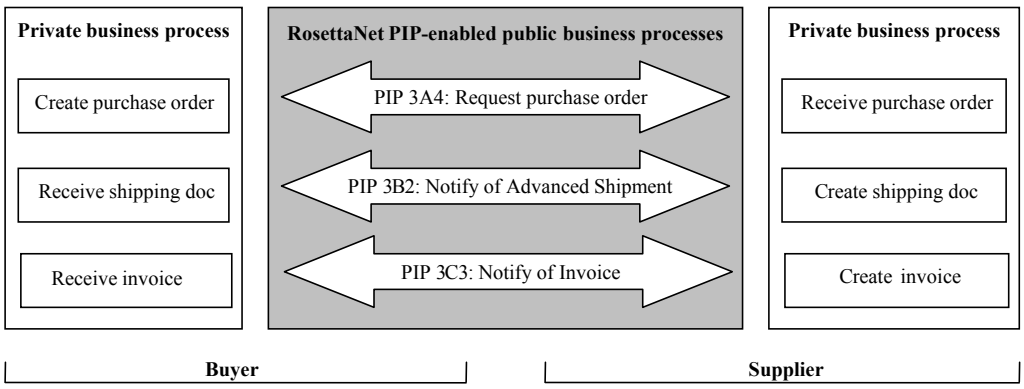
APPENDIX A: Research Methodology

We employed a case study methodology to understand the drivers, constraints, and actions required to transition to a modular enterprise architecture at Delivery Corp. and Electronics Corp. We collected data from multiple sources: interviews with senior executives at the firms, discussions with executives at customer and supplier firms, corporate documents, press releases, and trade press articles. Our work with Delivery Corp. began in its early years of growth through acquisition, which has enabled us to assess carefully the evolution of its enterprise architecture. We interviewed Electronic Corp.'s executives over a period of about two years and tracked various organizational activities and events during this time. Our data collection began during the time of Electronic Corp.'s adoption and implementation of RosettaNet PIPs. This helped us understand its transition to a modular enterprise architecture.

APPENDIX B: RosettaNet Partner Interface Processes (PIPs)

RosettaNet's mission is to develop global and open interorganizational business process standards to enable and support seamless business-to-business integration (B2Bi). Partner interface processes (PIPs) are the building blocks of RosettaNet standards. PIPs are organized into seven clusters—or groups of core business processes—that represent the backbone of a trading network: (1) partner product and service review, (2) product information, (3) order management, (4) inventory management, (5) marketing information management, (6) service and support, and (7) manufacturing. Below is a simplified schematic of supply chain automation using RosettaNet PIPs.

RosettaNet PIPs in Order Management Processes



Adapted from www.rosettanet.org

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