

**Trends in Enterprise Applications Architectures and
Their impact on Infrastructure**

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I. ABSTRACT

The Network is becoming the most critical infrastructure component as enterprises evolve their applications from client server to fully distributed architectures. This trend is being driven by changes in the underlying business processes and the emphasis on IT alignment to support these processes. Whether we call it BPM (Business Process Management), EPM (Enterprise Performance Management), or by some other term, the implications of these trends on network infrastructures are significant.

As a parallel trend, the enterprise software application industry is taking major strides and bringing to market solutions designed with network & network components as the fundamental bases for product architecture; providing platforms for

- Collaboration
- Visibility
- Integrated workflows and Heterogeneity
- Service provisioning and management
- Distributed processes

This development will enable enterprises to establish seamless interconnections required to integrate the various ERP, SCM & CRM applications which are already deployed and to maximize return on these investments.

A close examination of underlying network infrastructure supporting the applications would reveal that networks in the past have evolved in response to application needs. Emerging peer-to-peer applications require a more intelligent network and efficient any-to-any connectivity. Newer integrated processes and workflows require that enterprises extend efficient online connectivity to partners & customers. Applications are being built around Web standards and use Internet technologies as foundations. Networks today have to be much more application aware to meet the requirements of collaborative & distributed processes.

The network economy revolution has barely begun. Enterprises of the future will truly be Networked Virtual Organizations, with business processes spanning organizational boundaries seamlessly.

This paper:

- Highlights the shift to networked applications among enterprises and supply chains
- Discusses the business process changes driving requirements for more efficient networks
- Provides proof points in support of this trend by examining emerging enterprise application software trends
- Identifies the enabling components accelerating the trend towards distributed peer-to-peer applications
- Provides practical examples of how these processes are orchestrated through the network

II. BACKGROUND

Enterprises and supply chains today operate quite differently than they did some years ago. They are faster and more efficient. Decentralization is here to stay - in technology architectures, in business processes and in organizational structures. However these changes have created an increasing level of inter-dependence between different functions within an enterprise and across enterprises in a supply chain. With multiple interconnected components, variability in one component may cause an undesirable 'bullwhip' effect in the functioning of the enterprise and the supply chain. Without the right network support infrastructure, newly instituted processes would not be sustainable or scaleable.

The evolution in enterprise applications has followed a path that has more or less been in step with the hardware and infrastructure that formed the backbone of the enterprise's operations, from the days of the mainframe based centralized model to the now more common client server model that allows for distribution of workload between the server and the client. The realization of problems related to integration and heterogeneity with this approach coincided with the emergence of the Internet as the mode of business communication and operations. When the client became synonymous with the Internet browser, the rage was on 'thin-client' architecture – which was interpreted by some as a win for centralized modes of operation. While the applications took some advantage of processing speeds, faster connectivity and network bandwidth, the underlying application architectures remained the same. The changes were on the surface and not pervasive to application architectures, due either to concerns over investments made in earlier years in previous architectures or to a lack of formal business process definitions. (Interestingly however, the Internet itself and the developments surrounding the Internet are based on highly distributed and federated architectures). **Now, finally we are in an age where we are able to achieve the benefits from decentralization where every unit of any system – whether it is a software application, a business process or an organizational structure is able to perform at maximum efficiency, made possible by**

- **Natural and organic control rather than hierarchical control**
- **Support mechanisms and ecosystems**
- **Leverage from standardization of methods**

Specifically in application software systems, several factors have contributed to the development and deployment of a new breed of applications that take advantage of an enterprise's network assets:

- Continued competitive pressures
- Increasing awareness of the potential of a network centric computing paradigm
- Maturity of application packaging and application software industry
- Progress in the area of business process modeling and decomposition
- Standardization of business processes

III. ENTERPRISE PROCESS DRIVERS

Emerging enterprise processes are being driven by major themes around collaboration and visibility. These processes are being defined with an intrinsic dependence on connectedness. Here is an examination in more detail of these themes -

Collaboration

The Network will provide the mechanism for ad hoc peer-to-peer connection to support execution of collaborative activities. The need to facilitate quick informal interactions in the context of a formal business process, and the decision making cycle has gained major importance. Collaborative workflows are being built into business processes. Formal specifications for enterprise collaboration are starting to appear. The author helped develop such a specification for Collaborative Planning, Forecasting and Replenishment (CPFR) in the Retail industry.

A similar set of formal specifications is being defined for Collaborative Transportation Management (CTM). This set of specifications details the workflow for

- Initial survey of transportation vendors
- Establishment of contracts with these vendors
- Request for bids for specific shipments
- Iterative bid review and negotiation
- Finalization of bids and award of contract
- Assignment of shipment number
- Tracking of shipment

Formal methods for collaboration are being explored in a number of other processes – R&D, project management, knowledge management and e learning.

Visibility

The extended Network will enable the need for current and consistent visibility to information all along the supply chain, across functional boundaries within an enterprise and across enterprise boundaries . This in turn will help

- Reduce or eliminate bottlenecks due to information latency
- Avoid unnecessary and costly errors due to lack of information in the right place
- Facilitate a high velocity supply chain

Visibility up and down a supply chain across multiple trading partner's systems will be facilitated through online connectivity to applications, clearly stated agreements regarding which piece of information would be visible to which entity and for how long the visibility can persist.

Integration

Different functions and processes within an enterprise and across enterprise boundaries will be able to communicate and interrogate each other, with or without human intervention, using the underlying network foundation and the concept of an enterprise network bus. The number of processes that support these operations are on the increase and being redesigned to take advantage of network efficiencies. Integration among these process components will be characterized by

- Loose coupling among them
- Low levels of functional granularity
- Cross-functional workflows
- Standardization

Velocity

A distributed network infrastructure will help enterprise not only make the enterprise function faster internally, but also respond rapidly to changing external market conditions. Enterprises and supply chains need to be responsive to events that occur. Variability can never be eliminated in the operations of any business. The only way to counter the effect of variability is to

- Understand how it can be reduced and
- Determine how responsive the business can be in reacting to variability.

Flexibility

The emerging trend towards on-demand computing model enabled by networked infrastructure will necessitate businesses to build the flexibility and capability to redefine processes as their needs change - without undue burden on operations. These changes may be the result of acquisitions and mergers, internal reorganization or other market conditions. If components are defined at a low level of granularity, various different business processes can be orchestrated by the suitable combination of the right components. The greater alignment that exists today between the Business and IT functions in an enterprise is making it possible for processes and supporting applications to be defined in this manner.

IV. ENTERPRISE APPLICATIONS

Enterprise applications whether home grown or packaged serve essential business operations. Initially designed for stand alone operations, over the years they have become inextricably tied to each other and to the functioning of the business as a whole. While their designs have evolved to meet these needs, for the first time, there is a fundamental shift in application architectures that makes the applications intrinsically network aware. The network on the other hand is application aware. Let us explore this evolution in some more detail. Enterprise applications have traditionally fallen into two broad categories :-

1. Core business applications

These are applications that handle the core functions of a business – Planning, Sales & Marketing, Production, Distribution and Logistics, Financials, Customer Relations, Human Resources Management etc.

2. Office applications

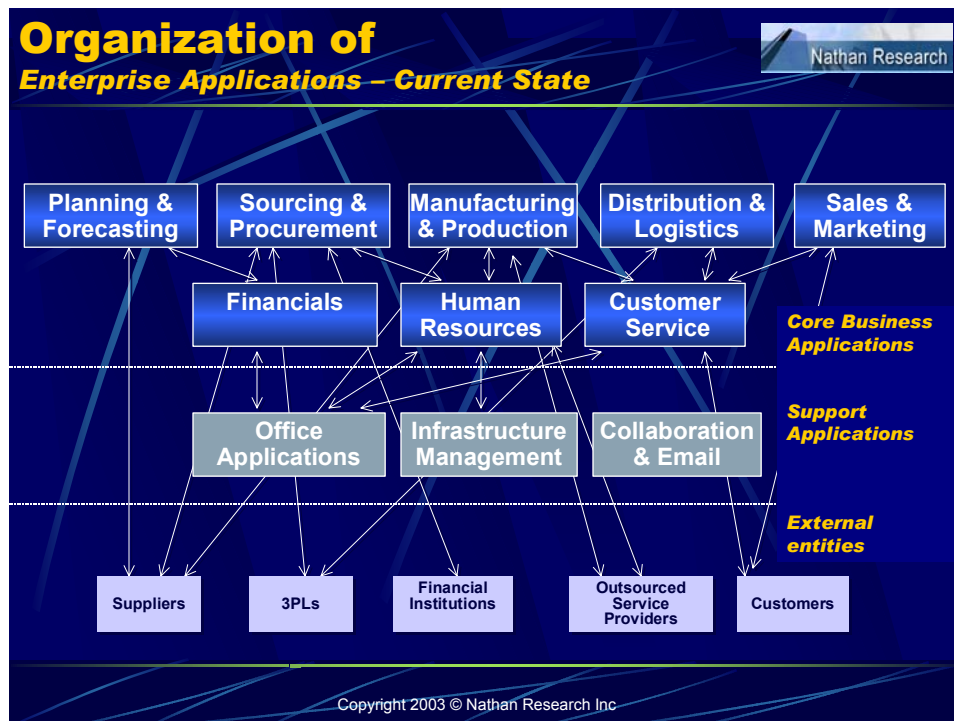
Applications that fall in this category include Office suites, Email, File sharing, Web conferencing (audio and video).

The core business applications that were initially mostly homegrown, gave way to packaged applications under a cornucopia of terms and acronyms – ERP (Enterprise Resource Planning), SCM (Supply Chain Management), CRM (Customer Relationship Management), EAI (Enterprise Application Integration) etc.

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The maturity of application packages has brought efficiencies to enterprise operations, but they have brought challenges as well. Some of these challenges are:

- The disjointedness with which applications have been packaged
- Inconsistency among different packaged suites when common data is referenced
- Redundant functionalities among applications
- Incomplete functionalities necessitating patchwork of fixes and high degree of customization
- An ad-hoc approach to integration among multiple suites



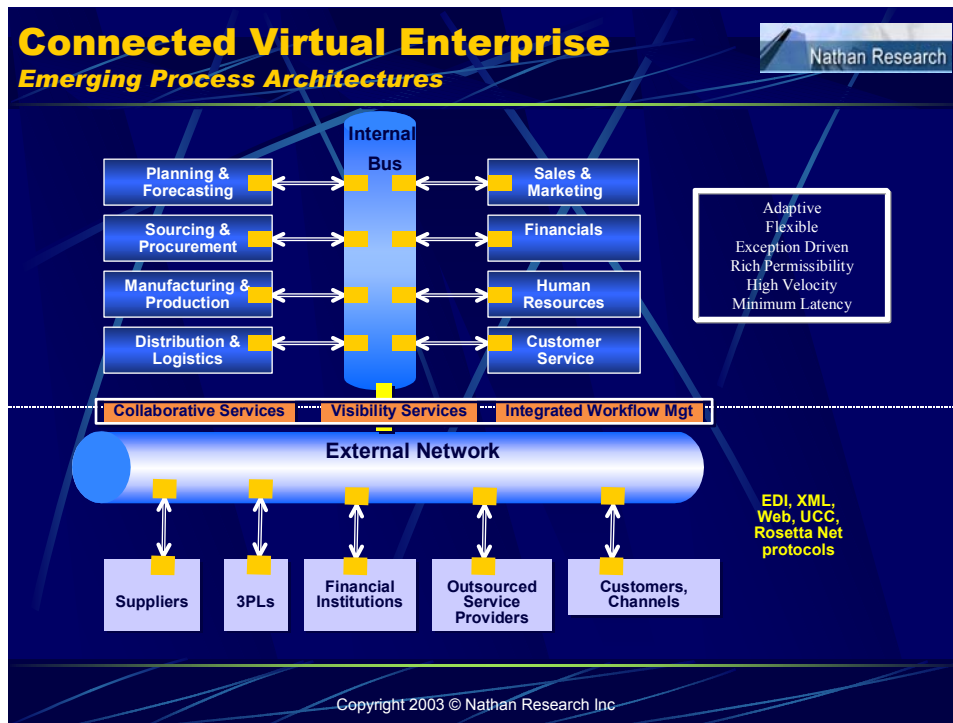
These challenges illustrated in the picture above, have caused significant strain on the enterprise IT function.

Enterprise Application Architectures are now undergoing a major shift, after the last decade of experimenting and learning with application suites. The new application and office computing paradigm is characterized by:

- **Roles based architecture** that is suited for individuals in an enterprise
- **Leverage of common software assets** spread across in the enterprise
- **Integrated workflows** that span across enterprise functions, i.e. components of an application with components of another application.
- **Straight through processing**
- **Modularization** of functions to their lowest levels
- **Orchestration of processes** – both standard and ad-hoc - some defined by end users themselves
- Availability of these application components as **Web services**

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- **Library of standards** and services that can be leveraged in building new applications
- **Integration of business and office functions**
- **Collaboration** – facilitation of informal and formal workgroups
- Support for a highly **mobile** workforce
- **Real time visibility** to information



The Enterprise Application Software industry is relatively young and currently going through the first major turning point in its history. Much of the shift is due to the capabilities in the network infrastructure supporting these applications.

V. ENABLING ECOSYSTEM

The new generation of distributed applications will be supported by the near-simultaneous development of an ecosystem that is forming to allow application components to easily be identified, registered, secured and managed in inter and intra-enterprise workflows.

1. Registries

Borrowing concepts from the Internet, information registries are getting formed – that are essentially the DNS (Domain Name Services) for business information. They store identifications of items traded between companies, companies' facilities, and trade terms. They will also function as registries for an abstracted set of services that can be 'rented' and tied together with other services to form complete processes. Registries allows trading partners to

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share essential trade item information between each other in an efficient manner, and conduct peer-to-peer business processes.

In the Retail/Consumer Goods sector, UCCnet – a registry that will store the Global Trade Identification Number (GTIN) and the Global Location Number (GLN), illustrates this concept. The UDDI (Universal Description, Discovery and Integration) system is another example with a broader scope of providing an infrastructure for identifying, registering and discovering services among applications.

2. Exchanges

Trade exchanges are morphing into nodes in a highly distributed application processing framework and becoming registries of services. In this model, they may become clearing houses for transactions and services in an architecture where transactions are initiated at one end of the value chain, interact with the services in these exchanges and finally complete their state at the other end of the value chain. They also serve as hosting platforms or outsourcees of full services that companies want to take advantage of rather than building them themselves – this option meaningful to the small and medium enterprises.

3. Interoperability

As business processes and supporting applications grow and evolve, the need for multiple peer-to-peer connections will increase. Clear handshake and interoperability standards will determine how such applications establish and release connections. Certification mechanisms for interoperability between multiple application services providing similar functions are starting to appear in the marketplace.

4. Computing Architectures

Centralized hub-and-spoke architectures that grew out of the command and control nature of organizational structures is giving away to distributed architectures to support today's reality of more collaborative workplaces. Large multidivisional companies are adopting a federated organizational structure. This has to be supported by a similar set of architectures in computing systems. Business relationships across enterprises are obviously decentralized, and have a peer-to-peer aspect to them. Centralized approaches to such a trend, results in inefficiencies and performance degradation. The platform solutions from various technology vendors promise the reality of component-based architectures. The distributed approach to application design bypasses the hub and treats every node equally.

5. Standards

The Internet's explosive growth has been fueled by a single factor: open standards, an agreement upon a common set of protocols—namely TCP/IP, FTP and HTML—enabling computers to communicate with one another across a common network.

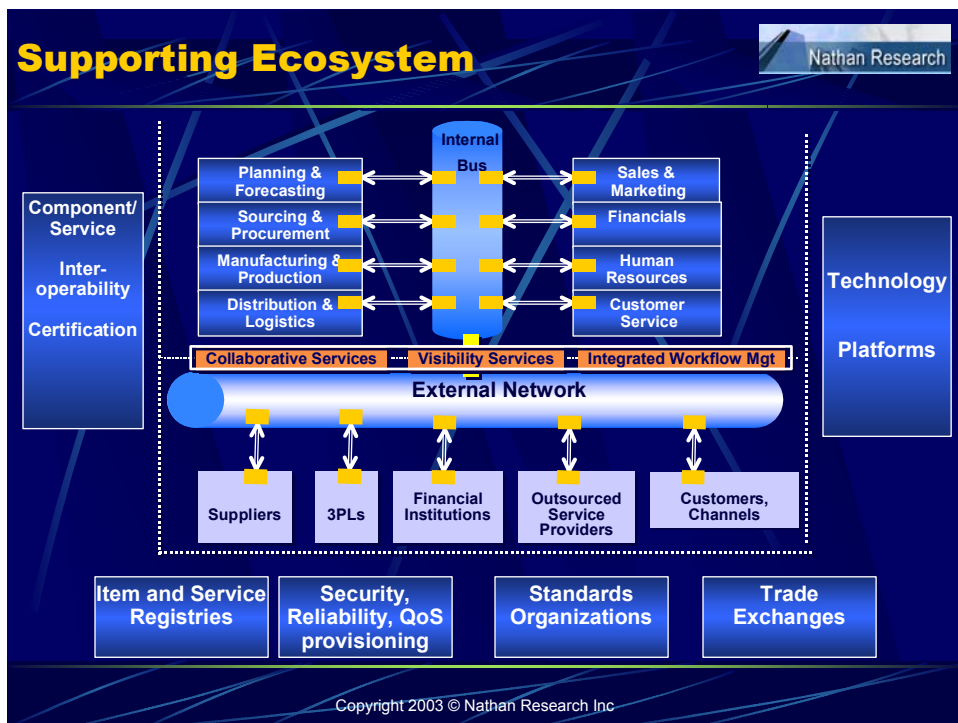
Using these Internet technology as the basis, a number of different Web Services standards are appearing in the marketplace. These standards will converge to a set of widely accepted protocols and definitions that will bring distributed computing to the mainstream. Organizations such as UDDI, OASIS (Organization for the Advancement of Structured Information Standards), BPMI (Business Process Modeling Institute), W3C (World Wide Web Consortium) and the Web Services Interoperability Organization are actively engaged in these efforts.

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Standards such as SOAP (Simple Object Access Protocol), WSDL (Web Services Definition Language) are the results of these efforts. These specifications will do to Enterprise Application Architectures what HTML did to the emergence of the World Wide Web and what TCP/IP did to the universal connectivity between machines, among multiple peers. Such a framework would allow each application to automatically discover other applications, coordinate the business process from application to application and transforms Web connections into secure collaboration networks.

By replacing the centralized hub-and-spoke architecture with software components associated with the individual applications that need to be integrated, businesses can construct systems that will deliver a high level of fault tolerance and scalability, require minimum maintenance, are cost-efficient and easy to deploy.

The emerging ecosystem around enterprise architecture is shown the picture below.



VI. TECHNOLOGY PLATFORMS AND APPLICATION SOFTWARE

Major software vendors and startups are responding to this new trend in application architectures with interesting offerings. These companies are approaching the subject from a couple of different angles:

- To provide the underlying platform for new applications to be defined, developed and deployed within the framework OR
- To provide the application components that will reside on the platform and network and become part of a library of applications

The larger software companies tend to offer a combination of these capabilities.

1. Technology Platforms

Companies such as IBM, Microsoft, Sun and Intel have brought to market a set of technology frameworks that define this new application-computing paradigm.

IBM

IBM's Business on-Demand campaign with a strong Integration theme brings together multiple technologies that the company has built or bought over the years including Websphere, Lotus, DB2 and Tivoli that combines Web service, Collaboration, Database and Systems Management. Notable recent additions to the portfolio include CrossWorlds and Holosophix that provide the capability to build business workflows. IBM's Websphere architecture combines Messaging, Collaboration, Portal, Application server, Integration Brokering, Business Integration, Data interchange and Access management.

Another initiative that IBM is investing in is Grid Computing. Grids are clusters of servers joined together over the Internet using standard protocols and other open technologies, such as Linux. Just as the World Wide Web allows people to share content via Internet protocols, grid computing allows widely dispersed organizations to share applications, data and other computing resources. Similar to the electric grid, the computing grid distributes computing resources to solve problems. Grids can also facilitate virtual organizations constantly changing groups of individuals and institutions to exploit resources for a variety of purposes.

Microsoft

Microsoft's .Net platform is another example of how fundamental changes in technology architecture is enabling faster business interactions.

The .Net framework provides a wide variety of capabilities including Portal Development, Office integration with business workflows, Content Management, database integration with SQL server, process orchestration through Biztalk server, and support for industry standards such as RosettaNet, CIDX, HIPAA . The framework allows enterprises to expose and extend their legacy applications and connect them to external systems.

In one reported case study, a software solutions provider that deployed a self-service model of its Channel Management Suite, on the .Net framework, has saved millions and realized as much as a 45% return on investments for its users by:

- Making order processing more streamlined, thereby reducing errors and cycle times.
- Fully integrating order processing into existing ERP systems.
- Reducing customer inquiries through more effective customer support.
- Increasing the potential to influence the buyer at the point of purchase, particularly with promotions

Microsoft Research sponsored *Pastry* is a generic, scalable and efficient substrate for peer-to-peer applications. Pastry nodes form a decentralized, self-organizing and fault-tolerant overlay network within the Internet. Pastry provides efficient request routing, deterministic

object location, and load balancing in an application-independent manner. Furthermore, Pastry provides mechanisms that support and facilitate application-specific object replication, caching, and fault recovery.

Sun Microsystems Inc

Sun's Java based environments continue to evolve. Application architecture support frameworks are being announced both by Sun and the Java standards movement it has cultivated. This environment includes apart from J2EE, the Java Connector Architecture (JCA), Java Message Service (JMS), and the Java Authentication and Authorization Service (JAAS). Sun's JXTA, is an open-source project that will provide a basic framework for building peer-to-peer applications. The project, intended to explore distributed computing architectures, was supplemented by InfraSearch, a start-up acquired by Sun in March that developed peer-to-peer search technology. Sun plans to push for standards to better enable peer-to-peer development, and to commercialize its peer-to-peer software and services such as file sharing, instant messaging and distributed processing. JXTA helps locate peers and manage low-level interactions among peers on JXTA networks. For example, a company could use JXTA to develop an application to parcel out computing tasks to PCs within its peer network or remote PCs via the Web with available processing power.

Intel

Intel, with its key role in the computing industry value chain, has significant commitments in all aspects of the emerging application architectures – Java, Mobile applications, .Net, P2P, Web services and XML. In the area of peer-to-peer, one of Intel's programs demonstrates how its technology can dramatically accelerate the discovery of important medical breakthroughs. This effort not only demonstrates how scientific computing is headed to a new era, but also illustrates the socially significant concept of PC philanthropy.

2. Major Application Software Providers

Service Oriented Architecture and Distributed Computing are major initiatives among Enterprise Application Software industry leaders such as SAP, Siebel and Oracle. Some of the capabilities of the products from these larger application software vendors resemble the platforms from IBM and Microsoft and are somewhat interchangeable. In addition, the core application portfolio has application components that run on their native platforms or those of IBM, Microsoft etc.

SAP

SAP's NetWeaver is an architecture that can handle a wide range of enterprise solutions across heterogeneous systems and company boundaries. It leverages today's IT investments and lays the groundwork for cross-enterprise processes. As a foundation for SAP xApps and mySAP Business Suite solutions, it provides a platform for services-based business solutions that combines enterprise applications with the flexibility of Web services and open technologies. Specific capabilities that Netweaver enables are Document integration, Global Collaboration, Content Syndication, in addition to systems management support for Sizing, Configuration, Data migration, Testing, QoS, Security, High availability, Component changes and upgrades. The capabilities include the flexibility for enterprise

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users to mix and match not only application components but also platform components from the IBM Websphere suite and Microsoft's .NET architecture. The Netweaver platform also includes SAP Mobile – SAP's offering to make applications available to clients such as the PocketPC. Netweaver supports open technology standards such as WSDL (Web Services Description Language), SOAP and UDDI as well as industry specific process standards such as the PIDX and RosettaNet.

Siebel

The Uniform Application Network (UAN) that Siebel has championed is an effort to provide standards based, vendor independent set of solutions enabling enterprises to integrate a diverse environment of legacy, packaged and custom applications through a framework. Siebel provides a portfolio of application components that are integrate-able within this framework. This portfolio covers horizontal applications (similar to the Integrated Workflow concept discussed earlier) such as Customer Lifecycle Management, Product and Catalog Management and Customer Order Management as well as Industry specific applications for sectors such as Automotive, Financial and Energy. For example, within the Financial sector, the suite provides Contact Management (as expected), Auto Policy Sales Management, Life Policy Sales Management and Claims Management. The component based architecture works with products from BEA, IBM, SeeBeyond, TIBCO as well as SAP and Oracle.

Oracle

The Oracle 11i E Business Suite is a portfolio of integrated business workflows such as Procure to Pay, Asset Management, Inventory Optimization, General Ledger, Demand Planning and Implementation and Global Order Management. The applications are supported by J2EE containers, built-in-caching, application integration, portal and mobile features. The suite also supports standard business protocols such as the Rosetta Net.

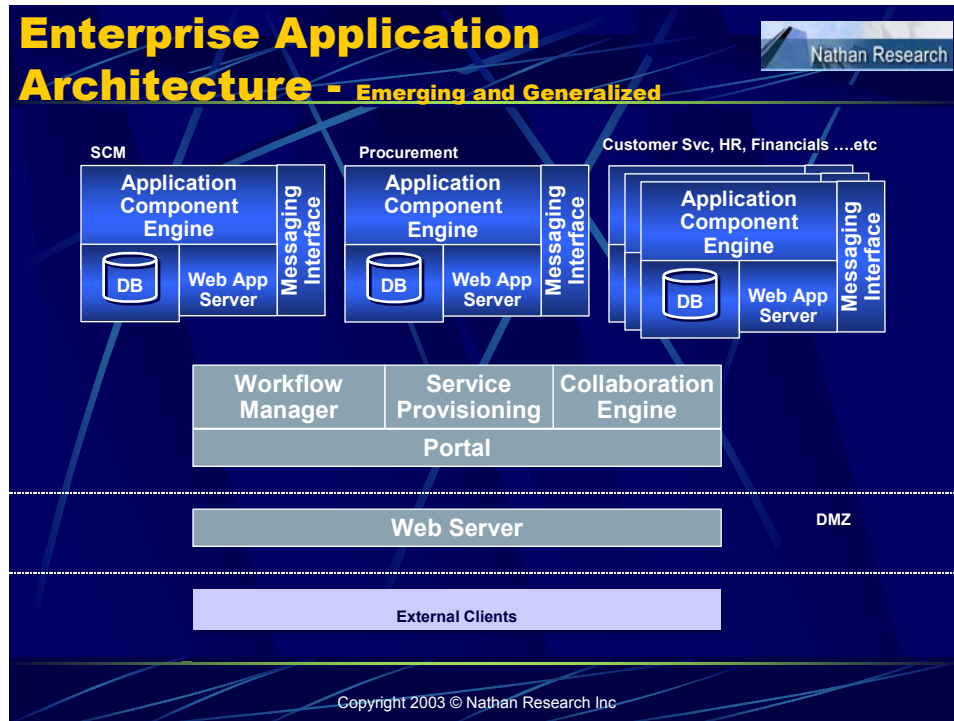
PeopleSoft

The Peoplesoft Internet Architecture supports a client-less server-to-server mode of operation with a stack of processors that handle

- Application functionality
- Messaging
- Scheduling
- Portal functions
- Security
- User Interface
- Directory
- Interlinks (to connect to third party applications)

The integration vendors Webmethods, BEA, Seebeyond, TIBCO and others in this category have their own flavors of similar set of platform offerings that are increasingly starting to include robust workflow capabilities.

In addition, interesting peer to peer and collaboration technologies are starting to appear from startup companies that promise a new wave of productivity enhancing applications (for example – Groove and Vizional)



Shown above is a generic, simplified view of the emerging enterprise application architecture

Characteristics of such an architecture are:

- Each component is defined at a low level of granularity
- Each component is able to scale independently
- There will be more, not less systems to be managed
- Support for high transaction volumes and throughput
- Support for easy fail over and redundancy operations
- Platform independence
- Asynchronous messaging
- Dynamic orchestration of low level activity based workflows
- Manifestation of processes as servlets or beans (Java) and .Net services
- The services can be packaged as fully functional entities

New standards will emerge for interactions among different computers and networks, including designs for self-healing, “autonomic” infrastructures—computing systems that will be able to configure, tune and repair themselves as well as have the intelligence to solve problems automatically.

A common thread among all these trends is the universal need for **more bandwidth**, and **more infrastructure**, for the enterprises and the service providers. In the next section, we will see look at some examples of integrated enterprise business workflow orchestration and their value.

VII. EXAMPLES, VALUE PROPOSITIONS

1. New Item Introduction (Retail)

Problem

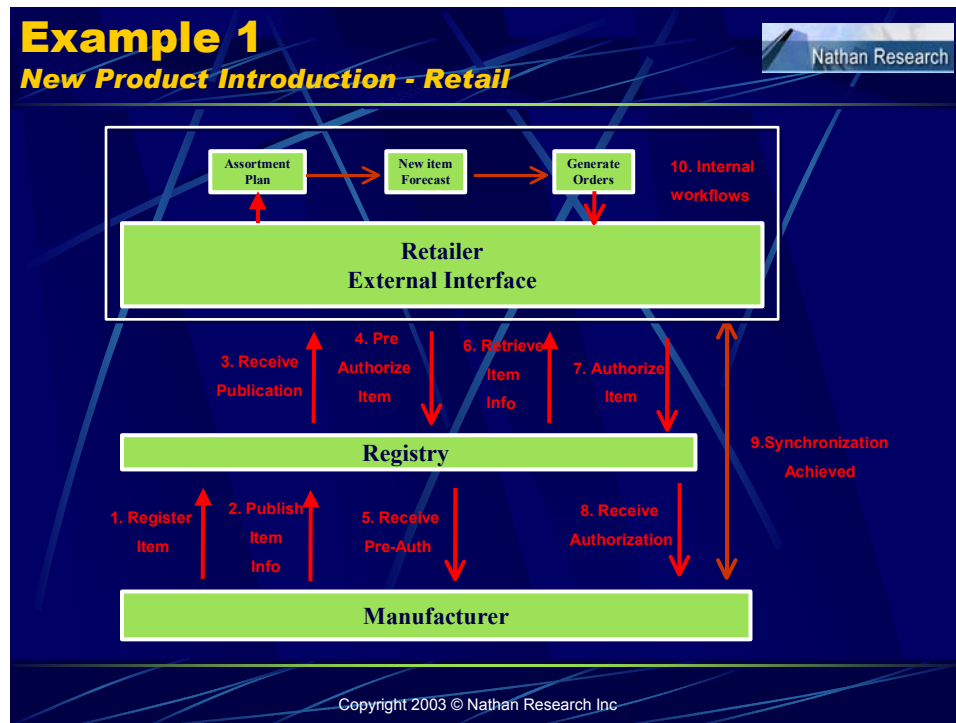
In the vast portfolio of products that the Retail industry deals with, information on new product introductions have been communicated between consumer goods manufacturers and retailers on an inconsistent, one-to-one basis creating a multitude of transfers, redundancies, inaccuracies causing industry wide inefficiencies, despite the availability of the standard UPC barcodes on products for over 25 years.

Solution

A network driven process of synchronizing information on consumer goods items (identification, prices and promotions) between retailers and manufacturers called Global Data Synchronization (cross enterprise business process sponsored by industry organizations such as the UCC (and UCCnet), and supported by Technology and Service providers. Major retailers and manufacturers have (Wal-Mart, P&G, etc) have endorsed this program and are actively participating.

Value

Decreased cost of IT operations (average 3-5% less); Speed to shelf of new items by 50 – 60%; Increase in market share for early arrival of new items by 5-15%; reduced loss of sales due to delivery errors



2. Collaborative Planning (Consumer Goods)

Problem

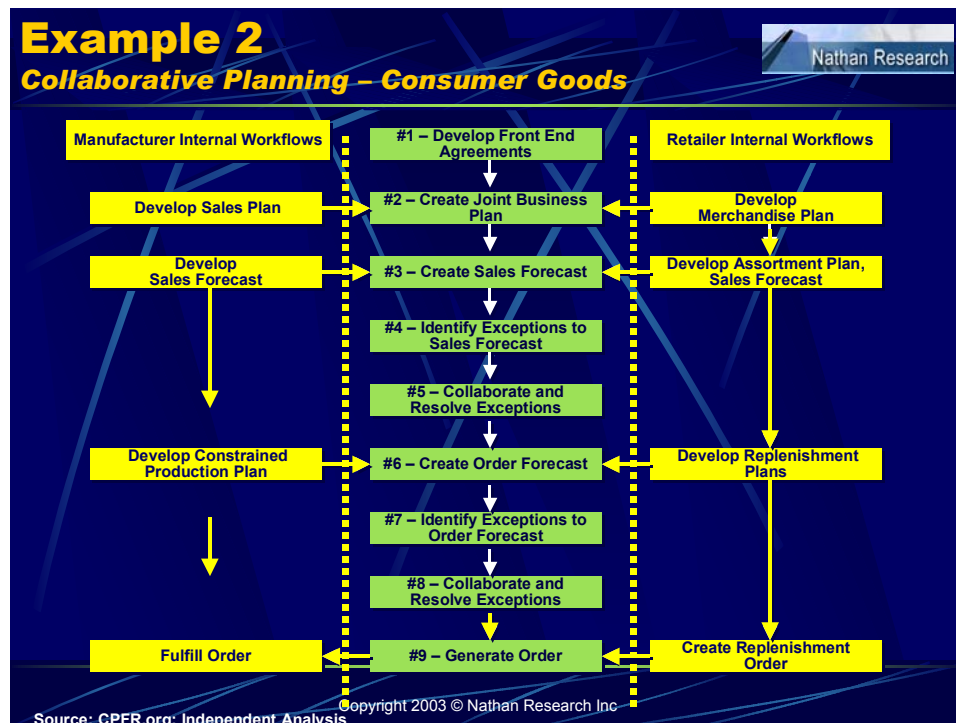
The process of exchanging information on business forecasts between Consumer Goods manufacturers and Retailers was extremely tedious, inefficient, prone to errors and unresponsive to events that affect forecasts. The activities at the two ends of the value chain were highly disjointed.

Solution

Led by VICS (Voluntary Inter-industry Commerce Standards) the industry developed a model that formalized the process and the workflow associated with exchanging forecast data that integrates the strategic planning function with tactical forecasting and operational execution of the order tying together various roles within both organizations. The interactions between Retailers and Manufacturers can either be direct connections or connections through trading exchanges, which provide the collaborative spaces for partners within the exchange.

Value

On average, benefits reported from implementation of this model among consumer goods companies and retailers include: - increase in sales of 10-15%; reduction in inventories of 20-40%; reduction in labor costs of 3.5% - 7.5%; proportional reductions in warehouse capacity and damage write-offs



3. Financial Settlement (Financial Services)

Problem

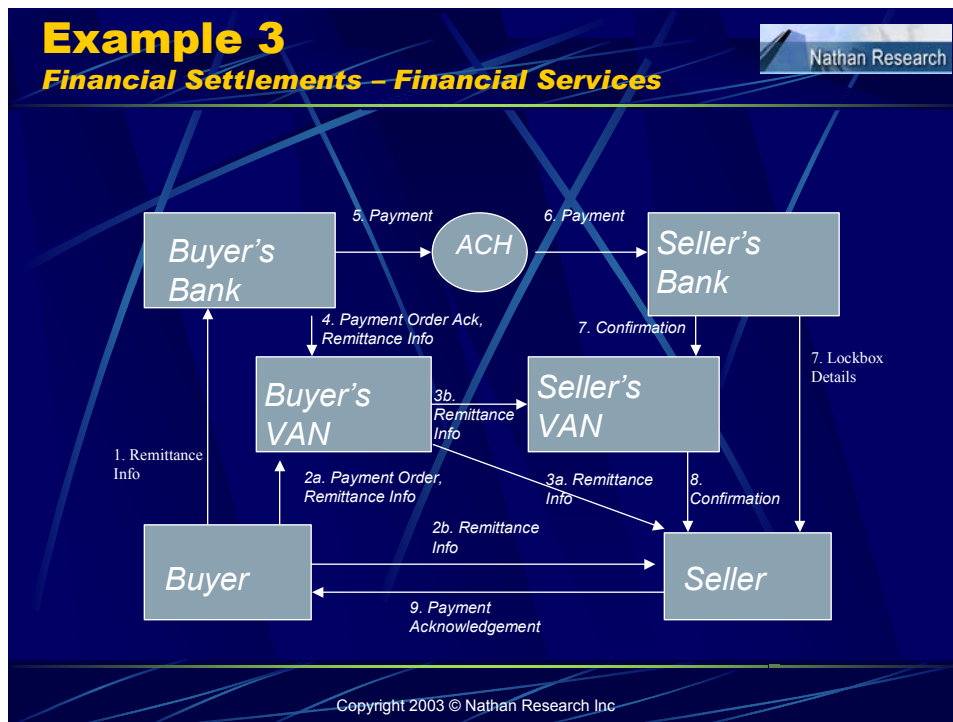
The financial settlements process between financial institutions, customers and suppliers is complex, mostly manual and subject to cost overruns.

Solution

Using best practice models such as ERS (Evaluated Receipt Settlement) that allows companies to determine automatically what is owed to suppliers based on order and shipment flows, develop processes that automates the steps involved, and manage the corporate payment cycle. Enable corporate customers and suppliers to initiate, track, manage and reconcile payments.

Value

Reduced cost of Accounts Payable; Reduced discrepancies and reduced reconciliation costs; Yearly bottom line savings achieved jointly by a buyer, seller, and the financial institutions involved on one project alone \$6-\$7 M.



4. Collaborative Design (Electronics, Apparel)

Problem

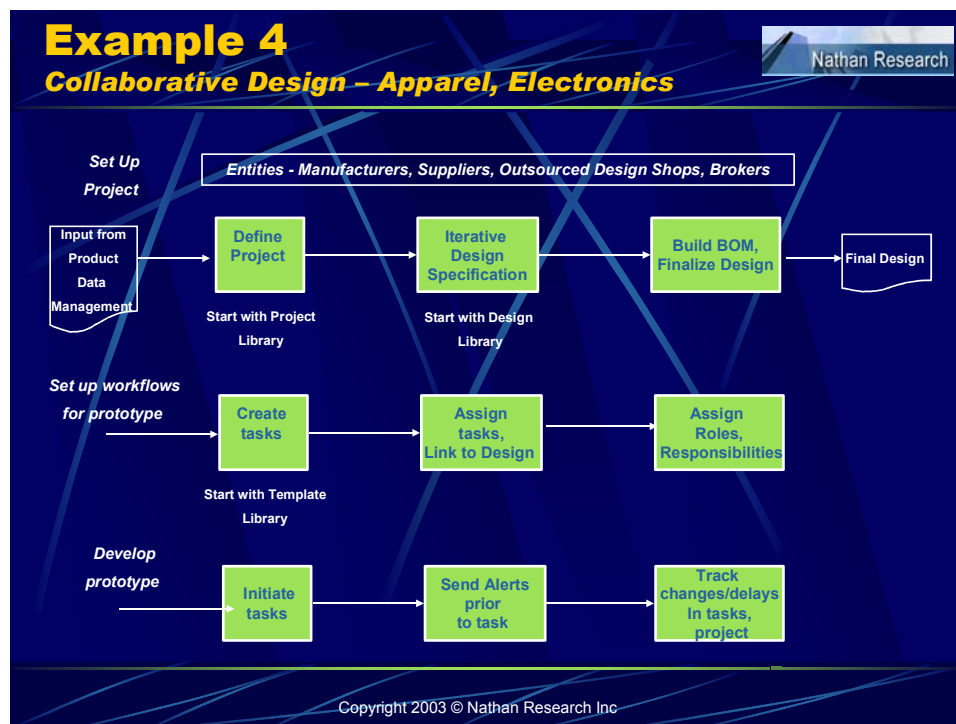
The fashion industry and the electronics industry are prone to short product lifecycles. The time spent by to design a new line of apparel or a chip often can make a big difference in the successful launch of a new clothing or chip design. These processes are cross functional, cross enterprise and often leverage offshore manufacturing. The process of iterative design changes leading to a finalization of a product needs a combination of workgroups from different continents being able to effectively collaborate and share documents and workspaces.

Solution

Using a combination of project management, collaboration and conferencing facilities bundled into a integrated collaborative design and project management solution, engineers and designers can bring together a library of previously defined specifications, make modifications to these designs and quickly and efficiently determine what a new line up or a new set of designs might look like.

Value

Reduction in design and review process by several weeks (typically 50%); less inventory liquidation and markdowns at end of season; Increased order integrity; Improved margins.



5. Healthcare Claim Adjustment (Healthcare)

Problem

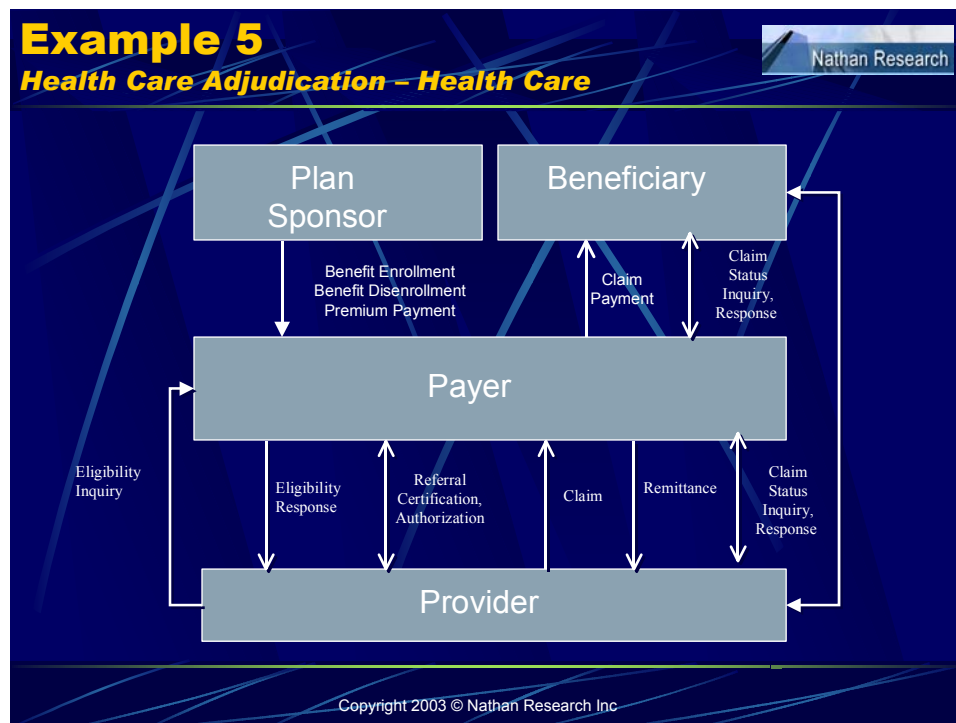
The process of determining eligibilities, co-payments and settlements in healthcare involves a number of different entities – the patient, the provider, the plan sponsor (typically the employer), and sometimes the hospitals – the process is complex, inefficient and error prone. In addition, recent federal mandates such as HIPAA (Health Insurance Portability and Accountability Act) have created the necessity to reduce the administrative complexity of this process.

Solution

Network based solutions that tie together various entities, their roles and jurisdictions in faster eligibility verifications, claims processing and claims payment using a set of previously defined EDI transactions sets are being integrated in overall end-to-end solutions by solution providers.

Value

Accuracy of data, quicker decisions on eligibilities and faster settlement of claims. Total benefits projected for plan providers (the insurance industry) is \$16 B and benefits projected for care providers \$20 B.



VIII. IN CONCLUSION

Businesses are undergoing operational transformations driven by business processes. These business processes are characterized by their granularity of detail, formalization and facilitation of role-based workflows.

Technology platforms and software applications to support these processes and workflows are being brought to market with architectures that support

- Decentralized operations
- Speed of execution
- Collaborative practices
- Cross functional and inter-enterprise workflows

Whatever new technologies and applications come into play in the next three to five years, it's clear that wide-bandwidth, high-speed, real-time communications infrastructures must be established to drive them. The vision of virtual corporations that only a few companies have been able to implement until now, is now ready for prime time and will follow a logical progression as follows:

