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A Three R Approach for Supply Chain Business Intelligence

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Abstract

Today, manufacturing enterprises are required to improve their competitive performance by establishing effective controls over the complex processes and datasets, both internal and external, which drive their business. At the internal level, mastery of this performance measurement can be assisted through the implementation of Enterprise Resource Planning (ERP) systems, Data Warehouses (DW) and appropriate report writing tools. These can integrate with other best-of-breed Executive Information Systems (EIS) components to create software platforms capable of delivering effective Business Intelligence (BI) that can support superior decision-making. However, at the external level, where there exists a larger degree of uncertainty, a plethora of isolated systems and commercial issues, such as data sensitivity and collaboration, can present formidable challenges. Within this paper we define what Small to Medium sized Enterprise (SME) management requires from supply chain performance and consider whether or not the desired corporate goals can be achieved through the use of effective use of IT-based BI frameworks alone. Through a range of case study implementations a process-orientated approach to effective supply chain BI execution, comprising of 3Rs: Right Quality, Right Time and Right Cost, is evaluated.

Keywords:

Business Intelligence, Supply Chain Management, Enterprise Resource Planning.

1 INTRODUCTION

In recent years, manufacturing enterprises have been confronted with ever-increasing challenges to their growth and even their survival. Whilst issues of market liberalisation and globalisation, innovation, mass customisation, cost management and raising customer expectations have continued, of late enterprises have had to navigate progressively rapid rates of technological change and to embrace the unfamiliar concept of supply chain collaboration. To achieve competitive success in the contemporary performance measures of quality, speed and price, enterprises need to develop capabilities, which further include mastery and monitoring of extended and virtual enterprise processes, together with effective relationship management. Enterprises are now required to deploy strategies and Information Technology (IT) solutions that can effectively support emergent globally focussed business models, integrate disparate supply chain partners and provide effective performance measurement feedback. Whilst the adopted use of commercial ERP systems have delivered some of the above capabilities, it is recognised that deployments of these all-encompassing business management applications have often fallen short in delivering upon their promise and may even place constraints on change [1].

Over the last few years, considerable efforts have been made, both by industrial and academic communities, to investigate and develop new holistic models of enterprise management systems, which not only build upon previous internally focussed ERP systems, but also recognise outwardly facing Supply Chain Management (SCM) imperatives and address Enterprise Application Integration (EAI) issues. Existing 'transactional' ERP systems can typically require additional bespoke or best of breed, Complementary IT Systems (CITS) [2], such as Customer Relationship Management (CRM), Advanced Planning and Scheduling (APS), Collaborative Planning Forecasting and Replenishment (CPFR), Electronic Commerce (EC), DW and EIS and to provide extra business support in terms of superior customer interaction, supply chain control and effective management reporting. From these wider business requirements, the notion of ERPII system was coined by Gartner [3] to classify an evolutionary step from internal systems operation to full collaborative and external supply chain support. By combining this functionality expansion with the use of Internet technology, enterprises should be able to achieve increased customer loyalty and improved service from their suppliers. It is further explained [4], 'ERP systems are used to integrate and optimise an enterprise's internal manufacturing, financial, distribution and human resource functions. In contrast, ERPII addresses the integration of business processes that extend across an enterprise and its trading partners'.

Whilst, this extended scope of the ERP platform is desirable, few IT solutions providers have been able to address complexities of SCM, ERPII and EAI due to the diversity of existing technologies, together with data latency problems and incompatible standards. Through the adoption of centralised ERP systems, company information was readily made available to all within one enterprise; thereby key decision makers were better equipped to undertake their tasks. Within the concept of ERPII, the ability to effectively share information throughout the supply chain is a fundamental key. Over the last few years, a plethora of new Internet-based collaborative systems have been developed to improve supply chain development, collaboration and co-ordination, but many of the issues surrounding supply chain performance measurement remain. The work contained within this research paper aims to address some of the BI issues surrounding the evolution of ERPII and the adoption of new collaborative systems. The foundation for this work was developed with assistance of the ERDF funded B2B Manufacturing Centre.

2 RESEARCH OBJECTIVES

The principle purpose of this work was to develop improved understandings of how to implement novel BI approaches for contemporary manufacturing SMEs operating within industrial supply chains. Research scope was centred on requirements formulation, specifying and assessing the use of a process-orientated approach for effective supply chain BI execution, comprising of 3Rs: Right Quality, Right Time and Right Cost. The work is firmly centred upon the shifting focus of ERP to ERPII, new methodologies for enterprise systems design, and IT support strategies for Internet-based collaboration. The specific objectives of this work were to:

a. Review current IT systems strategies for SME performance measurement and IT based approaches for supply chain collaboration.
b. Investigate, analyse and formulate a requirements specification for SME supply chains operating within an individual industrial cluster.
c. Specify and develop a process-orientated test-bed system for demonstrating effective supply chain BI execution, comprising of a 3R approach.
d. Part-evaluate the benefits gained through the application and adoption of the test-bed and 3R concepts within an industrial case study.

The implemented approach for this research was based on an arrangement of descriptive and experimental research. From the foundation aims proposed earlier, descriptive research in the form of a literature review, industrial survey, and case studies were initially utilised to examine the problematic situation. This was seen as a valid approach because a clear statement of 'what is' is an essential prerequisite to understanding 'why it is so' and 'what it might be' and it would be seen to reduce the common argument against the use of case study research alone. This is often observed in the notion that case study data is based upon qualitative data only, and therefore can lack precision and rigor.

3 BACKGROUND

The impetus for this work is based upon three existing, but now converging strands of IT-supported research; namely ERP, SCM and BI. This convergence has been driven and supported by the rise in new collaborative solutions, global Internet connectivity and the wider adoption of electronic business-to-business (B2B) commerce. It is acknowledged by Porter [4] that IT has deeply affected the way business is conducted and the way that enterprises compete. Whilst there is no doubt that the growth of Internet technologies is due to continue its rapid rise, it is evident that collaboration and tighter integration will form significant attributes. It is proposed by the authors that closer, integrated use of these system elements will form the backbone of next-generation solutions.

3.1 Enterprise Resource Planning

ERP systems have now been widespread for over 15 years and have their roots firmly founded in earlier work by Joseph Orlicky on MRP (Material Requirements Planning) [5] and Oliver Wight on MRPII (Manufacturing Resource Planning) [6]. ERP systems can be viewed as packaged business software solutions that allow enterprises to; automate and integrate the majority of business processes, share common data and practices across the entire organisation, and produce and access information in a real-time environment. This typology of system further developed the scope of standard MRP and MRPII systems for new areas of manufacturing business; such as sales management, product data management, purchasing, shop floor scheduling and control, distribution, transportation, financial services, and tracing of historical data for quality systems. Figure 1 details the scope of an ERP system.

At the heart of the ERP system is a central database that draws data from and feeds data into a series of application modules supporting diverse business processes. Using this single database dramatically streamlines the flow of information throughout the enterprise. Also, a high degree of implementations have to undergo bespoke customisation to ensure a reasonable degree of business fit. If standard ERP software is customised, two major problems can occur. Firstly, package integrity can become difficult to maintain and support and secondly, the enterprise can become locked into the version release as it may be prohibitively expensive and difficult to upgrade [8]. ERP may be seen as technological advance that extends the scope of planning, implementation and control to higher and wider levels of capability. The benefits of an ERP system are that it is a multi-business, multilingual, multi-country system that can integrate into a high variety of existing IT systems.

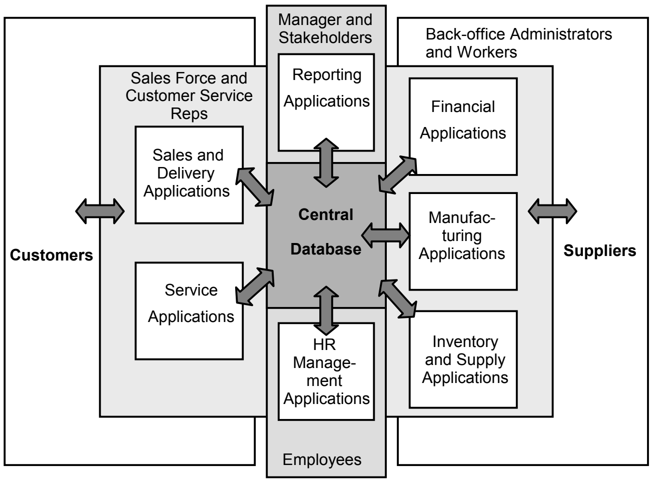

Figure 1: Enterprise System Anatomy, Davenport [7].

Despite vendor claims that ERP systems are all encompassing IT solutions, they can only really act as a primary sub-system for manufacturing supply chains and not total, end-to-end solutions that can generate competitive responses to internal or external requirements [9]. Limitations of traditional ERP type systems have begun to be realised for new mass customised production strategies. The future for ERP may be more as a transaction engine that is based around core processes, such as sales order and invoice processing, rather than as an all-round enterprise-wide solution. Additional CITS applications then may be used to deliver additional functionality to key business areas. These business growth applications require specific attributes: i) Seamless Integration with the core transactional ERP system; ii) Enterprise-access to current information, including web-enablement; iii) Effective data latency; and iv) Portability and interoperability between ERP systems. Huang and Mak [10] have reviewed the use of the Internet to support product design and manufacture, using web-enabled decision support and workflow technologies, but comment the web-based approach is just in its infancy. The challenges faced include extending business processes and applications to provide customer support; as well as supplier and partner collaboration; manufacturing to demand and order; managing maintenance, repair and overhaul operations; integrating the research and design function; together with making decisions in support of product life cycles. Gartner [12] suggests that 'ERP is shifting from the foundational enterprise application to a key component of an inter-enterprise application-oriented environment'. The result is the emergence of what they term 'next-generation ERP' or 'ERPII'. An ERPII application approach emphasises outward-looking collaborative integration, which enables multiple enterprises to co-ordinate activities across the whole of the supply chain.

3.2 Supply Chain Management

During the last few years, business focus has shifted from factory to enterprise level due to the increasing global presence of enterprises. High proportions of manufacturing enterprises are now organised as networks of manufacturing, assembly and distribution sites, which may be scattered around the world. These networks, which we refer to as 'Supply Chains' affect crucially both customer service and the total cost to the customer of products and services. SCM is now recognised as one of the best means by which manufacturing enterprises can make instant improvements to their business strategies and can be easily related to a concept comprising of a stream of activities which are linked together. Kruse [12] defines SCM as 'The process of developing and co-ordinating a sequence of business relationships, in order to deliver optimum end-customer value, whilst satisfying stakeholder requirements'. The Supply Chain Council [13] have developed a valuable model entitled, ‘Supply Chain Operations Reference (SCOR) Model’ that: i) Helps capture the ‘as-is’ state of a process and derive the desired ‘to-be’ future state; ii) Quantify the operational performance of similar companies and establish internal targets based on ‘best-in-class’ results; and iii) Characterise the management practices and software solutions that result in ‘best-in-class’ performance. An overview of the SCOR model is presented in Figure 2 and it can be used to powerfully link together and measure supply chain partner interactions.

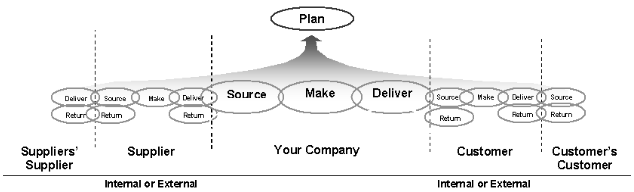

Figure 2: SCOR Model Processes [13].

The success and failure of SCM is ultimately determined in the marketplace by the end customer. Getting the correct product, at the right price, at the agreed time to the customer is not only the route to competitive advantage but also the key to survival. Supply chain performance improvement initiatives strive to match supply and demand thereby driving down costs simultaneously with improving customer delight [14]. First step changes, to optimising enterprise logistic processes have relied upon concepts such as BPR, JIT and TQM to become faster and more agile. But the potential improvement possibility of these approaches is only limited. This is because most of the business processes concentrated upon, within the enterprise, cover only a small proportion of the whole value chain. The implementation of SCM techniques, as a second step, should lead to enhanced cost saving opportunities as the whole supply chain can be considered and optimised. When applying SCM principles, primary factors to consider are supply chain goals and performance measurement?

- How can we get our partners to reduce costs (not our value or prices) and increase flexibility and service?
- How can we get partners to think in terms of the benefits of change to themselves and their own supply chain customers?

3.3 Business Intelligence

Business Intelligence (BI) software tools or as they have been more commonly called, Executive Information Systems (EIS), have been around since the 1980s. EIS can be defined [15] as, 'a computerised system that provides executives with easy access to internal and external information that is relevant to their critical success factors' and can assist in generating considerable cost savings for an enterprise. Typically, BI tools have the following characteristics: i) An easy to use and maintainable, graphical interface; ii) Integrated capabilities for varied data access, security and control; iii) On request 'drill-down' capability to lower levels of detail; iv) Depiction of enterprise key performance indicators; v) Data analysis and advanced report generation and vi) Statistical analysis functionality for summarising, grouping and re-structuring data. BI tools can only become a strategic weapon when business users are able to obtain answers to questions in a time frame consistent with the requirements of a dynamic and agile enterprise. For today's enterprises to succeed they need a level of agility that can only be achieved through decision makers who are able to manage multiple plans in parallel, switching between alternative scenarios in near-real time reaction to new information. BI tools are superimposed onto ERP systems, because underlying data may only be accessible in standard paper-based lists and the development of bespoke reports can be prohibitively expensive.

Data warehousing has the capability to, extend the BI concept and provide an accurate and all embracing data store, upon which all reporting can be based. A data warehouse is said [16] to be 'a collection of technologies aimed at enabling the knowledge worker (executive, manager, analyst) to make better and faster decisions’. An alternative definition is proposed [17], 'A data warehouse is a subject oriented, integrated, non-volatile and time variant collection of data in support of management decisions'. In essence, a data warehouse is expected to have the right information at the right quality, at the right time, with the right cost to support the right decision. In the traditional view, data warehouses provide large-scale caches of historic data. They sit between information sources gained externally or through online transaction processing systems (OLTP), and decision support or data mining queries, following the vision of on-line analytical processing (OLAP). Primitive data is detailed data used to run the day-to-day operations of the company. Derived data is the data that is summarised or otherwise calculated to meet the needs of the management of the company. Live versus historical. There can be seen to be three types of different data warehouse architectures, centralised, federated or tiered. As a consequence the design and implementation of BI solutions can be difficult and complex.

3.4 Convergent Solutions

With the search for new management methodologies and IT solutions to support supply chain collaboration at the fore of current industrial developments, a variety of new solutions have recently been developed. At one side of the corporate spectrum are solutions such as APS, CPFR, Product Data Management (PDM), Electronic Data Interchange (EDI), and industry specific e-trading hubs such as Exostar (aerospace), Covisint (automotive) and Elemica (chemical), have been developed to support more effective strategic customer-manufacturer-supplier interactions. At the other end of the spectrum, more specialised solutions have emerged to support more opportunistic relationship development. Whilst, for customer interaction, emphasis has been placed upon CRM systems development, EC websites, and e-bidding portals such as e-Bay; for suppliers, the picture has been less complete. Within this area work has been focussed upon e-marketplaces and exchanges, but a major issue has been that of supplier quality assurance and proven credibility. To combat this and address process rather than product requirements new SCM portals have been developed such as Yorkshire Forward's Virtual Enterprise Networks (VEN) and the West Midlands Collaborative Commerce Marketplace (WMCCM) [18]. Within such systems, independently quality assured, enterprises are able to rapidly form innovative partnerships, based upon complementary competencies, and serve larger tender opportunities. A high-level landscape of the discussed solutions is provided in Figure 3.

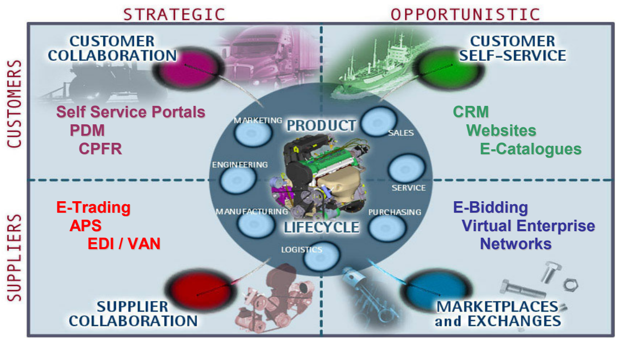

Figure 3: IT Solutions Landscape, Developed From [18].

From the explosive growth and implementation momentum of these collaborative supply chain driven solutions, it can be seen that initial value has been placed upon systems focus and EAI. Whilst this area has been key to strengthening and capitalising strategic relationships, it highlighted the need for: i) Improved BI to better monitor the new, more tightly integrated supply chains; and ii) more holistic and accessible opportunistic solutions for SMEs. Within such a context, the typical long adoption period of contemporary IT solutions by SMEs poses many practical, financial and organisational problems. These, often volatile, enterprises at the lower end of the corporate scale, have resource constraints in terms of technology, skill, finance and business processes that deny them access to the, perceived, fast track approach to competitive advantage and sustained success [19]. Whilst efforts are being made to provide wider systems accessibility to SMEs, through techniques such as integrated EC shop-fronts and XML transaction email by small company IT vendors such as Sage; and shared, portal hosting of APS systems such as Magnugistics within the Elemica chemical e-trading hub; little work is current to deliver integrated ERP, SCM and BI solutions which effectively meet contemporary SME performance requirements.

4 BUSINESS INTELLIGENCE FOR SMES

There has been long recognition that senior management in SMEs must escape the trap of crisis management, and on a more regular basis devote more time to strategic goals. We have seen that there is plethora of often-costly tools, which now exist that, can enable SMEs to gain from the analytical power and decision support offered through collaborative IT solutions. Business environments have become increasingly competitive, managers need to significantly improve their ability to rapidly unlock their existing information databases, and intelligently analyse the available information. However, despite the fact that BI is available this does not mean that it is easy for SMEs to adopt it across their supply chains. There are important architectural and implementation issues that need to be addressed before they could take full advantage of the analytical power of these solutions. Essentially, a practical approach to supply chain BI implementation is needed. The approach should allow SMEs to evaluate quality, time and cost effectively.

4.1 Industrial Cluster Investigations

To supplement the descriptive research base, already undertaken within the earlier section of this paper, it was envisaged that further survey and case study investigation would be required to more fully develop understandings of the problematic situation. To this end, a rapidly growing local industrial cluster group was selected for survey. This comprised the standard industry classification code defined, Creative and Digital Industries (CDI) cluster, based within the Yorkshire and Humberside Region of the United Kingdom. This cluster comprises: 13,400 enterprises, of which 99.4% are SMEs; 123,000 employees with 65.1% working within SMEs; and growth over the 1998-2004 period of 19.4% [20]. A survey questionnaire was developed; encompassing sections relating to the business environment, supply chain collaboration, systems implementations and key issues. Of the 100 enterprises surveyed, 47 usable responses were received (47%) and comprise the survey findings. From the responding enterprises, the following key results were elicited. All enterprise management were concerned about the impact globalisation would have on their business, profitability margins, and decreasing UK markets. Whilst 62% agreed that the establishment of more collaborative partnerships was a key issue, only 19% were actively pursuing opportunities at the time. All surveyed enterprises, did have websites and familiarity with Internet technologies, but only 26% had an EC shop-front capability, with a further 8% using further forms of electronic trading partner integration. Of this group of 4, all had been forced to adopt the new solutions due to customer pressure. Whilst only 21% had implemented a recognised ERP system for business operations, 63% did utilise a computerised system for basic financial administration, with the rest using a mixture of paper-based and spreadsheet systems. Of the enterprises that had implemented ERP, all but two ran MRPII/MRP for manufacturing control, with one using an integrated APS and the other a Distribution Requirements Planning (DRP) solution. 57% Used a BI tool, other than spreadsheets, to monitor their business performance, with 9 out of the 27 using a third party application for BI such as Seagate Crystal Reports or Cognos. None of the enterprises within the survey could provide any externally shared metrics across their supply chains, but all would welcome such a development if it could be effectively provided. In summary, SMEs are not well engaged in collaborative and performance-driven approaches to integrated SCM. Whilst closer collaboration with trading partners is desired, easy to apply methodologies and solutions seem not to widely exist. The main problems relate to overall perceived costs, expanded timescales, fear of new technology, and unclear benefits. Key issues were cited as legality, viability of partners, trust, security and different company cultures.

4.2 Requirements Formulation

From the earlier findings presented in the paper, more detailed work was undertaken with a small CDI cluster group to define potential characteristics of SMEs that operate supply chain strategies and to identify partial requirements for the development of test-bed solutions. Through previous institutional research work a supply chain group of four collaborating companies was established. This linked group comprised a customer, a manufacturer and two suppliers. All enterprises utilised various forms of IT for their main business operations, but no methods of electronic supply chain integration had been employed. Primary trading between the partners was conducted through paper-based business documents comprising quotations, purchase orders, delivery notes and invoices. Further communication was undertaken by telephone, fax and email, with occasional face-to-face meetings. With high-level business and process analysis undertaken by the researchers over a period of 4 weeks, management representatives from the group enterprises were assembled at a workshop to brainstorm performance management issues and discuss potential attributes for a pilot test-bed solution. Throughout the period of analysis individual performance statistics were collated and then additionally shared at the workshop. During the workshop discussions, essential requirements for new solutions were considered and validated by the research partners. These business and technical requirements comprised:

1. Provide shared business and process performance monitoring (horizontal and vertical integration) through partner supply chains throughout the entire life cycle of the products and services supplied.
2. Deliver support for virtual enterprise development, to enable supply chain partners to maximise opportunities for collective work delivery.
3. Enable and support partner collaboration, whilst maintaining individual system integration, security and ensuring an environment of trust.
4. Provision of accurate, relevant, real-time and concurrent planning information upon all supply chain aspects, which are capable of deeper interrogation.
5. Supplied data is provided in a well-grained format that is relevant to appropriate levels of information security and organisational decision-making.
6. Provide proactive alerting of problems, throughout the supply chain, so that awareness levels are raised. An important principle was that BI should be as timely as possible. All too often delays would only surface on delivery due dates. As such, little corrective action could be implemented.
7. Data validation and consistency checking facilities are integral to the whole system, so as to enforce systems integrity.
8. The new system would need to be easily accessible, low cost, low risk, secure, and require little technical maintenance.

The characterisation of these high-level BI requirements presented within this paper section were developed to provide an abstract picture of how new, collaborative systems might be shaped and what additional functionality and capability would need to be provided in this domain. Newly developed systems, which incorporate listed capabilities, should more effectively contribute to supply chain goals and deliver significantly improved performance.

5 PILOT IMPLEMENTATION

From the conducted research, it was concluded that the most appropriate methodology to effectively investigate and prove the concepts under study, would be through the implementation and testing of a supply chain BI execution solution. The solution would form a process-orientated test-bed system and would be based upon a 3R approach, namely; Right Quality, Right Time and Right Cost. The aim of the system would be to take the best elements of existing collaborative systems and develop a novel and improved solution, which could be used to improve competitive performance for a cluster group of trading partners, whilst meeting some of the identified issues and new requirements presented within this work. Part-evaluation of the system could then be undertaken through an industrial pilot implementation.

5.1 Test-Bed Development

The primary design attributes of the systems were simplicity, collaborative supply chain visibility, and monitoring, proactive alerting based upon a tiered user model, and ease of integration within existing research partner IT systems. From detailed consideration of existing systems architectures, their functionality and limitations, together with the newly developed collaborative BI requirements, a detailed requirements specification was developed and authorised for design and implementation. The central aspect of the test-bed would comprise:

- The development of a neutral format Internet portal, with the capability to manage collaborative virtual company formation and supply chain enablement and execution.
- Provision of a shared planning grid for online partner modification and discussion, together with integrated purchase and works order requirements workflow.
- Business document import and integration functionality for products, bills of material, lead-times, schedules and inventory.
- Incorporation of standardised Extensible Mark-up Language (XML) business document formats.
- Modified transaction routines for real-time business data extractions, transformation and DW load.
- Implementation of a shared traffic light based problem-highlighting system for overall issue monitoring.
- Performance measurement reporting based upon printed reports, portable document format (PDF) delivery and online reporting analytical processing.
- Proactive problem alerting, based upon a tiered user architecture, which would allow rapid notification, based upon defined management authorities, using online reports, emails and SMS messages.

The initial, developed system was designed to conform to an idealised SCM process flow. This comprised:

1. The placing of an electronic XML purchase order into the Internet portal from a Customer's business system.
2. Manufacturer review and sales order acceptance.
3. Manufacturer XML integration uploads of extracted ERP products, bills of material, lead-times, schedules and inventory.
4. Manufacturing schedule explosion to planned works order and purchase order requirements.
5. Supplier requirements notification, delivery planning, schedule discussions and approval.
6. Supply chain wide monitoring utilising an inbuilt traffic light monitoring and alerting system for issues raised.
7. Supplier to Manufacturer delivery notifications and automatic progress updates.
8. Manufacturer to Customer notifications and automatic sales order completion.
9. Automatic supply chain performance monitoring, based upon automatic data warehouse feeds and online reporting, using product quantity, delivery date and price criteria.

An architectural overview and sample screens of the system can be viewed in Figure 4. The test-bed environment was run on a common open source platform, but client-server and web enabled BI software from vendor Cognos was used for integral reporting and OLAP interrogation. The Customer had implemented a Sage accounting system, for which an XML extraction utility was created in Visual Basic, whilst the Manufacturer's ERP package was BAAN. For this system bespoke extraction utilities were constructed using its inbuilt 4GL development tools. System notification alerts and proactive reports were distributed via a Microsoft Exchange Server and 3rd Party SMS gateway based upon a matrix of issue escalations, management authority, and defined user groups. The test-bed transaction engine was designed such that changes to activity based upon product quantity (*or quality*), delivery date (*time*), and price criteria (*cost*), were automatically tracked and updated within the developed DW.

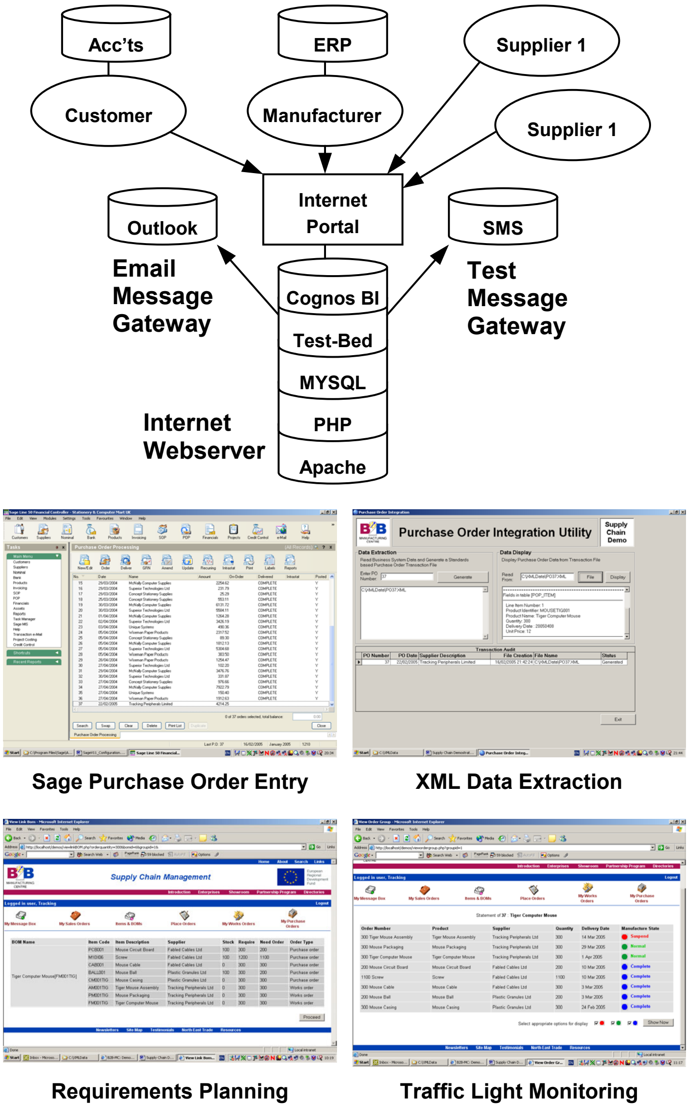

Figure 4: Test-bed System Overview.

5.2 Development Evaluation

The test-bed system was pilot tested and evaluated over a period of two weeks by the four partners who had been previously involved in the requirements phase. For the evaluation process a range of existing product line items, with relatively short-lead times, were run through the system. Overall, the system worked as anticipated. Data extraction routines were successful and planning applications could be considered on-line with verbal telephone support. Setting specific times each day to discuss system progress between the partners, genuinely improved inter-relationships and communication. Problems were encountered though with training, familiarisation with the alert system and the additional workload required to feed and continually maintain the system. Within the period of the pilot, the systems value was proven when one of the suppliers had a machine breakdown and as a consequence product delivery would be delayed. The delivery due date was amended within the system, the relevant traffic light turned red and all the partners were notified by the relevant mechanism; SMS for factory planners and email for production managers. Delivery date changes were made through the system and an issue review was undertaken at the next planned conference call. Regular monitoring reports were produced from the DW and BI system showing previously unavailable holistic supply chain data. Feedback from the partners was encouraging and all felt that a more fully developed system would allow then to better manage their work. All highlighted the fact that it is much better to be aware of a problem as soon as possible, rather than for await potential bad news later on when no corrective action may be taken.

6 CONCLUSIONS

This paper has presented a novel approach to the implementation of a supply chain BI execution system. Whilst largely conceptual in nature, the development and evaluation of the test-bed, have shown encouraging results. The methodology and design concepts could quite be quite easily extended to both larger enterprises as well as to other industrial groups. The applications technology is widely available and low cost. Whilst issues around security, maintenance and support remain, it is clear from the research and user responses that this typology of system will continue to evolve over forthcoming years.

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