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SCOR Modelling of RFID Enabled Supply Chain for ROI Analysis

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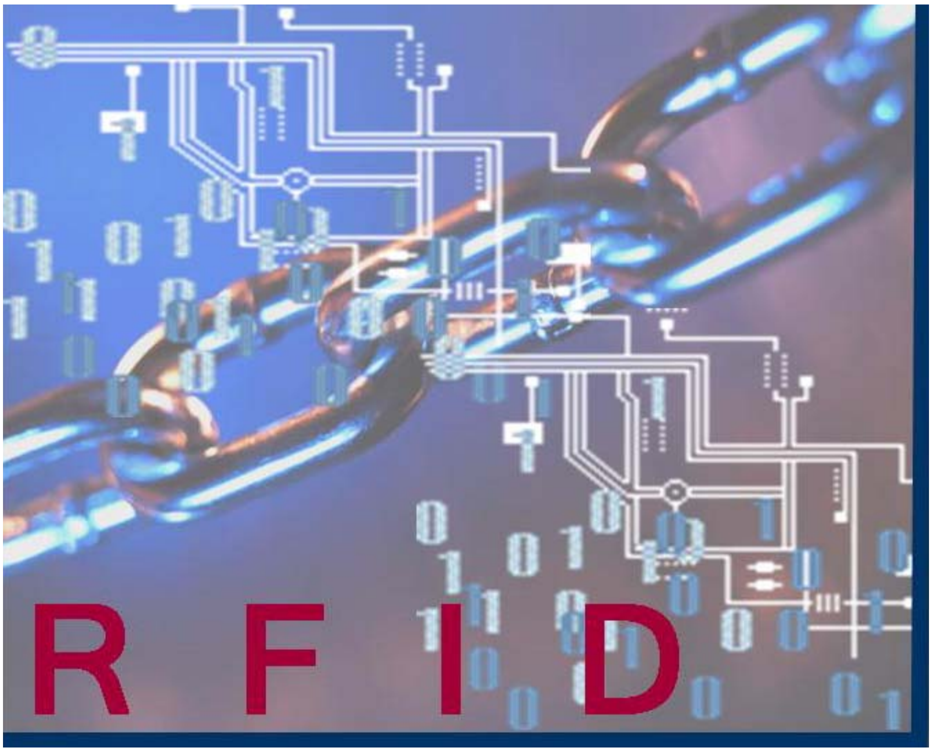

The Logistics Institute Asia Pacific

A Collaboration Between

NUS National University of Singapore

Georgia Institute of Technology

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The Logistics Institute – Asia Pacific (TLI – Asia Pacific) is a collaboration between the National University of Singapore and the Georgia Institute of Technology. Modelled after The Supply Chain and Logistics Institute (formerly TLI) at Georgia Tech, the Institute's vision is to be the premier institute in Asia Pacific nurturing logistics excellence through research and education. TLI - Asia Pacific was awarded the prestigious Asian Freight & Supply Chain Award (AFSCA) for Best Educational Course Provider for four consecutive years, from 2003 to 2006.

The Institute provides postgraduate education in logistics and SCM at the MSc and PhD level, notably the Dual Masters Degree in Logistics and SCM. It also undertakes leading-edge research and development in supply chain engineering, technology and management in collaboration with industry; and hosts a regular series of Think Tables that brings thought leaders in research and industry to discuss contemporary issues, challenges and solutions in supply chain management in a dynamic environment.
The key research themes for Phase 2 include:

Supply Chain Intelligence: This area seeks to focus on providing an overarching analysis of the logistics market, the trade flows, and economic barometers of the various countries in Asia as far as it pertains to effective supply chain management for various industries. Interest in this area is heavily driven by data, empirics and company cases. The Institute conducts annual on-going surveys to test the pulse of the respective markets and industries such as cold chain, 3PL, etc.

Supply Chain Optimisation: This, being the traditional and existing strength of the Institute, seeks to deepen expertise in supply chain global network design and optimisation, involving the respective modes of transportation. Intensive supply network simulation on a regional/ international basis e.g. port and maritime logistics, consolidation of logistics hubs, flexibility of regional distribution centres are a primary feature of this group. Other areas of interest include system productivity at the port, the integration of manufacturing and services within the value network, dynamic pricing and revenue management for high end perishables, and the study of mergers and acquisition and its impact on the respective industries.

Supply Chain Technology: This is an emerging area for the Institute, which intends to look at the test bedding of RFID and data capture related technologies, within the context of an independent environment. Work done in this area involves both investigative led research and joint development of supply chain technology based innovation with other agencies and companies. Policy and implementation issues pertaining to new supply chain technology and the end-to-end supply chain network are undertaken on a contract research basis.

SCOR Modelling of RFID Enabled Supply Chain for ROI Analysis

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SCOR Modelling of RFID Enabled Supply Chain for ROI Analysis

Executive Summary

This paper is set in the context of providing a framework for ROI analysis for a Global Supply Chain ecosystem that is RFID enabled. Adoption of RFID technology is a significant business investment for most organizations, requiring commitment to build a solution with dedication of resources and funding to implement the project. The use of RFID technology offers opportunities for further supply chain automation, making the processes efficient, providing accurate and timely data capture, thus improving the reliability in the handling of any shipment item from make to delivery.

For any organization considering RFID implementation in their supply chain, a formal justification of the business case will help gain project implementation approval from management. Our intention is to provide a modelling tool for this purpose, with a structured approach to identify whether the RFID project will generate positive business benefits and a tangible ROI. Our method involves quantitative analysis of labour costs and productivity gains achieved through RFID data and process automation, and better use of manpower resources within business processes.

RFID implementation involves an opportunity to critically examine business processes and re-engineer them with the goals of improved data-capture and reduced data-entry error. One of the many benefits is the reduction in manual processes through automated data capture to improve productivity, thus allowing manpower resources to be reallocated.

The approach described in this paper uses the Supply Chain Operation Reference (SCOR) model for business process modelling of the supply chain with the ability to capture the data elements used in the process. The use of SCOR provided a common language to model the related business processes across the whole supply chain in a panoramic way and enables business processes to be analyzed at different levels.

RFID Landscape

RFID today is not rocket science like it used to be since the proliferation of commercial-available RFID products in the market today. RFID vendors have been conducting trials and collaborating with users. The results are pockets of RFID applications across the island, across multiple industries. RFID adoption in Singapore is moving forward, albeit slowly. Almost all the RFID applications being implemented are closed-loop systems. Those who are not adopting are looking for viable business cases to justify their investment. To champion this cause of justifying RFID investment, TLI-AP has developed a ROI calculator for the supply chain industry using the SCOR model for process modelling.

SCOR Model

The Supply-Chain Operations Reference-model (SCOR) is a process reference model that has been developed and endorsed by the Supply-Chain Council. Widely promoted, it has gained acceptability. The supply chain models developed in this paper were based on the SCOR method in order to provide a common language for disseminating the results among supply-chain partners. The Model itself contains several sections and is organised around five primary management processes, namely: Plan, Source, Make, Deliver, and Return as defined in SCOR. The “as-is” state and the desired “to-be” state are documented using the SCOR process terminology.

SCOR is a hierarchical model with specific boundaries in regard to the supply chain management processes. In terms of process decomposition, it contains three levels of process detail. The hierarchical decomposition, using the Deliver management process, is illustrated in Figure 1. However, the four other management processes are not shown.

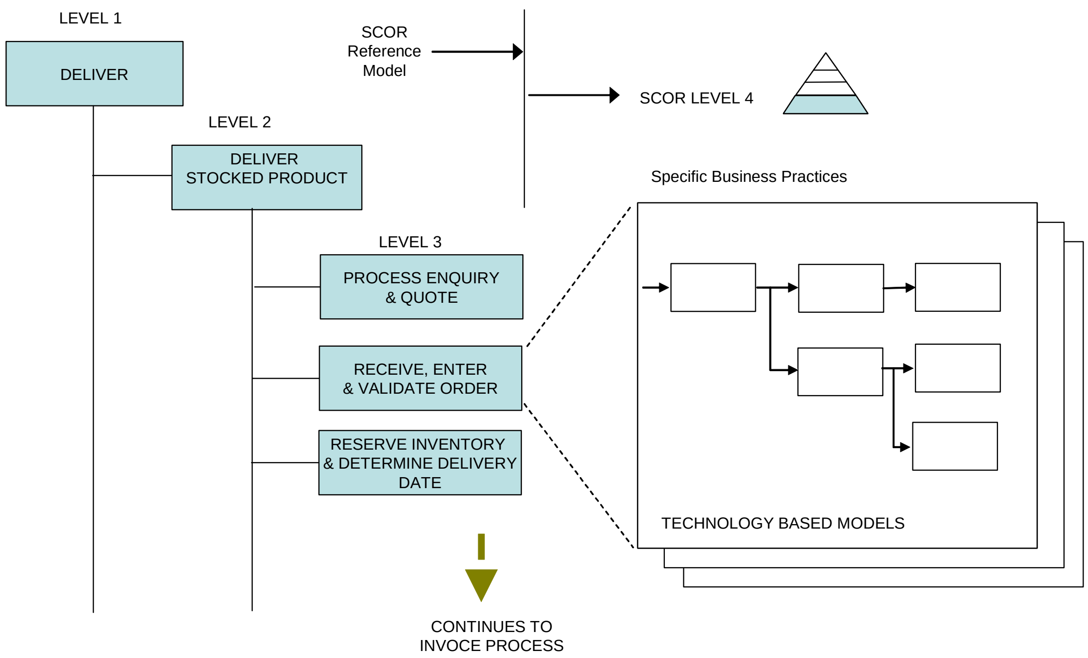

Figure 1: Modelling of specific business processes at SCOR Level 4

The primary management processes of Plan, Source, Make, Deliver, and Return are defined at Level 1. Within the Deliver process, there are other Level 2 processes, such as: the “Deliver Stocked Product”, the “Deliver Make to Order”, the “Deliver Engineer to Order” and the “Deliver Retail Product”. Each Level 2 process is further decomposed into “Configuration Processes”, which are at Level 3.

The SCOR model is focused on three process levels. It does not prescribe how a particular organization should conduct its business or tailor its systems information flows. This research examined supply chain improvements using the SCOR-model through extension of the Model to Level

4. With the incorporation of RFID technology, specific processes are modelled at Level 4 to reflect how the supply chain costs and savings would be affected. With this approach, the definition of the reference model to Level 3 provided a reusable framework of SCOR supply chain processes and helped us avoid the wastage of re-invention.

ROI Analysis of an RFID Enabled Supply Chain

The proposed framework for this research is illustrated in Figure 2. The SCOR model is used as the foundation which also enables portability of the resulting technology models. Business processes are mapped based on the SCOR level 3 processes and from there, the resources, inputs, outputs and triggers of each process are identified and the data are extracted into a spreadsheet. The ROI calculator is embedded in the spreadsheet and computes the ROI based on the data provided.

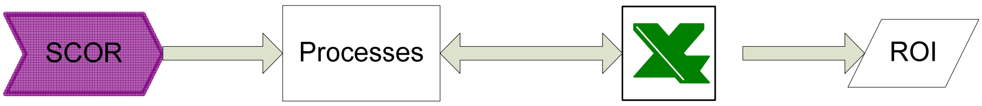

Figure 2: The approach to modelling ROI

In modelling SCOR activities, particular attention was given to factors such as terms of the costs and time that are consumed by individual activities. Certain investments in technology allow business process or re-design improvements. For this reason, the inclusion of cost and time factors enabled ROI analyses is to be carried out across the process chain.

RFID technology enhances visibility and accuracy of information throughout the supply chain via the automated collection of product data, as well as data associated with product movement. The study of the supply chain therefore progressed from the business process layer into the data layer. This was to focus the modelling of data elements that could benefit from RFID automation and quantifying the associated cost and time weightings for subsequent ROI analysis.

IDEF0 is a descriptive method that shows the activities of a process. It is a notation for specifying the input, control, output, and mechanisms (ICOM) associated with each activity. Figure 3 is an abstract view of the IDEF0 notation.

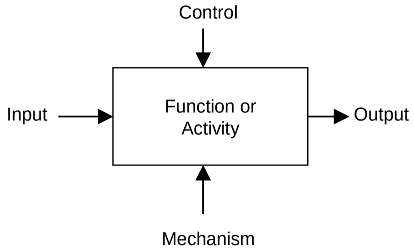

Figure 3: The IDEF0 Notation for Function or Activity Modelling

In addition to the activities, the arrows represent the "data" associated with the ICOMs. Inputs are the typical artifacts such as resources consumed or transformed by a process. Output(s) are the results of the transformations of the inputs by the process. Controls are the standards, policies, guidelines, etc., that guide the process. Mechanisms are the agents (people, manual tools, automated tools, etc.) that accomplish the actions delineated within the process.

An example of applying the IDEF0 notation to the supply chain process is a process artifact representing the shipment documentation (see Figure 4). Key data elements may include the Container Number, Shipper Details, Products, Quantities or Packing Units. The data identified are in an un-normalised form, which in terms of data analysis would be the initial step in the process of restructuring a logical data model.

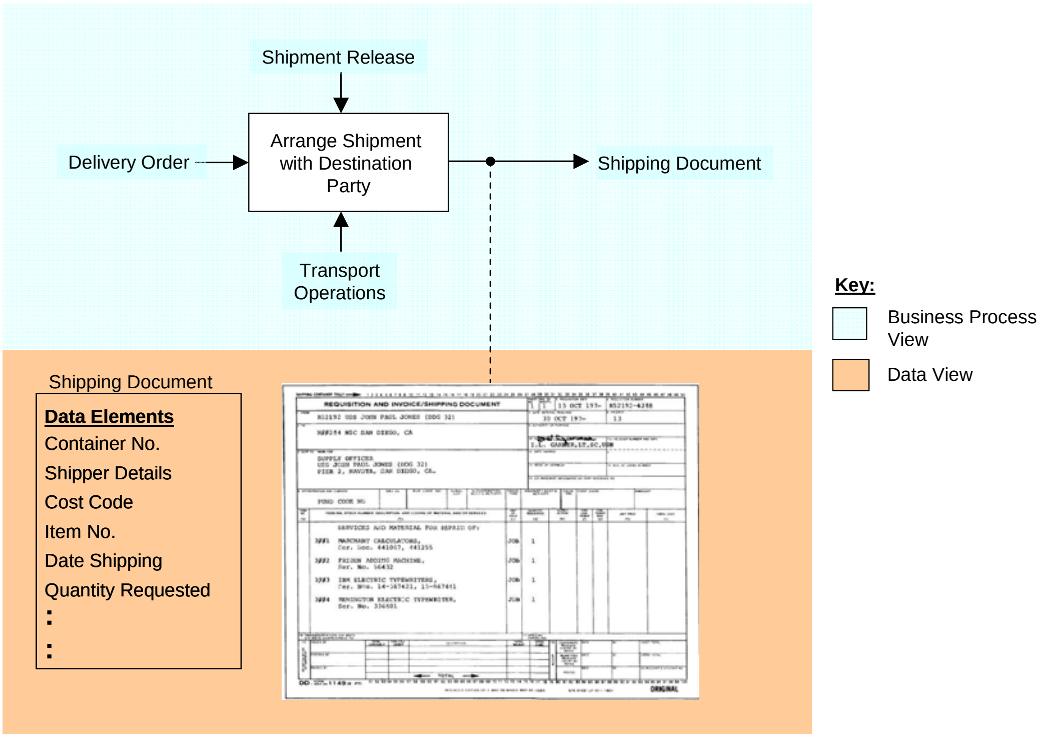

Figure 4: The identification of a process artifact and associated data elements

The concept of cost penalties is introduced at the stage where the activities are analyzed and where the artifacts are identified. The transition from process modelling to data analysis was made by examining the process artifacts. At this stage, the authors were concerned with associating a “penalty” against the artifact, such as the time or cost taken to populate the element of data. This approach was taken with a view to weighting the overheads of data redundancy in systems.

In addition to the approach of collecting cost and time weightings to measure ROI at the data-element level, it is likely that inefficiencies will exist in their operations. Examining the process in terms of the business process chains should be done in anticipation of achieving savings in labour and operational efficiencies. Significant opportunities for improvement are likely to exist in these areas and major improvements can be achieved prior to applying RFID to the "to-be" process. Cost and time implications also exist at the data level, when RFID technology is used to automate data entry, e.g. product location as opposed to collecting the data via bar-code technology, or even manually with pen and paper. Automated collection of data enables a smoother throughput of shipments by reducing manual operations. Moreover, the accuracy of information is also improved. For the purpose of determining ROI, the method that is discussed later will provide a quick means of identifying cost differences when processing paperwork manually and when technology is used to simplify the task.

SCOR Modelling Tool

To benefit across different horizontals of the industry and to make the SCOR model readily usable, a visual modelling tool was developed. This visual tool was based on the SCOR process hierarchy and incorporated the IDEF0 modelling method for describing the individual activity. The modelling tool can be readily distributed to supply chain partners, which may provide a means to increase the uptake of SCOR. The tool provides two instances of the SCOR hierarchy in terms of the "as-is" and "to-be" models.

The software perspective of the tool is shown in Figure 5, and presents the UML model upon which the logic of the tool was based.

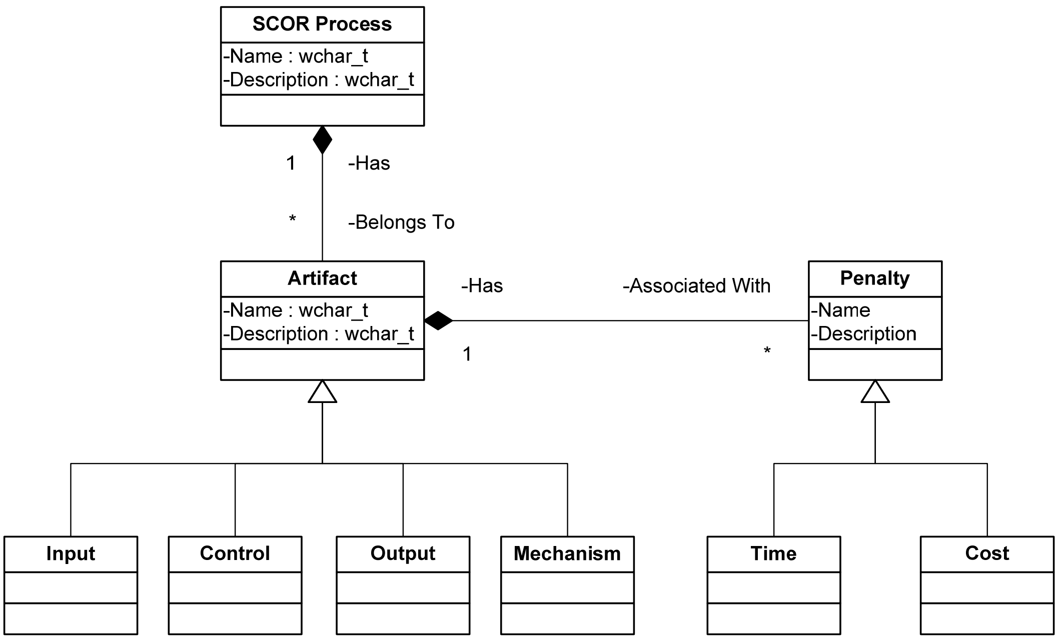

Figure 5: UML representation of the SCOR activity model

The model implements the IDEF0 constructs (as previously shown in Figure 3**Error! Reference source not found.**) and extends the modelling notation to capture the cost and time overheads. The activity has a collection of artifacts, which is indicated via the aggregation relationship, shown in

Figure 5, between the SCOR Process and Artifact classes. The sub-typing of the artifacts into Input, Control, Output and Mechanism is shown via the inheritance relationship between the individual child artifacts and their parent Artifact class. An advantage of inheritance relationship is that the ICOM classes that have similar interfaces can share a lot of code, reducing the complexity of the program. This was also applied for the Time and Cost, which inherit from the penalty class. Figure 5 shows the relationship between the Artifact class and the Penalty class, where each artifact is associated with a cost and time penalty. The software structure of the modelling tool was designed to promote code re-use and to make it easily extendable (where behaviour may be specialised via overriding functions of parent classes).

Implementation of the SCOR Model Hierarchy

The SCOR process hierarchy is implemented using a tree control (shown in Figure 6), which is a type of control that provides the ability to show the hierarchical relationships of the SCOR processes, indenting the child processes and showing the sibling processes at the same level. The user can navigate through the individual processes in the SCOR model by expanding the list of child processes of an individual parent.

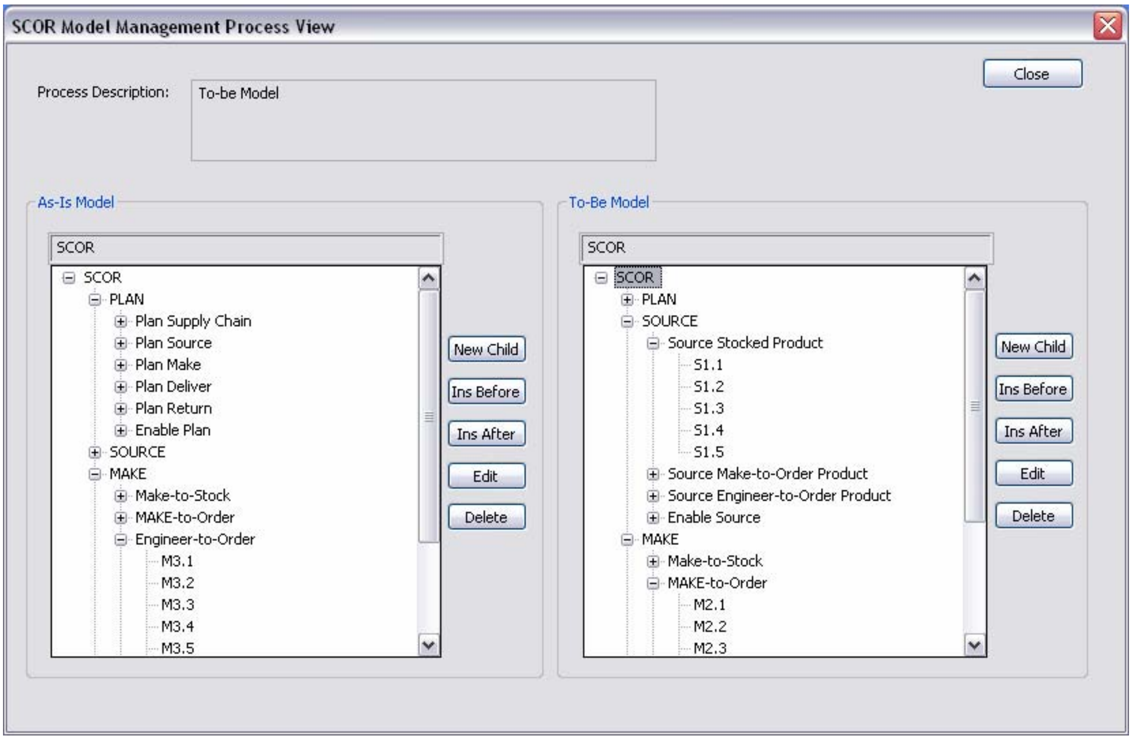

Figure 6: Using the SCOR process hierarchy

The “as-is” model is presented in the left pane and the “to-be” model is presented in the right pane. The SCOR model is fully implemented, providing end-users with a suitable basis for tailoring their models. End users may insert or delete new processes as appropriate, in order to create the configuration of specific business processes at SCOR Level 4 (illustrated previously in Figure 1). A particular study tends to be focused on specific processes, for example, the Make-to-Order branch. It is possible therefore, for other branches of the hierarchy to be deleted where appropriate. Using the tree control, users may expand or collapse the various levels of the SCOR tree and navigate through the various levels. The most important feature is the ability to create two models ("as-is" and "to-be") for comparative studies.

As shown in Figure 7, in order to capture the time and cost data associated with the processes, an activity control is presented to the user. It implements the constructs of the IDEF0 notation which was described previously in Figure 5. This was designed to provide a visually-friendly means for capturing information about the process artifacts. Each activity has cumulative time and cost components determined by the contents of the process artifacts. Process artifacts may be added, deleted, edited or viewed to reveal further details.

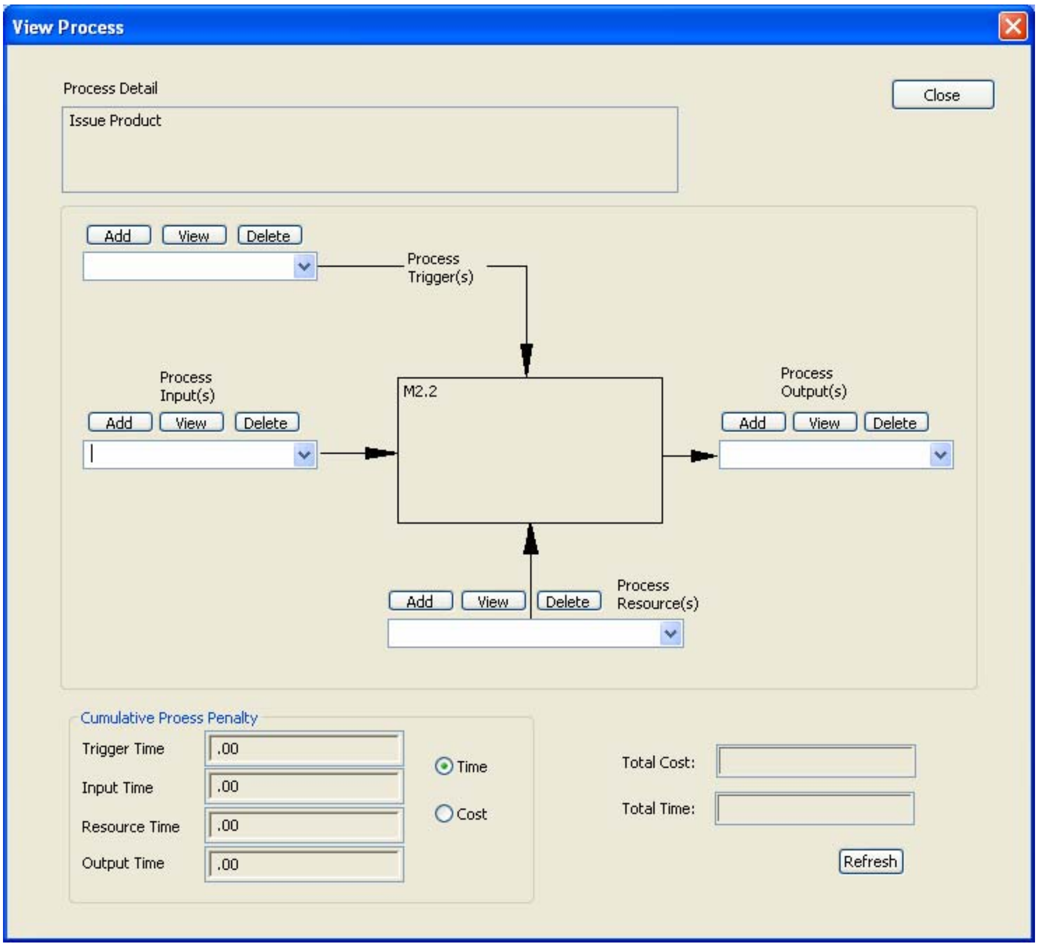

Figure 7: The Activity Control

Cost and time are accumulated and displayed for individual ICOM(s), and accumulated in terms of a total cost and time for the activity itself. The user may view either the cost or time value by selecting the appropriate check-box.

For each SCOR activity, four individual combo-boxes are associated with their corresponding ICOM arrows. Each combo-box provides a drop-down arrow that users click to display the associated list of process artifacts, shown in Figure 8.

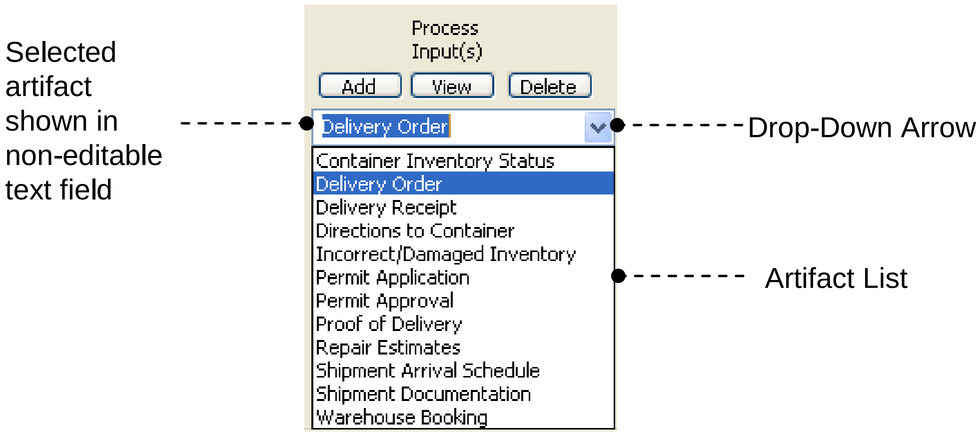

Figure 8: Associating Artifacts to the Process Input

If the list of process artifacts is too long to display fully, a vertical scrollbar appears to allow scrolling through the list. This enables the user to add a number of artifacts for each ICOM and when artifacts are created, cost and time may be specified. The current artifact selection appears in a non-editable text field next to the drop-down arrow.

The view into an individual artifact may be expanded to show the overheads and further data elements if relevant. An artifact, as shown previously in Figure 4, may be a document that comprises several data elements, which the user may consider necessary to model in detail in order to measure their impact on the process in terms of their overheads. This is achieved by the modelling tool using the detailed view of the process artifact, shown in Figure 9.

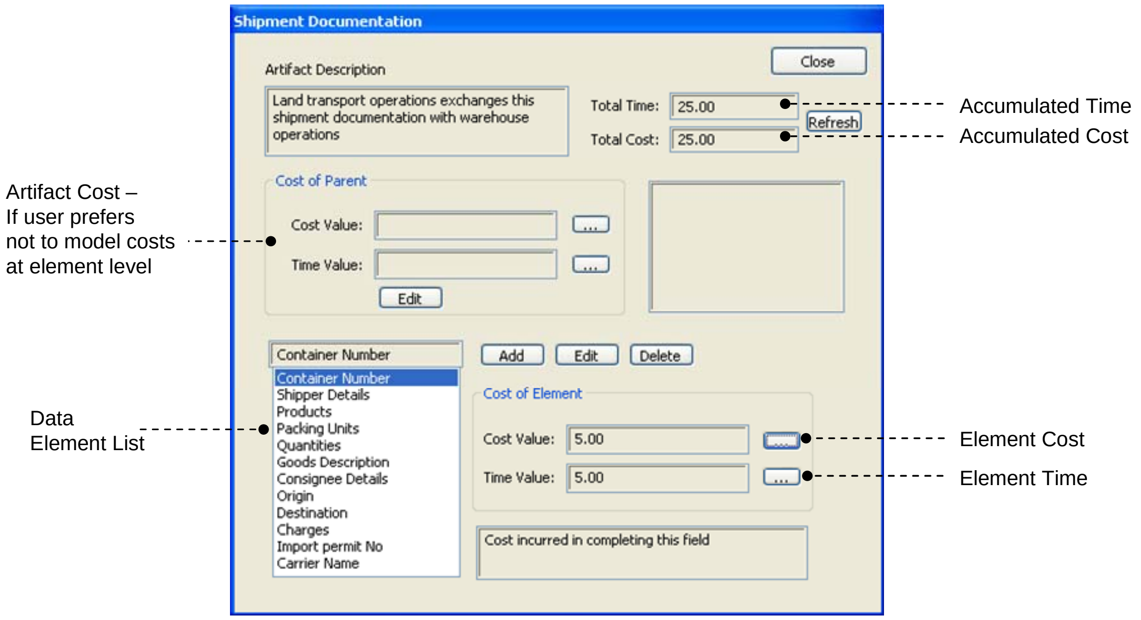

Figure 9: View of a process artifact

The expansion of the artifact view demonstrates how an item such as a shipment document, which may comprise several data elements, such as: Container Number, Shipper Details, etc. is modelled using the extended SCOR concept. Two levels of penalties are shown in Figure 9. These are related to the time and cost of the artifact and also to the time and costs associated with an individual element. This is to give the user flexibility to model costs either at a more abstract level, i.e. in terms of the overall cost of an artifact or to account for the contribution of the individual elements to the time and cost of the artifact. The weighting in terms of the cost and time of individual artifacts may be similarly modelled for all the SCOR process ICOMs.

ROI Analysis

ROI analysis is important for the justification of an investment where the investment is evaluated by comparing the magnitude and timing of expected gains to the investment costs. To involve a wider number of stakeholders, the details of the Cost and Time data collected are output into a spreadsheet for subsequent analysis. The ROI calculator developed in this research is based on a Microsoft Excel spreadsheet and uses VBA to aggregate all the data collected via the SCOR modelling tool.

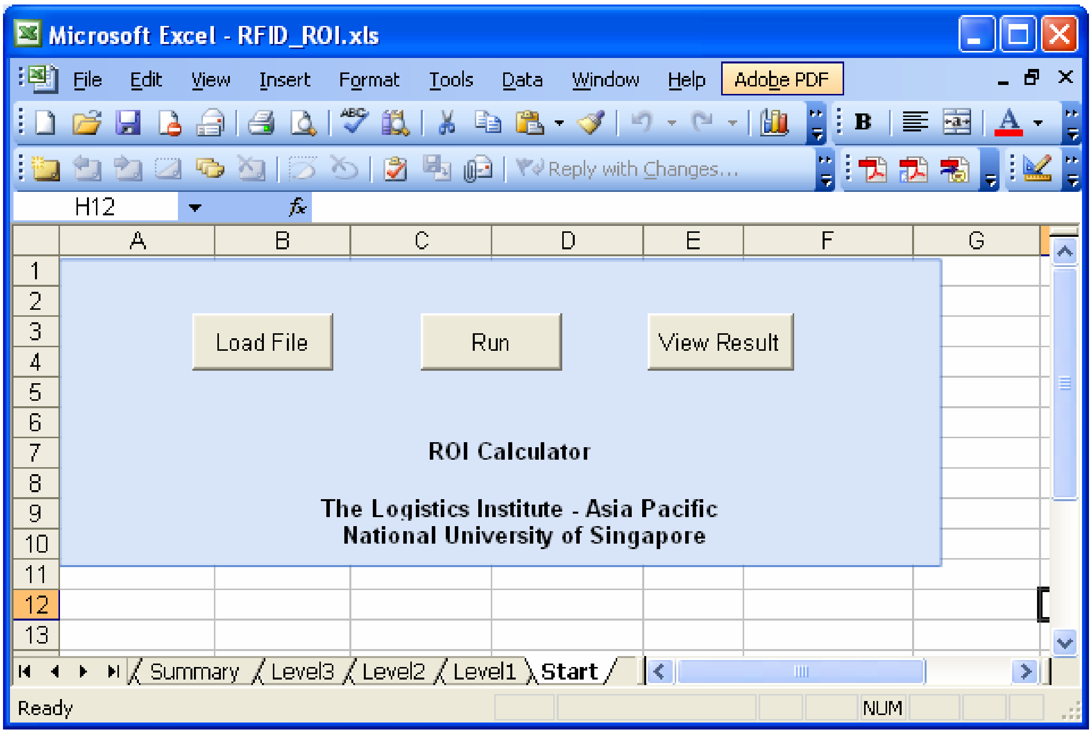

Figure 10: Interface of the ROI Calculator

Figure **10** shows the interface of the ROI calculator. First, the file generated from the SCOR modelling tool needs to be loaded. The "Load File" button is used to import the input file, which should be in the following hierarchical format, where items, costs and times are separated by tabs; there should not be any blank line in the file. Processes and sub-processes are differentiated in the way they are represented in the SCOR model.

To-Be Output from SCOR Modeller

Plan cost time

Plan supply chain cost time
P1.1 cost time
P1.2 cost time

Source cost time
…

As-Is Output from SCOR Modeller

Plan cost time

Plan supply chain cost time
P1.1 cost time
P1.2 cost time

Source cost time
…

The “Run” button in Figure 10 aggregates the data from the input file and summarizes them at SCOR level 1, 2 and 3 and puts the overall cost and time into the “Summary” worksheet shown in Figure 10. The aggregation of cost and time is made in a way that all cost and time happen at a particular level and all subordinate levels are summarized up to that level. Therefore, comparison can be made for different processes at different level.

Case Study

The case study investigates an IT product assembly line, where the RFID technology is used for assembling and handling over to a third party logistics (3PL) provider. The results shown here have been sanitised as the real numbers are confidential to the manufacturer. The assembly process needs to associate part A and part B serial numbers with the box which they are packed in so that tracking of products can be achieved.

The “As-Is” Assembly-Dispatch Scenario

The “As-Is” scenario for the assembly, test and packaging lines is supported by barcode technology. Parts are assembled to order after which the assembled unit undergoes several stages of testing before the final packaging and is sent to a dispatch area for pallet building.

To associate parts serial numbers with the box serial number, the operator needs to switch operations between packing equipment and scanning barcode serial numbers. Therefore, picking up a barcode scanner, performing the actual scan and replacing the scanner handset in its original position need to be carried out whenever a serial number needs to be recorded.

Following the final packaging, the shipment of several cartons is consolidated into a pallet and the pallet is physically handed over to the designated 3PL. This takes place in close proximity to the end of the packaging area, prior to moving the pallets to the loading and transport bay. At the hand-over, the barcodes of the several cartons on a pallet are scanned. Then the pallets, along with the necessary dispatch paperwork, are given to the 3PL. The process of scanning the individual carton barcodes is a time consuming activity. From the perspective of the manufacturer, one person is required to hand-over the consignment of pallets to the 3PL handlers. From the perspective of the 3PL, two handlers are required to accomplish the confirmation scanning and the take over of the pallet consignment.

Before the 3PL loads the pallets into trucks for dispatch, the handlers from the 3PL shrink-wrap the pallets and consolidate them into full truck-loads.

The “To-Be” Assembly-Dispatch Scenario

The “To-Be” scenario for the assembly, test and packaging lines is supported by RFID technology. RFID tags are printed and applied to the carton instead of using barcodes. Therefore, all serial number associations can be done automatically through the RFID technology. The operator only needs to concentrate on the packing activities. This considerably reduces the manual handling activities and consequently speeds up the packaging rate. Furthermore, the person who handles the packaging is alerted when a wrong part is included in the package. As a result, should mispacking occur, there is also the traceability feature to the source of the problem. Similar to the previous situation, the parts are sent to a dispatch area where they are consolidated into a shipment comprising a pallet of a number of cartons.

The shipment is consolidated following the packaging and each pallet (on a pallet truck) is physically handed over to the designated 3PL. A total of four RFID antennas are installed (facing two opposite sides of the pallet) and these read the RFID tags as the pallets are pushed between them. From the perspective of the manufacturer, this is accomplished by a single handler and there is no reduction in cost. From the perspective of the 3PL, there is a saving of one handler and this cost saving is passed to the manufacturer in terms of a reduction in the cost per pallet handled.

Apart from the ordinary order consolidation and shrink-wrapping activities as in the “As-Is” scenario, a further RFID scanner is installed for the benefit of the 3PL in the loading bay as the 3PL had a separate operation to scan the RFID tags prior to shrink wrapping and loading onto the trucks.

Process Analysis

The RFID Process Modeller developed in this research is used to capture the various activities involved in the barcode and RFID enabled processes, respectively. The “As-Is” and “To-Be” scenarios are modelled and the corresponding costs are captured as penalties as shown in Figure 11.

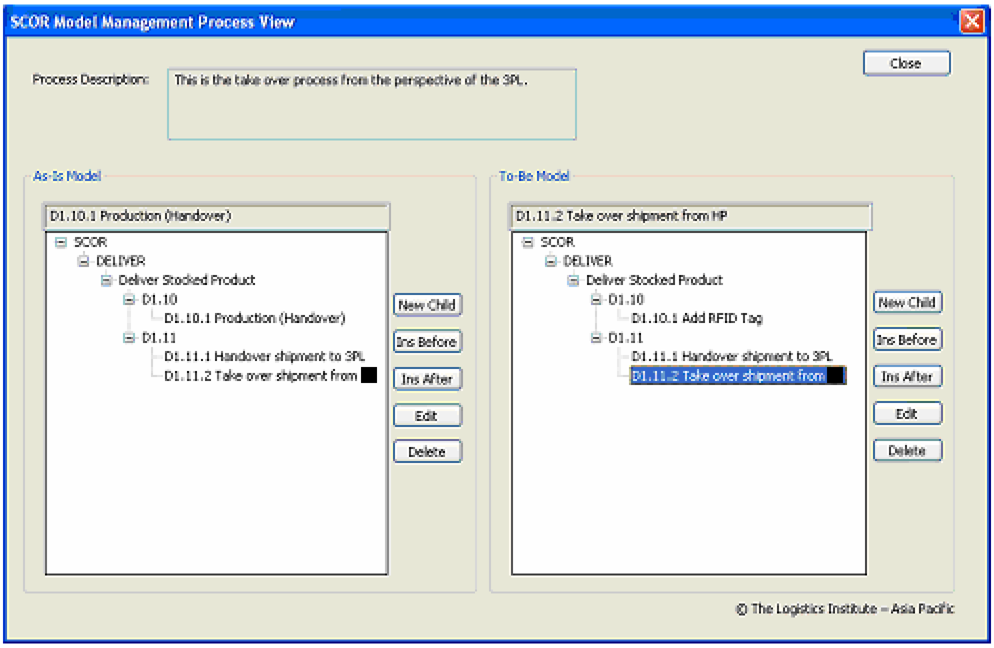

Figure 11: Use of the RFID Process Modeller to model the assembly and dispatch

In the case of the cost savings that are passed to the company from the 3PL, this is modelled as a negative value as shown in Figure 12. The cost savings are given in terms of the cost per pallet, i.e. where the 3PL is able to reduce the number of manual handlers by one. The capture of other cost and time components can be modelled similarly.

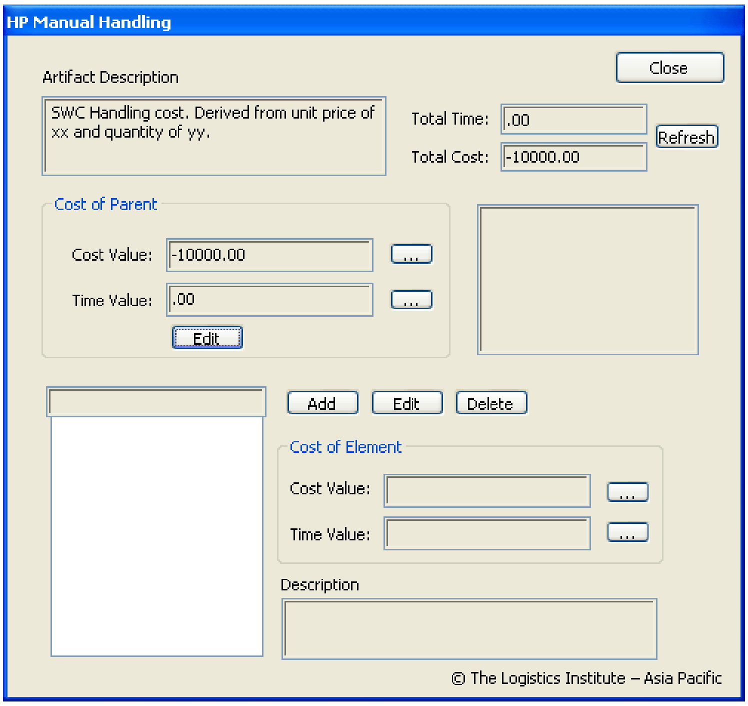

Figure 12: Modelling the cost savings in pallet handling

ROI Analysis

The output from the RFID Process Modeller is read by the ROI Calculator and processed. The results are shown in Figure 13 over a five-year horizon. Although there are time savings using RFID tags, the ROI analysis does not consider them due to the fact that there is no reduction in the number of operators on the assembly line. Based on the annual maintenance cost of $10000, there is a negative ROI. However, this is acceptable by the manufacturer as they realized other benefits in areas beyond the limits of the assembly line and that with full-scale implementation, the economy of scale spreads the software maintenance cost, thus much reducing the software maintenance cost per unit associated with this RFID implementation. This case study allows the RFID Process Modeller and the ROI calculator to be validated and the ROI figures have been confirmed to match with those produced by the manufacturer in their own study.

Input	
Salary ($/hour)	15
Interest Rate	15%
Fixed Costs ($)	0
Software Maintenance Cost ($/year)	10000

	Cost	**Time**
AS-IS	0	0
TO-BE	10066.3	0
Total Savings Yearly	-10066.3	0

	2007	**2008**	**2009**	**2010**	**2011**
Fixed Costs	0				
Maintenance Costs	10000	10000	10000	10000	10000
Total Costs	10000	10000	10000	10000	10000

	2007	**2008**	**2009**	**2010**	**2011**
Total Cost Savings	-10066.3	-10066.3	-10066.3	-10066.3	-10066.3
Total Time Savings in $	0	0	0	0	0
Total Savings	-10066.3	-10066.3	-10066.3	-10066.3	-10066.3

Delta	**2007**	**2008**	**2009**	**2010**	**2011**
Net Inflow	-20066.3	-20066.3	-20066.3	-20066.3	-20066.3

Output		
NPV	**($67,265)**	
NPV (Costs)	$33,522	(Cash Outflow)
NPV (Benefits)	($33,744)	(Cash Inflow)
Ratio Benefits to Costs	-101%	
IRR		

Figure 13: ROI Results for the case study

Conclusions

To increase the uptake of RFID technology in the supply chain, “early adopters” need an approach that can quickly identify positive business benefits and a tangible ROI. The use of the SCOR model has provided the framework of business processes for modelling supply chain scenarios for ROI analysis. The SCOR model is applicable across the supply chain industry and avoids re-invention of process models. The use of the SCOR model to underpin a modelling tool is to provide a method for ROI analysis that can be readily used, in this case, for studies involving RFID enabled supply chains. Through process decomposition, specific business processes may be modelled in detail at SCOR Level 4 and a number of candidate “to-be” processes can be evaluated.

The constructs of the SCOR process framework have been extended, where cost and time penalties are included in the model via process artifacts. Invariably, RFID implementation also has an impact on the information system architecture in terms of data and application integration. The SCOR modelling tool involves the first step of data analysis by introducing activity artifacts and their data elements into the SCOR model. Associated costs and time are captured and accumulated to enable a comparison between the “as-is” and the RFID enabled (“to-be”) models. This enables the ROI to be calculated on the basis of the running costs and technology investment. The development of a visual based interface to represent the SCOR and IDEF0 constructs offers a tangible and intuitive method for end-users to specify process artifacts and associated cost and time weightings.

Employing a spreadsheet as the basis for ROI calculation has several advantages. Firstly, spreadsheets are widely accepted and easily available; secondly, the data communication between process modelling and ROI calculation is convenient based on the output file from the SCOR modelling tool; finally, it is easy to add user-customized functions or for the user to write their own functions when necessary. The SCOR modelling tool provides an easy to use interface for business process re-designs. The subsequent use of a spreadsheet provides a format that would make the ROI results easily appreciated by a wider audience of stakeholders.

The SCOR modelling tool and ROI calculator developed in this research can be applied to other cases where “as-is” and “to-be” scenarios can be constructed to justify the adoption of new technologies or additional investments in projects. While the SCOR concept provides a good starting point for process representations, the feature of allowing user customization of the tool enhances the flexibility of business process modelling.

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