EML:A TREE OVERLAY-BASED VISUAL LANGUAGE FOR BUSINESS PROCESS MODELLING

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Abstract: Visual business process modelling can fulfil an important role to enable high-level specification of system interactions, improve system integration and support performance analysis. Existing modelling approaches typically use a workflow based method. Cobweb and labyrinth problems appear quickly when this type of notation is used to model a complex enterprise system with users having to deal with either very complex diagrams or many cross-diagram implicit relationships. In contrast, a tree based presentation can be very efficient for handling visual relationships. We present an overview of EML (Enterprise Modelling Language), a novel tree overlay-based visual specification for enterprise process modelling and its support tool. The highlight is its flexibility in modelling business processes using different layers. A service-oriented tree structure represents the system functional architecture. Business process modelling is constructed as an overlay on top of this service tree. By using a multi-layer structure, an enterprise system can be modelled with a variety of early aspects to satisfy design requirements. An Eclipse based software tool, MaramaEML has been developed to edit EML diagrams integrated with existing modelling languages such as BPMN and supports automatic generation of BPEL code.

1 INTRODUCTION

Since the early 1970s many languages, standards, methodologies and tools for enterprise modelling have been created. Examples include Entity-relationship models (Chen. 2002), Data Flow Diagrams, Flow Charts (Urbas, Nekarsova and Leuchter 2005), Scenarios, Use Cases, and Integration Definition for Functional and workflow Modelling (Eriksson and Penker, 2000).

The Unified Modelling Language (UML) is used to specify enterprise systems using the Model Driven (Marshall 2000) and business patterns approaches (Eriksson and Penker, 2000). UML 2.0 Activity Diagrams (Schnieders and Puhlmann 2005) provide additional modelling elements that make them more expressive than UML 1.0. BPMN (BPMI 2006) is a new process modelling language that allows definition of business processes in diagrammatic form. It aims to abstract away technical details in order to be understood by both IT and business people. Many new tools have adopted BPMN's box and line notation to represent enterprise system processes. ARIS (Scheer 1996) is a process modelling and analysis method. It represents a holistic view of process design, management, workflow, and application processes based on Event-Driven Process Chains. The form-based enterprise method (Draheim and Weber, 2005) analyses the whole enterprise system in a form-based style to achieve an optimized modelling framework for the system. BioOpera (Pautasso 2005) is a workflow based visual process language for service composition. It has conditional execution, failure handling, optional safety, iteration, nesting and recursion features. JOpera, its support tool, offers an autonomic execution platform for building distributed systems using the graphical editing framework (Pautasso 2005). Web Transition

Diagrams (WTD) and T-Web systems (Kornkamol, Tetsuya and Takehiro 2003) automate construction of web applications/web services from templates. ZenFlow (Martinez etc 2005) is a visual composition tool for web services written in BPEL4WS. It provides visual facilities to ease process definition. More recently, a young but rapidly growing research field, aspect-oriented modelling (AOM), has been recognized as valuable for dealing with crosscutting concerns at early stage software development (Gokhale and Gray 2005). This approach analyses a complex system from multiple viewpoints to identify abstract components. Most Enterprise visual modelling languages adopt box-and-line style diagrams. These generally work well for small to medium diagrams.

However, a common source of difficulty in all of these approaches is an appropriate visual method to reduce the complexity of large business modelling diagrams. Most existing modelling technologies are effective in only limited problem domains or have major weaknesses when attempting to scale to large systems modelling e.g. "cobweb" and "labyrinth" problems (Guerra et al 2005). Multi-view tool support and multi-level structure approaches have been applied to mitigate this problem (Schnieders et al, 2005; Zhu et al, 2004). These approaches have achieved some success but cannot fully solve the problem, because using the same notation and flow method in a multi-view environment just reduces individual diagram complexity, but increases hidden dependencies. (Erkisson 2000; Grundy et al, 2006). It requires long term memory of the users, as they have to build and retain the mappings between views mentally. In addition, most existing flow based business modelling notations lack multiple levels of abstraction support.

In contrast, using a tree structure is an efficient way of representing the hierarchical nature of complex systems graphically (Li et al, 2004; Phillips 1995). Trees also support navigation, elision and automatic layout in ways difficult to achieve with graph-based approaches. We have designed EML, a novel tree overlay-based visual notation and its integrated support environment to supplement and integrate with existing enterprise level modelling solutions. The study in this paper aims to address two main research questions:

- whether it is valuable to use EML's novel tree structure-based visual modelling language as a supplement to overcome the shortcomings of existing business process notations.; and
- whether EML models of complex business processes effectively reduce presentation complexity.

2 ENTERPRISE MODELLING LANGUAGE

Given the discussion in section 1, we designed EML and its integrated tool to address the visual and business limitations of existing modelling languages and their support tools. Our approach does not exclude existing modelling notations. We aim to incorporate them into our EML support tool while providing additional richer, integrative views for enterprise process modelling. Indeed, our MaramaEML support tool includes several BPMN, UML and Form Chart views.

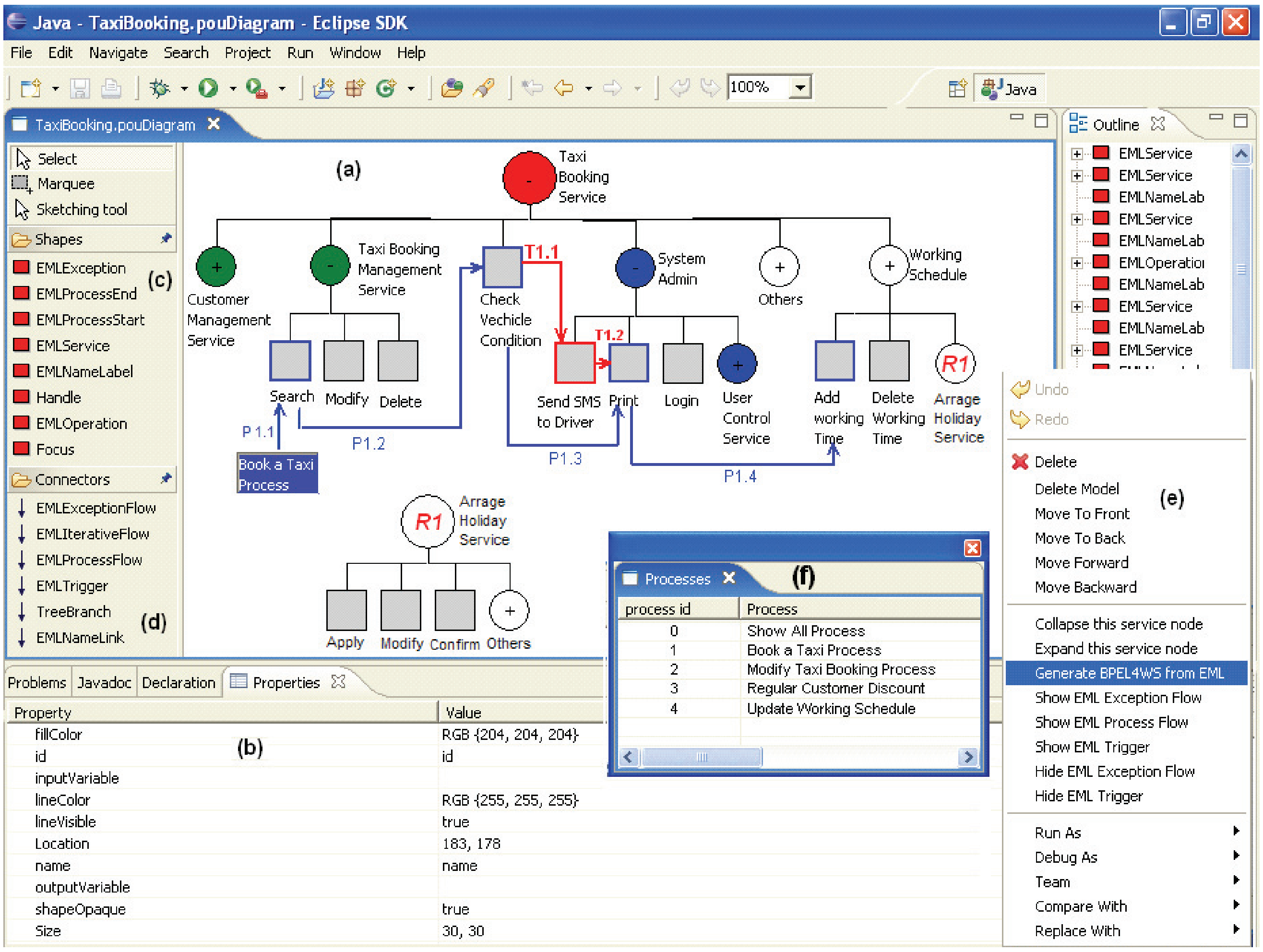
2.1 Tree Structure

EML uses a tree layout to represent the basic structure of a service. We chose to use trees as they are familiar abstractions for managing complex hierarchical data for business modellers and business people; can be easily collapsed and expanded to provide scalability; can be rapidly navigated; and can be over-laid by cross-cutting flows and concern representations. Earlier work on modelling complex user interfaces and their behaviour with tree-based overlays demonstrated these benefits (Li et al, 2004).

Figure 1 (a) shows a simple example of an EML tree structure modelling a composite taxi booking service. The customer management, taxi management, system admin and working schedule services are sub-services (represented as ovals) of the taxi booking service. The system admin service also includes an embedded user control service. The rectangle shapes represent atomic operations inside the service. In an EML-modelled enterprise system, major services are represented as separate trees.

Symbols inside each service are used to identify the elision level of the service visualisation. A minus symbol indicates all activities in the service have been expanded (e.g. *Taxi Booking Management Service, System Admin Service*). A plus indicates that part or all of the sub-tasks (services) are elided (e.g. *Customer Management Service*, *Other Service*). Every notation in the diagram has elide and expand attributes to give the users freedom to control the size of the diagram via elision of selected parts.

Each element in the tree has a list of associated properties (in Figure 1 (b)). For example, service properties include service type, status, input, output, loop, condition, rule etc. By setting these properties, EML users can specify detailed levels of design in stages catering to different modelling needs.



process id	Process
0	Show All Process
1	Book a Taxi Process
2	Modify Taxi Booking Process
3	Regular Customer Discount
4	Update Working Schedule

Property	Value
fillColor	RGB {204, 204, 204}
id	id
inputVariable	
lineColor	RGB {255, 255, 255}
lineVisible	true
Location	183, 178
name	name
outputVariable	
shapeOpaque	true
Size	30, 30

Figure 1: Using MaramaEML to Create Book a Taxi Process

2.2 Process Flow

Each business process is represented as an overlay on the basic tree structure or an orchestration between different service trees. In a process layer, users have the choice to display a single process or collaboration of multiple processes. By modelling a business process as an overlay on the service tree structure, the designer is given a clear overview of both the system architecture and the process at the same time. Processes can be elided mitigating the cobweb problem common in existing flow based visual notations.

P1.1 to P1.4 in Figure 1 (a) shows the *Book a Taxi* process on the *Taxi Booking Service* tree. The process starts with a process name followed by a process flow (blue arrow) to represent the sequence. Each flow has a sequence number, for a complex process, the user can use this number to represent concurrency / synchronization. The outline borders of involved operations or services become bold to identify the track. Data is bound to a process flow to feed in or out of the operations. In this process, the operator uses the *Search Booking* operation to check the taxi booking record. When a suitable record is found, the vehicle's working condition is checked, and the booking confirmed. Detailed booking information is printed and added to taxi driver's working schedule.

2.3 Dependency / Internal Exception

It is important to know if a specific event occurs or condition met. Events and conditions are referred to as dependency relationships. In some cases, we can also treat internal (system) exceptions as triggers. An EML trigger layer can be used to solve dependency problems. T1.1 to T1.2 in Figure 1 (a) shows how dependency information can be passed from one part of a process to another if a normal process flow is insufficient.

The *Book a Taxi* process (P1.1~P1.4) starts with an invocation of the *Search* operation. If the system finds a record, it checks the vehicle's working condition and then prints the booking and adds it to the schedule. In this process, the system also needs to send an SMS message to inform the driver of the vehicle checking result. However this operation is not executed until after the *Check Vehicle Condition* operation is completed. The red single arrowhead trigger connector (T1.1~T1.2) represents the dependency. The user can define the trigger conditions as attributes at both ends of the connecter to control the dependency situation. The start and end point of a trigger can be a service, operation or process. Since EML uses a multi-layer structure, users can choose to combine the trigger layer with the process layer (as in figure 1) or separate them by using different views to reduce diagram complexity.

2.4 Reuse

An EML reusable component is represented in a separate tree. The user pre-defines its structure and saves it in the library. Reusable components have a unique name for future usage. The user can easily attach a reusable component to any branch of an EML tree. Figure 1 (a) shows a *Arrange Holiday Service* has been reused in a *Taxi Booking Service*. The unique service name "R1" (in the middle of service notation) indicates it as a reusable service.

2.5 Iteration

EML supports specification of process iteration at different levels. A single activity loop is represented as a dashed outline border (Figure 2(a)). Attributes control the iteration (e.g. loop times, start and complete conditions, input/output data etc.). Loops of two operations, use a dashed line with two arrowheads. Figure 2(b) shows iteration of the *Search Booking* and *Modify Booking* operations. The process loops until a termination condition is met. Figure 2(c) shows a loop involving three operations. A single arrowhead dashed line guides direction, linking different operations or services in a closed circuit. In all three situations, the designer can set loop start and end conditions as iteration properties.

2.6 Exception Handling

The exception overlay in EML is used to model transaction errors. A failure handling notation (a green question mark in the middle of each operation or service) is used to specify/annotate a transaction failure. The user can set up a start condition to discriminate different kinds of failures and activate an appropriate exception handler. An exception handling layer is constructed to model transaction error handling in detail. This differs from the process flow and trigger layers but users can combine them to generate an integrated view of the whole processor separate them to show individual parts.

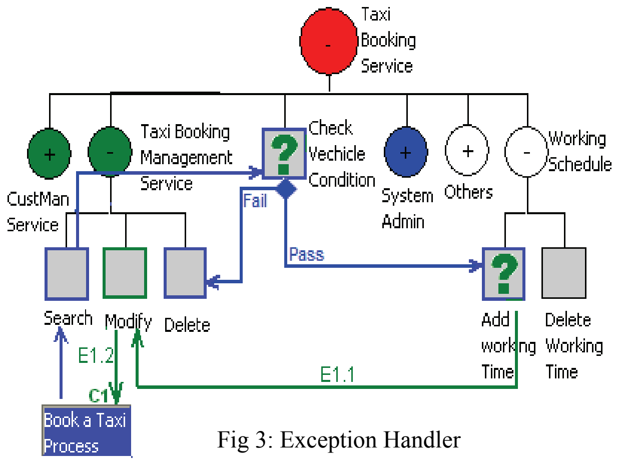


Fig 3: Exception Handler

Figure 3 represents a taxi confirm booking process with two different exception handlers overlaid. When the user checks the vehicle condition, an error handler is added to the operation (a green question mark in the *Check Vehicle Condition* square). A diamond shape (attached at the boundary of the *Check Vehicle Condition* square) is used to express the condition flows. If the vehicle cannot pass the condition check (*Fail*), it will *Delete* the booking and drive the exception handler to carry out an alternative process. In this figure, such a process is defined in another layer. The designer can only see an exception handler icon in this process view.

If the vehicle *Pass*es the checking, the system will then *Add Working Time*. A second exception hander is added to the *Add Working Time* operation. Here, if all taxi drivers are busy at the required time a booking cannot be taken. The alternative transaction is to negotiate with the customer for an alternative booking. Two green arrowhead connectors (E1.1~E1.2) represent the exception flow. The border of operations and services are green to track the sequence. Symbol *C1* is an annotation used to describe the flow execution condition. Here, it may be a reference to the process name in a policy manual. At the end of this exception flow, it links to the start point of the process to repeat the previous process again after the booking time changes. The second transaction flow is integrated into the process flow allowing users to obtain a more systemic overview.

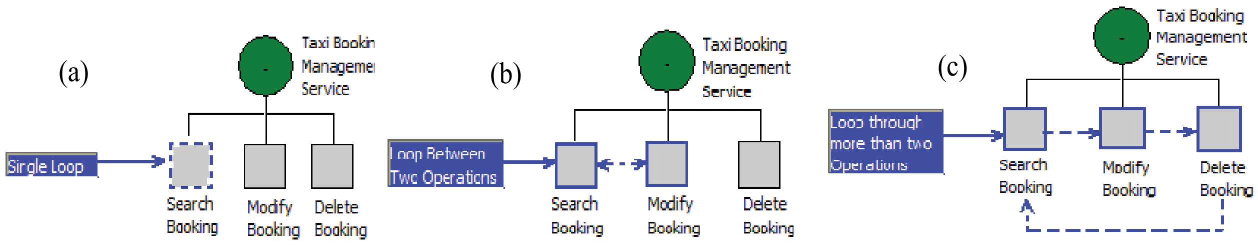

(a)
Taxi Bookin Manageme Service
Single Loop
Search Booking
Modify Booking
Delete Booking
(b)
Taxi Booking Management Service
Loop Between Two Operations
Search Booking
Modify Booking
Delete Booking
(c)
Taxi Booking Management Service
Loop through more than two Operations
Search Booking
Modify Booking
Delete Booking

Figure 2: Different Loops in EML

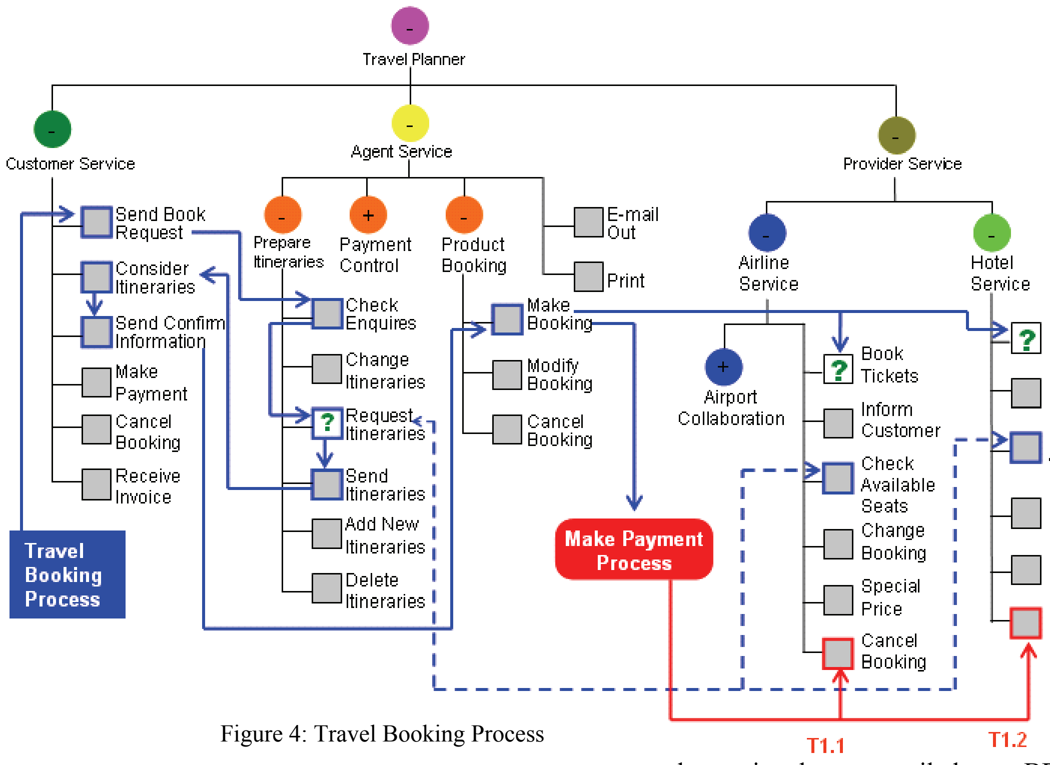


Figure 4: Travel Booking Process

3 MARAMA-EML

We have developed an integrated design environment (MaramaEML) for creating EML specifications. MaramaEML aims to provide a platform for efficiently producing EML visual models and to facilitate their creation, display, editing, storage, code generation and integration with other diagrams. We have used the MVC pattern to implement this tool (Buschmann and Meunier etc. 1996). MaramaEML is implemented using our Marama meta-tool (Grundy et al 2006) as a set of Eclipse plug-ins, providing a robust and scalable design tool. MaramaEML provides a good basis to enhance the integration and generation ability of different notations. The tool supports close integration with UML, BPEL, 3rd party model analysis and coding tools via Eclipse models. By using generated XML-based BPEL scripts as an interchange format a single notation can be integrated effectively with other modelling technologies. This integration approach provides multi-level framework support for flexible and broad integration of complex enterprise system models.

Figure 1 shows a screen dump of a MaramaEML model in use with a typical EML tree with a process overlay. The user produces a *Book a Taxi* process in Figure 1 (a) using the MaramaEML modeling diagram tools. To the left of the EML diagram area are the MaramaEML shapes (c) and connectors (d) toolbars. This provides options relating directly to the construction and editing of EML tree in the central work area (a). The EML process layer is then compiled to BPEL4WS executable code via code generation handler in (e). Code is generated by model dependency analysis and translation to structured activity constructs.

MaramaEML aims to provide a platform for the efficient production and navigation of EML. The tool supports a drag and drop approach and any parts of an EML tree can be directly selected and moved. Elision and expansion are triggered via popup menu (e). *Collapse this service node* and *Expand this service node* functions are available for the user to elide or expand a service node. The user can also select *Show/Hide EML Process/Exception/Trigger Flow* functions to view or hide overlays. When a *Show/Hide Flow* function is selected, a detailed flow list is brought to the screen for further selection. Figure1 (f) shows the detailed *Process List* when the user selects the *Show EML Process Flow* function. By double clicking the process names in this list, the user can select to view one (or more) appointed process or all of them. Similar operation applies to the *Exception and Trigger Flows.*

4 CASE STUDY

Figure 4 shows a *Travel Booking Process* in an EML process overlay. Only process related services and operations are shown; other, unrelated services have been elided (e.g. *Payment Control Service, Airport Collaboration Service*). The process starts (left rectangle) with a client side application passing a request message to the *Send Book Request* operation of the Customer Service. The Agent Service receives the request through the *Check Enquires* function, and uses its *Request Itineraries* operation to check availability information with the Airline and Hotel services. The agent requests flights and rooms with a list of parameters. There are iterations (dashed double arrowheads links) between *Request Itineraries*, *Check Available Seats* and *Check Available Rooms*. When the agent finds that both the air ticket and the hotel room are available on the requested date, it terminates the loop and sends the client a report generated by the *Send Itineraries* operation. The customer *Considers Itineraries* and *Sends Confirm Information* to the Agent Service. The agent receives this information and then *Makes Booking*. After both *Book Tickets* and *Book Room* operations are successfully completed, the agent calls *Make Payment Process* to ask the for payment and end the existing process (Rounded Rectangle).

The process also includes exceptions and triggers to handle transaction failures. These are defined in different layers to keep the process diagram clear and simple but can be integrated in the same place for a comprehensive overview if required. Figure 6 does include a trigger flow (T1.1 and T1.2) and an exception icon (question mark) in the process layer to demonstrate basic integration. The trigger flow specifies that if the agent doesn't receive the payment in ten days (condition defined in flow property), it will automatically cancel the booking. In an enterprise system, the designer usually needs more than one transaction to handle an exception. In the above, we can encapsulate all transactions as a single icon in the process view (e.g. in *Book Ticket, Book Room & Request Itineraries*), and model them using detailed exception flows.

5 DISCUSSION

To the best of our knowledge, EML is the first tree overlay structure visual language in the area of business process modeling. Service architectures are represented as trees and business sequences are modelled as process overlays on the service trees. By combining these two mechanisms EML gives users a clear overview of an enterprise system structure while business processes are modelled by overlays on the same view. EML uses a multi layer structure to model business processes, exception handlers and dependency triggers in different levels. This approach significantly reduces the complexity of business processes.

There are some limitations in our approach. Firstly its empirical base is still somewhat limited as we have only applied EML to seven substantial case studies. However, despite this small number, our results are encouraging. Second, no formal usability evaluation has been applied to the MaramaEML tool. Hence, we are aware that tool usability and efficiency will need further iteration.

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