A Flow-Through Workflow Control Scheme for BGP/MPLS VPN Service Provision*

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Abstract. In a competitive telecommunications marketplace, operators must provide customers with rapid access to both new and traditional service offerings. Market share is developed through greater customer satisfaction and by reducing dissatisfaction. To maximize profitability, an operator must reduce the costs of delivering new services while building revenues from existing services. This paper proposes a workflow-based service delivery architecture for telecommunications services. We describe an business process management in telecommunications and propose the workflow patterns that are commonly applicable for the workflow management of the proposed telecommunications architecture. In addition, this paper proposes an XML-based workflow control scheme incorporating the workflow patterns for providing telecommunications services. Finally, we describe a scenario for the delivery of the BGP/MPLS VPN service adopting the proposed workflow-based service delivery architecture.

1 Introduction

In the 1990s, workflow was often used as part of business process reengineering exercises to automate reengineered business processes. The emphasis was on technology, i.e. applications and systems, with less thought given towards human interactions within the process, and as a result, workflow developed a poor reputation. However, because of its ability to model and monitor business processes in real time and to easily change those processes in response to volatile market trends and technology, interest is again growing in business process management [1,2,4,5].

This has been a particularly difficult time for telecommunications businesses in most countries, with the saturated wired services, the depressed markets and the recession. On the other hand, by opening the door to competition, most telecommunications carriers need to act rapidly to differentiate themselves from

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others. Modern carriers face increasingly growing market challenges and must be able to fulfill even the most sophisticated customer demands. As a result, they must continuously invest in IT and telecommunications infrastructure and solutions, which help carriers to survive and win in the global market. However, networks and applications are becoming more and more complicated, so that keeping them effectively and efficiently operating requires additional effort.

Therefore, most telecommunications carriers should move quickly to set key technology solutions in place to streamline their service delivery operations. One of the breakthroughs is the automation of carriers' service delivery process, in whole or in part, during which documents, information or tasks are passed from one participant to another for action, according to a set of procedural rules.

2 The Business Process Management in Telecommunications

The integration of BSS and OSS is ultimately about business process support. There are many functional management components in the telecommunications architecture. These components are integrated with each other with the aim of supporting some overall set of defined business processes that together comprise the business model of the service provider [3]. An example of business process management in telecommunications is the Enterprise Application Integration (EAI) solution, which is a kind of middleware that integrates the various telecommunications components without any dependency on their technology and infrastructure to achieve the business goal.

Sales & customer care, billing, inventory management, activation and workflow management components are key ingredients in achieving the business goal of telecommunications service delivery. The sales & customer care component enables and supports all other components of the integrated architecture [3].

The sales & customer care component can be considered as a form of marketing - a happy customer will inform five people: an unhappy customer may inform ten. Unsatisfied customers will then go elsewhere and consequently, you lose a customer to your competitors and in turn, they may drag others with them. Create a customer relations policy instead of just making it up as you go along. Your policy is a guarantee to your customers that you are dedicated to achieving customer satisfaction.

The inventory management component is seen today as a service provider's resource platform rather than just a static list of network assets. Modern real-time inventory integrated with other OSS/BSS can deliver significant improvements in operational effectiveness and efficiency [3]. With in-depth understanding of network infrastructure resources and services, operators can reduce equipment costs and improve operating margins. The inventory management component can be composed of the following functions: network modeling & planning, inventory reconciliation, data migration service, inventory management application maintenance, and business process consulting & package implementation.

The business process management in telecommunications provides a full range of information management services, freeing communications providers to focus on revenue generation and customer care. The billing component can produce the bills in their final format, print them and mail them to our customers. Or we can provide them in electronic format for final processing by another billing fulfillment company.

The activation component provides various kinds of APIs that allow the development and integration of telecom management components, taking into account the device-specific and service-specific characteristics. From a single request, the activation component is able to provide multiple services across different network technologies. This greatly reduces the cost of service delivery while increasing the accuracy of deployed services. Rapid, fault-free deployment of new services is essential in maintaining your competitive advantage. The flexible service configuration of the activation component greatly reduces the time to market new services and simplifies the modifications to existing services. On the other hand, a fully automated service provision and activation platform is essential for increased customer satisfaction and generating maximum revenue from your network. An activation platform must be able to handle high volumes of transactions and provide flow-through activation for multiple services.

Enterprise Application Integration (EAI) has been a sorely misunderstood and misrepresented term. In the past, EAI applications have concentrated on middleware solutions aimed at connecting disparate applications together. Now, businesses are realizing that technical solutions alone cannot help us tame the legacy dragon. EAI has been and continues to be a technology driven by a real business need - to make effective use of existing and future data and application assets. It has been estimated that organizations spend 20-40% of their technology efforts on these types of integration tasks. By reducing this amount by just half, organizations can save millions.

Faced with limited resources, you are interested in rapidly planning for what must be done in order to have your EAI initiatives succeed. Data engineering principles enable us to formulate an approach to these types of challenges using structured techniques - where the form of the problem can be used to guide the form of the solution. The resulting framework-based solution provides a system of ideas for guiding the analyses; a means of organizing the project data and metadata; a data integration priorities decision-making framework; and a means of assessing progress toward project goals. Every XML-based initiative that begins with metadata recovery also begins with a clear understanding of the information content of the subject data. Thus, every time you wrap some of your data in XML, it provides an opportunity to contribute to overall EAI efforts.

Figure 1 shows a service delivery process with mutual interaction among the integrated telecom components using the EAI embedding workflow engine.

The process of Provisioning and Service Activation involves the acceptance of service orders from billing and customer care systems or separate order management systems. These service orders are translated into provisioning requests

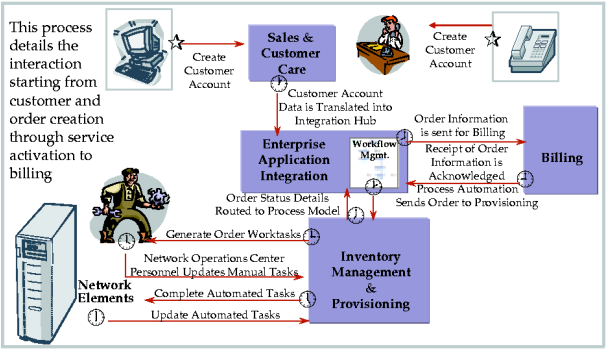

Fig. 1. Order to cash process

that need to be performed on one or more network elements. Typically, an operator will choose the best of the breed applications and network elements to suit its operations, and it is therefore not unusual that the service requests from the billing and customer care system are in a completely different format from that which is understood by the different network elements. In addition, there are situations where features supported in the billing and customer care system are not supported by the network element(s) or vice versa. Therefore, a service provisioning system needs to be flexible enough to handle these different scenarios.

3 The Workflow-Based Service Delivery Scheme

Workflow management consists of the automation of business procedures or "workflows" during which documents, information or tasks are passed from one participant to another in a way that is governed by rules or procedures [6,7]. Workflow software products, like other software technologies, have evolved from diverse origins. While some offerings have been developed as pure workflow software, many have evolved from image management systems, document management systems, relational or object database systems, and electronic mail systems.

Vendors who have developed pure workflow offerings have invented terms and interfaces, while vendors who have evolved products from other technologies have often adapted terminology and interfaces. Each approach offers a variety of strengths from which a user can choose. Adding a standard-based approach allows a user to combine these strengths in one infrastructure.

3.1 Workflow Patterns

There can be five basic workflow patterns [4,6] for the realization of workflow-based telecommunications service delivery.

Sequence is the most basic workflow pattern that is required when there is a dependency between two adjacent tasks. So, one task cannot be started before the adjacent task is finished. Sequence workflow pattern can be represented as , where '—' represents the sequence. Split is required when two or more tasks need to be executed in parallel. Split workflow pattern can be represented as , where ' ' represents the concurrent processing. Merge is required when a task can be started only when two or more parallel tasks are completed. Merge workflow pattern can be represented as , where ' 'represents the merge point. Cycle is required when a task has to wait until a number of tasks are finished. Cycle workflow pattern can be represented as , where ' ' represents the recurrent point. Branch is required when the next task is determined according to the status or condition of a task. Brach workflow pattern can be represented as , where 'if' represents the condition. We define a workflow pattern schema that can fully represent the above workflow patterns.

3.2 Workflow Control Scheme

In order to provide telecommunications services, we need a well-defined workflow control scheme besides the previously defined workflow pattern. The workflow control scheme is basically based on the workflow patterns. The service provision workflow can be described with the various combinations of workflow patterns.

Our workflow control scheme consists of two major modules of Workflow Control Module (WCM) and Work Process (WP), as shown in Figure 4. WP represents the application process and takes on the role of specific activities such as order receipt, order validation, device activation, order completion, etc. On the other hand, WCM takes on the roles of service order distribution and workflow administration and monitoring.

In WCM, the workflow is designed by the service designer via GUI interface using the Workflow Administration and Monitoring Tool (WAMT). The designed workflow is maintained in the Workflow Information Base (WIB) in eXtensiable Markup Language (XML). In addition, the service designer can dynamically

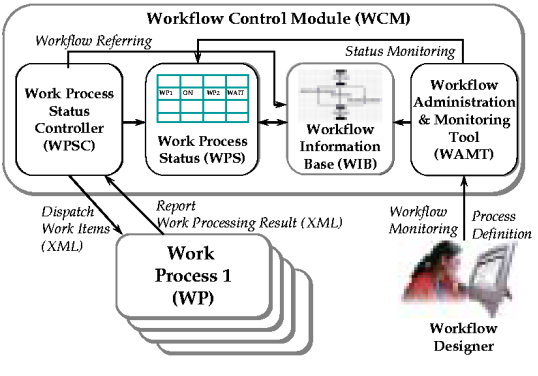

Fig. 2. Workflow control model

change the business process by modifying the business workflow with the graphical interface. The WAMT supports on-line workflow status monitoring. With the WAMT, the network operator can monitor the detail work processing status and can estimate the completion time of a certain workflow.

The Work Process Status Controller (WPSC) refers the WIB in order to decide on the current work process (WPcurrent) and the next work process (WPnext) to be executed and maintains the status of the WPcurrent and WPnext in the Work Process Status (WPS). In addition, the WPSC distributes WPcurrent to the appropriate Work Processes (WPs) that are distributed and executed in different machines. Each WP executes its own role in the delivery of the telecommunications services according to the activation request from the WPSC and reports the processing result to the WPSC via XML. On the other hand, the WPSC receives the processing result from the WP, and it changes the status of WPcurrent and moves the WPnext to WPcurrent.

4 Provisioning BGP/MPLS VPN Service

The IP virtual private network (VPN) feature for Multi-protocol Label Switching (MPLS) [9,10,11] allows a network service provider to deploy scalable IPv4 Layer 3 VPN backbone services [8]. IP VPN is the foundation used by companies for deploying or administering value-added services, including applications and data-hosting network commerce, and telephony services to business customers.

In this paper, we explore the issues surrounding the provision of MPLS VPNs, in particular, BGP/MPLS VPN known as MPLS-based Layer 3 VPNs or RFC 2547bis VPNs [8,9]. One of the services being investigated by many ISPs is that of BGP/MPLS VPNs. BGP/MPLS VPNs can form the center of an offering that provides substantial value to the customer in the form of increased simplicity, greater flexibility and outsourced routing, while representing a significant revenue stream for the ISP [8].

The BGP/MPLS approach to VPNs defines three roles for routers, which are as follows [8]:

- Customer Edge (CE) routers, which are associated with customer sites and usually managed by the customer.
- Provider Edge (PE) routers, which serve as the customer's entry and exit points for the VPN and are managed by the provider. Most of the VPN functionalities of the BGP/MPLS solution are concentrated in the PE routers.
- Provider (P) routers, which form the core of the provider network and are primarily concerned with forwarding VPN traffic that has been placed in MPLS frames by CE and PE routers. P routers are managed by the provider.

A BGP/MPLS VPN is formed when the provider associates the individual routing tables in the PE routers with MPLS Label-Switched Paths (LSPs) leading from that PE router to other PE routers that provide service to other CE routers on the same VPN [8]. A single PE router may serve many different

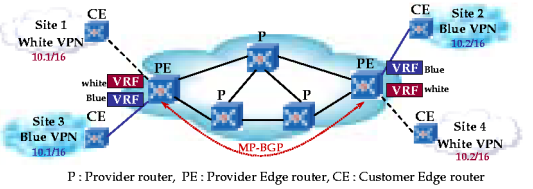

Fig. 3. An BGP/MPLS VPN model

CE routers and VPNs. The reference model for BGP/MPLS VPN is shown in Figure 3.

PE routers use an extended form of the Border Gateway Protocol version 4 (BGP4) routing protocol to share routing information and to populate the routing tables belonging to each VPN. The P routers, therefore, do not take part in the IP routing of customer traffic, but rather perform forwarding for the MPLS LSPs carrying that traffic. P routers do use a standard Interior Gateway Protocol (IGP) to maintain provider routing tables [9].

There are two broad configuration activities: one is for network configuration and the other is for VPN service configuration, as shown in Figure 4. The Network Configuration Activities (NCA) is for activating the signaling protocols for the management of LSPs in the MPLS network and the MP-BGP session configuration for the delivery of VPN information over the MPLS network. The Service Configuration Activities (SCA) is for creating VRF containing Route Distinguisher (RD)[9] and Route Target (RD) [9] and for activating the necessary routing protocol between CE and PE. The routing protocols between CE and PE can be OSPF, IS-IS, RIP and static.

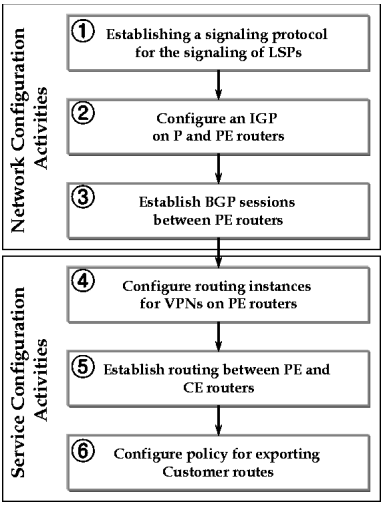

Fig. 4. Workflow for BGP/MPLS VPN configuration in terms of device activation

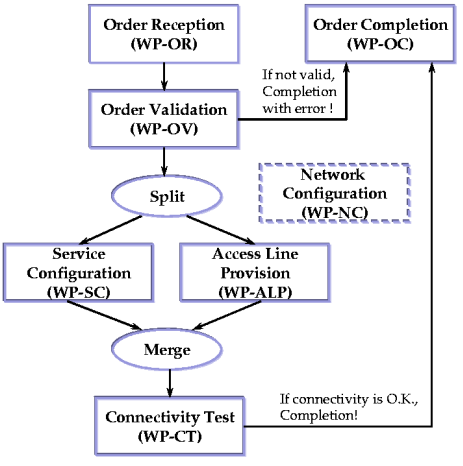

Fig. 5. A workflow for providing BGP/MPLS VPN service

Because the NCA can be a part of network provisioning and the SCA can be a part of service provisioning, this paper focuses on the SCA.

In this section, we describe the IP-VPN service delivery scheme using the workflow control scheme described in the previous section. In order to provide the Provider-Provided Virtual Private Network (PPVPN) using the proposed workflow control scheme, we define the various Work Processes (WPs) as follows:

Order Reception (WP-OR) - The WP-OR receives the service delivery order from the Customer Care and Billing System (CCBS) and notifies the CCBS of the completion of service delivery.

Order Validation (WP-OV) - The WP-OV validates the received orders from the CCBS. If the received order is not valid, WP-OV issues a completion notification with error to the CCBS.

Access Line Provision (WP-ALP) - The WP-ALP provides the facility for access lines between CE and PE. The access lines between CE and PE can be xDSL, ATM, Frame Relay, Ethernet, dedicated leased line and others.

Service Configuration (WP-SC) - The WP-SC activates the network elements, PE routers, for configuring BGP/MPLS VPN. In the WP-SC, it takes on the role of Service Configuration Activities (SCA), as defined in Figure 6.

Network Configuration (WP-NC) - The WP-NC takes on the role of network planning, as described in Figure 6. It does not participate in the service delivery process.

Connectivity Test (WP-CT) - The WP-CT provides the test functions for network operators to test the end-to-end connectivity or accessibility among the configured VPN sites.

Order Completion (WP-OC) - The WP-OC notifies the CCBS of the service delivery result, whether it is successful or not. In the WP-OC, the customer master is created.

There is a concurrent workflow. The WP-SC and WP-ALP are processed in current. The WP-CT is processed after the WP-SC and WP-ALP are finished.

5 Conclusion

This paper proposed an order management system and infrastructure to encompass and support all functions involved in the telecommunications service delivery process. We defined the generic workflow patterns that can simply manage the complicated and various telecommunications service orders and designed the workflow-based service delivery model for telecommunications services.

We also proposed the workflow patterns that can be applicable for telecommunications service delivery. This workflow patterns automate the entire service delivery process. Our workflow-based service delivery architecture is a highly scalable one adopting the web service. This architecture allows network service providers to manage their service orders. Our workflow-based service delivery architecture allows network service providers to simplify and accelerate the entire telecommunications service workflow.

In addition, we described a case study that applied the workflow-based service delivery architecture to the provision of MPLS provider-provided virtual private network (PPVPN).

With this workflow-based service delivery architecture, we can achieve the following:

- Differentiate the carrier as a provider of exceptional customer service, aggressively meeting the demand for new telecommunications services
- Increase service visibility to the customer, providing up-to-the-minute information on the status of orders and services.
- Provide customers with faster telecommunications services
- Expand markets and increase order-processing volumes without a simultaneous increase in human resource
- Increase productivity and reduce the number of personnel involved in the service delivery process

With the proposed workflow-based service delivery architecture, we can achieve low operating expenses while supporting the carrier's growth strategy.

Our further studies include solutions that enable customers to manage their own VPNs via web-based self-care, enable better tracking and feedback of real-time SLA conditions and rebates, and rapid deployment of additional products and services.

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