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Business Models for Next Generation Transport Networks

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Abstract. Control plane technologies will play a major role in next generation transport networks. Many publications and standards claim that approaches like Generalized Multiprotocol Label Switching (GMPLS) and Automatically Switched Optical Networks/Transport Networks (ASON/ASTN) will simplify network operation and will enable new services. In this paper, an approach is presented to analyze the business processes of transport network operators. The main operator processes are mapped to the well-known value chain concepts of Porter. This allows investigating the advantages of control plane technologies from an economic point of view. This paper shows that the introduction of control plane technology affects the business of the individual operators as well as the overall value system they form as a virtual enterprise. Moreover new business opportunities are identified and two business cases are presented.

Keywords: ASON, GMPLS, business models, value chain, processes

1 Introduction

The next generation of transport networks is characterized by extensions towards the support of multiple client signals, using e.g., approaches like the Generic Framing Procedure (GFP). At the same time, techniques like the Link Capacity Adjustment Scheme (LCAS) will provide a finer adjustability of the bandwidth. This flexibility is complemented by an increased automation using control plane technologies like Generalized Multiprotocol Lable Switching (GMPLS) [1] and Automatically Switched Optical Network Transport Networks (ASON/ASTN) [2,3].

While these control plane technologies were introduced in the technical discussions already a few years ago, currently their exact influence on the business situation of network operators still remains unclear. On the one side, a bright future is promised to operators being able to use the new control plane structures and to offer open interfaces to customers. On the other side, many people heavily doubt the usefulness of the corresponding investment.

In [4] the cost structures of network operators were analyzed for ASON/ASTN networks based on the value chain concept of Porter [5]. In the present paper, we use a systematic approach to investigate the business impact of the control plane architectures in transport networks. We start with a brief introduction to the concepts of GMPLS and ASON/ASTN, including overviews on equipment, interfaces and functionalities.

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After that, we elaborate on the value chain of a network operator based on the general concept of value chains and value systems. Typical operator processes are then described and possible improvements with the new control plane structures are outlined. This is finally used to identify the improvements by deploying GMPLS/ASON/ASTN in transport networks. Besides these improvements, we present several new business opportunities and business cases. The paper concludes recapitulating the main findings.

2 Concept of GMPLS and ASON/ASTN

ASON/ASTN are protocol-independent control plane architectures, which are standardized by ITU [2,3]. GMPLS is an IP-based control plane protocol suite standardized by IETF [1]. Both ASON/ASTN and GMPLS use distributed real-time signalling and routing algorithms that allow clients to set-up, configure, and release (unprotected or protected) connections automatically.

The network can be divided into administrative domains (e.g., different carriers). Each domain may be further subdivided into routing areas, e.g., for matching geographic regions or for grouping different types of equipment (see Fig. 1). To realize the communication between the clients and network entities different interfaces are defined.

3 Transport Network Architecture and Interfaces

The GMPLS and ASON/ASTN architecture consists of a transport plane, a control plane, and a management plane. The lower part of Fig. 1 illustrates the partitioning of the equipment into the three planes. The encircled numbers correspond to the path given in the upper part. The management plane is concentrated in a few Network Management Systems (NMS) and performs common management functions for the managed system. The transport plane provides the transfer of user information between different locations. Also control and management messages can be transferred by the transport plane equipment.

The important capabilities of the GMPLS/ASON/ASTN network are realized in the control plane. Functions for call control and connection control enable a fast and automatic configuration of connections through the transport layer network without manual intervention.

A general GMPLS/ASON/ASTN node contains a cross connect (XC) controlled by a connection controller (CC). A connection controller can have five different classes of interfaces:

1. The connection controller interface (CCI) is a node-internal interface and enables the communication between CC and XC.
2. The network management interface (NMI) connects the CC with the NMS.
3. The user network interface (UNI) enables the user to request connections. It supports information elements like end-point name and address, authentication, connection admission control (CAC), and connection service messages (CSM).
4. The external network–network interface (E-NNI) is the reference point between domains with an untrusted relationship. The supported information elements are reachability of network addresses, authentication, CAC, and CSM.
5. The internal network–network interface (I-NNI) is the reference point between entities within a domain. The minimal supported information elements are topology and routing information, CSM, and optional information needed to control network resources.

4 Functions and Capabilities of GMPLS and ASON/ASTN

As already mentioned, the architectures of ASON and ASTN allow clients to set-up, configure, and release connections automatically by the UNI. Also administrative functions like automatic topology discovery, address configuration, and basic functions for traffic engineering are included in these architectures. In addition, the dynamic and fast provisioning of connections through the ASON/ASTN network enables several capabilities:

- Traffic engineering using routing optimization (including wavelength assignment).

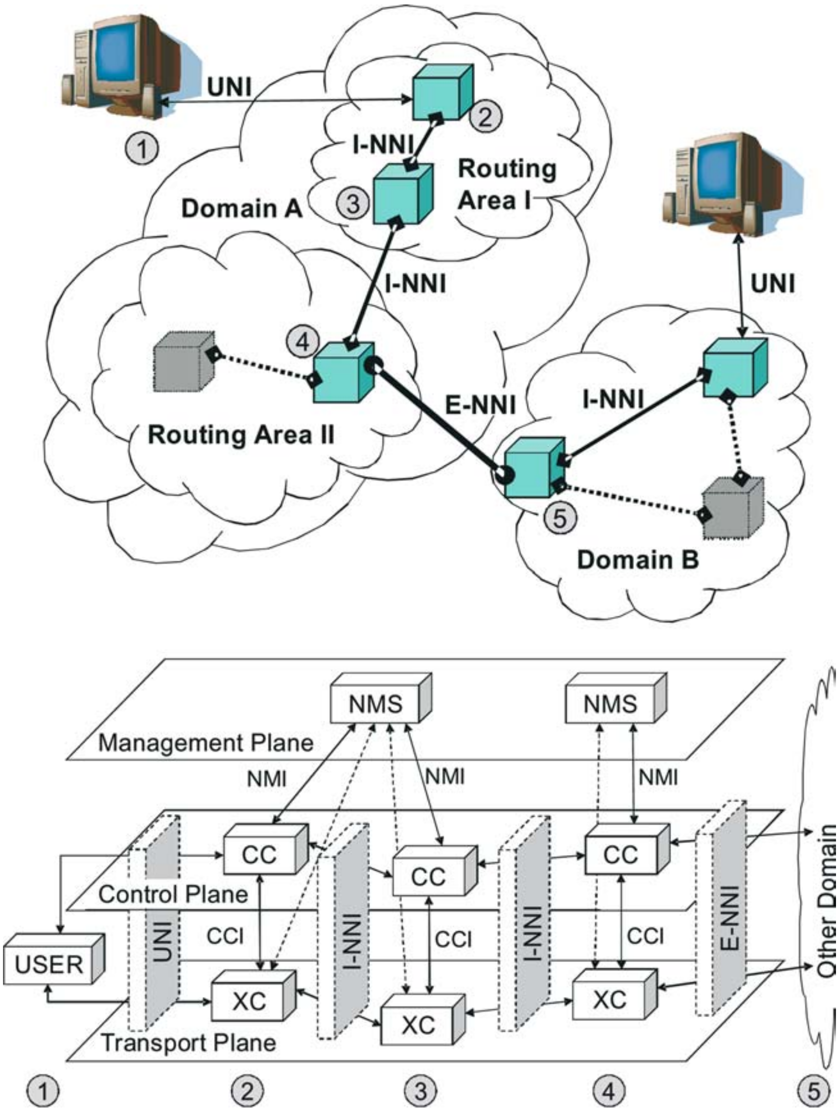


Fig. 1. ASON/ASTN Network Model and Network Architecture.

- Opportunity for the implementation of different meshed protection and restoration mechanisms.
- Provisioning of dynamic bandwidth and connectivity to a higher layer application (e.g., IP).
- Introduction of new services like bandwidth on demand and Layer-1 Virtual Private Network (L1VPN).

A set of candidate protocols for the ASON and ASTN architectures is developed within the Generalized Multi-Protocol Label Switching (GMPLS) framework. GMPLS extends the existing IP routing and signaling protocols for application as control plane protocols in transport networks. The standardization for GMPLS is done by the Common Control and Measurement Plane (CCAMP) working group of the Internet Engineering Task Force (IETF).

The transport plane (denoted data plane in GMPLS parlance) supports generically any kind of switching and multiplexing in time, wavelength, or spatial domain. The new Link Management Protocol (LMP), which can be deployed in

GMPLS, can perform automatic link configuration and keeps track of the correct operation of links [6]. LMP incorporates fault localization measures, which the connection controllers can use for fault recovery of connections.

As far as the control plane is concerned, GMPLS extends the routing protocols Open Shortest Path First (OSPF) and Intermediate System to Intermediate System (IS–IS) to include the advertisement of the resources in transport networks [6]. Moreover, the signaling protocols Resource Reservation Protocol (RSVP) and Constraint-based Routing Label-Distribution Protocol (CR-LDP) are enhanced to allow for explicit connection specification in these networks [1]. Many traffic engineering, protection, and restoration techniques are proposed for GMPLS [1]. Because of functional similarity, the applicability of the GMPLS protocol suite to the UNI and the NNI does not imply the need to specify two separate ("per-interface") GMPLS protocol definitions [7].

While the protocols within GMPLS benefit from reuse of the established Multi-Protocol Label Switching (MPLS) protocols [6], other deployed protocols are conceivable as candidates to be run in ASON and ASTN. For example, a modified version of the Private Network–Network Interface (PNNI) protocol [8] can find application as an ASON/ASTN routing protocol.

5 The Value Chain Concept

In his book "Competitive Advantage" M. Porter presents the concept of the "Value Chain" for collecting and structuring the activities of a company concerning the production, marketing, delivering, and supporting of a product [5], as shown in Fig 2. This concept has been used within many industries to identify and analyze the key sources of competitive advantage by considering the differences among competitor value chains and chain interactions.

5.1 Primary and Support Activities

The value chain displays total value (the amount buyers are willing to pay for the product) and consists of value activities (building blocks to create a product) and margin (difference between value and costs of activities). Primary activities are the activities involved in the physical creation of the product and its sale and transfer to the buyer as well as after-sale assistance. They can be divided into five generic categories:

- Inbound Logistics: Activities like receiving, storing, and disseminating inputs in context of the product (in the case of network operators this mainly consists of the leasing of lower layer services as fibers from utility compannies or ordering of bandwidth and services from other operators).
- Operations: Transforming inputs into the final product, i.e. operating the network(s).
- Outbound Logistics: Collecting, storing, and distributing the product to buyers or service delivery processes in the case of network operators.
- Marketing and Sales: Making the buying of the product possible and attractive for the consumer.
- Service: Providing service to enhance or maintain the value of the product.

Support activities support the primary activities and each other by providing purchased inputs, technology, human resources, and various company wide functions. We focus in this paper on the primary activities. Company infrastructure is not associated with particular primary activities but supports the entire chain.

Especially the indirect and quality assurance (QA) activities within each category of primary and support activities represent a large and rapidly growing proportion of cost and can play a significant role in differentiation through their effect on direct activities. Testing and inspection are associated with many primary activities and the cumulative cost of quality assurance can be very large – always making the simplifying or eliminating of QA a very desirable goal. Here the new control plane structures may play an important role through the necessary standardization of the exchanged product strongly decreasing the necessary QA efforts.

In the process of defining a value chain those activities have to be isolated and separated that have different economics, have a high potential impact on

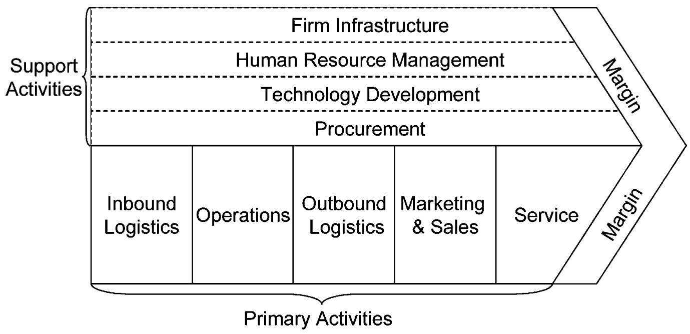


Fig. 2. Value chain concept (M. Porter).

the competitive performance of the company, or represent a significant or growing proportion of cost. The single value activities should be assigned to categories that best represent their contribution to a company's competitive advantage.

5.2 Linkages

Linkages relate the activities within and between the value chains. Exploiting linkages usually requires information or information flows that allow optimization or coordination to take place. Thus, the company's internal and external information systems get vital importance for achieving competitive advantages.

Especially, vertical linkages that exist between the value chains of the company itself and those of its suppliers and customers allow many opportunities for cost reduction and differentiation to arise (e.g., inbound logistics will always interact with the suppliers' order entry systems). Generally, there is a tendency that vertical linkages are more easily achieved together with coalition partners than with independent companies. These coalitions have to be supported by the corresponding coupling of the information systems via control plane structures and standardized interfaces.

Great differentiation advantages also can be achieved by considering the interaction with the buyers' value chains: Cooperation in the design phase, ongoing technical assistance, trouble-shooting, etc.

5.3 The Value System of a Network Operator and its Customers

Looking into typical network provider structures we can identify the following basic interactions (see Fig. 3):

Transport network operators lease or build fiber infrastructures. They sell bandwidth to carriers or end customers, mostly in the form of SDH/SONET. Carriers in turn retail this bandwidth to end-customers or other carriers/retailers.

6 Operator Processes

Network operators organize their activities in processes. Typically, two main processes cover the primary activities of the value chain. We refer to them as *Network Extension Process* and *Service Delivery Process*. Besides these main processes there are of course others that cover mostly support activities, like for example Technology Development.

6.1 Network Extension Process

The network extension process covers the planning, ordering, and installation of extensions of the network. In the initial deployment phase of a network, this includes very often also the installation of new equipment. In a mature network, as most of the core and metro networks are today, this is mostly just an upgrade of the link bandwidths.

The network extension process covers the Inbound Logistics step in the value chain. Fig. 4 depicts a typical network extension process. In the planning process step the (additional) capacity is determined based on forecasts and utilization reports. The result of this planning leads to work packages that are used in the build process to generate orders and control the according rollouts. This step also includes documentation. It ends with the handover of the extension to the network management.

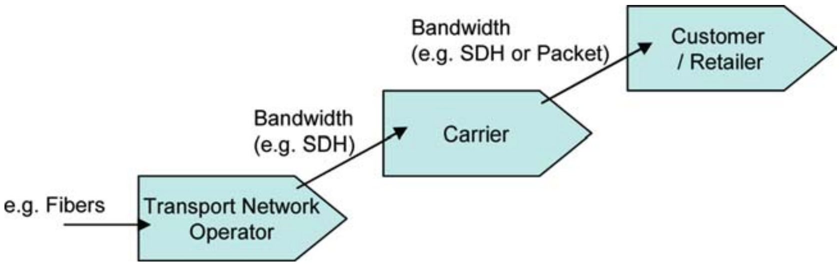


Fig. 3. Value system of network operators.

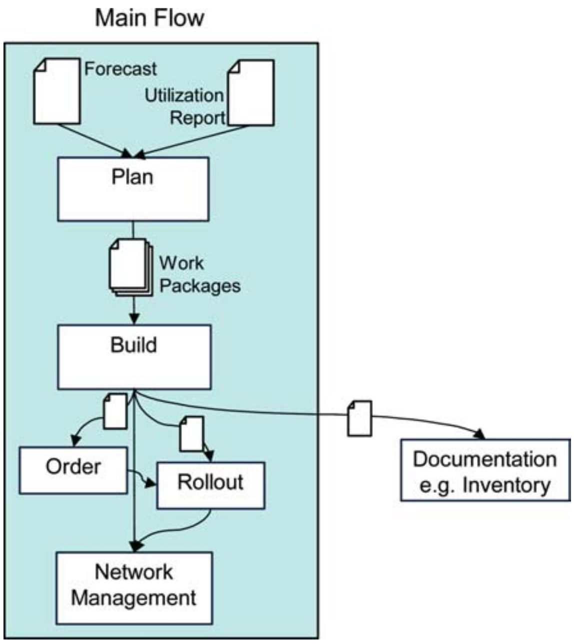


Fig. 4. Network extension process.

Typical planning periods are 3 or 6 months. Taking into account the time for ordering, delivery, and potential installation of new equipment the lead-time can be considerably longer than 6 months.

Room for improvement arises as the necessity for the deployment of additional equipment is becoming more and more obsolete. Most of the upgrades of data service providers are additional bandwidth from lower layer transport network providers. In a later section we will describe how control technology allows automating this extension process, leading to less effort, faster reaction, and lower costs. Moreover, the consequences of forecast uncertainties can be alleviated.

6.2 Service Delivery Process

The service delivery process is the most important process of a network operator. It implements the handling of all orders. Usually, this process covers several steps and involves multiple departments in the organization.

In Fig. 5, a simplified typical traditional delivery process is shown. At the network operator, several major functions are involved. In the example, these are *Sales*, *Order Management*, *Delivery Coordination*, and *Network Management*. In Fig. 5, they form the main flow of the service delivery process. This main flow is supplemented by several sub-processes, which are partly optional.

The service delivery process starts with an order. Even today often still in paper. The order is scanned and stored in a document management system. The sales staff also types information in the customer database, for example for billing. A very important step is the decomposition of the end-to-end service in separate sub-orders for all required service parts. This information is handed over to the order management.

The order manager processes the separated orders obtained from Sales. This includes distributing the orders to bandwidth suppliers where required due to missing geographical coverage (OLO, Other Licensed Operators). For new customers internal or external field service units may have to be instructed to supply special hardware, e.g., converters. Finally, the order management hands over the order to the Delivery Coordination.

The delivery coordinator handles the workflow of the provisioning of the services. This includes the detailed planning of paths (routing) using the network management system NMS, the documentation in the inventory system, and the orders

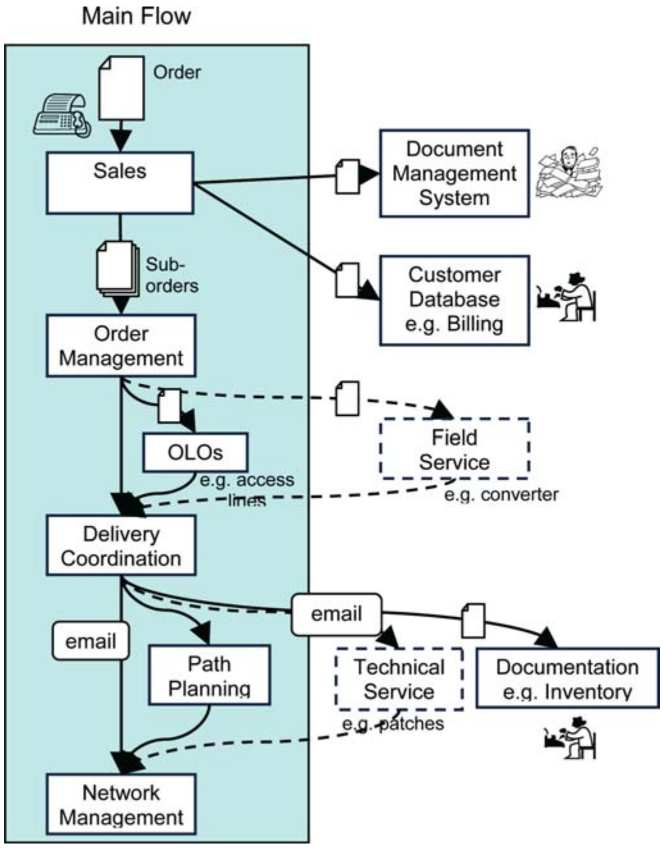


Fig. 5. Service delivery process.

for the technical service, e.g., for required patches. Finally, the delivery coordinator hands over the configuration to the network management center, where it is checked and released in the network.

The service delivery process covers the steps Operations and Outbound Logistics of the value chain.

6.3 Sequence Charts

In Fig. 6, sequences of messages and operations of a typical service delivery are shown. Obviously, this process is quite long and time consuming. Therefore, even with the support of electronic tools, provisioning of services takes sometimes several weeks. It has been described how new control plane technologies allow to automate the bandwidth ordering and delivery process. Hereby, the control plane has especially the potential to cover the technical aspects of the main flow of the order: The splitting of the service in sub-parts, the ordering of these sub-parts, the automated provisioning of the sub-parts, and finally also of the end-to-end service.

Fig. 7 shows a simplified message sequence as it arises with control plane technologies.

With the control plane, human interaction is almost eliminated. The roles of the coordinators in the traditional provisioning process are taken over by call and connection control using standardized interfaces like UNI and NNI.

7 Improvements by GMPLS/ASON/ASTN

Using the new control plane technologies improvements within the single value chains as well as within their interactions can be achieved. This predominantly holds for carriers, customers, and retailers as transport network operators still have to invest in the rather inflexible physical network infrastructure.

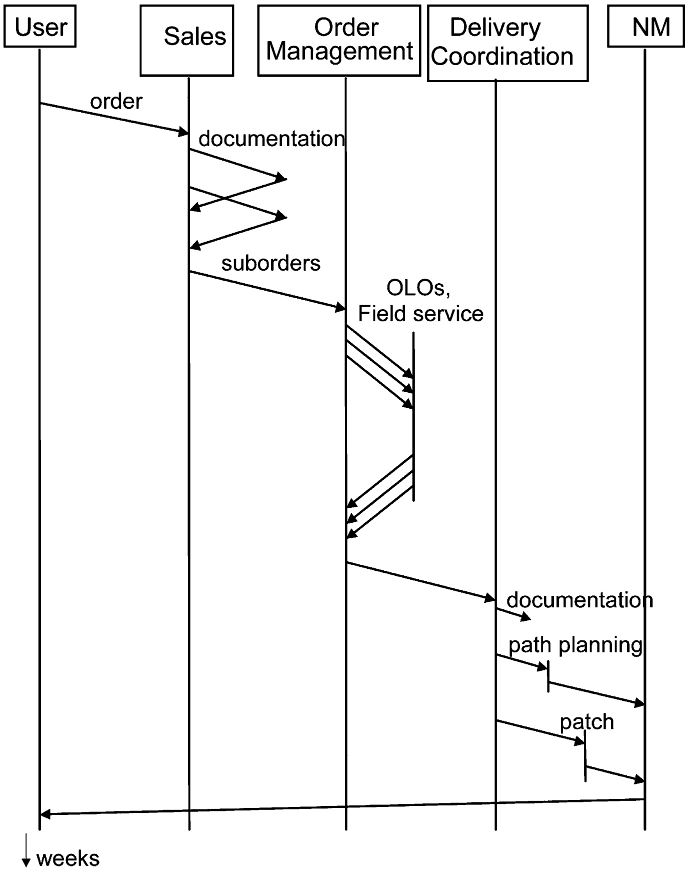


Fig. 6. Message sequence of traditional service delivery.

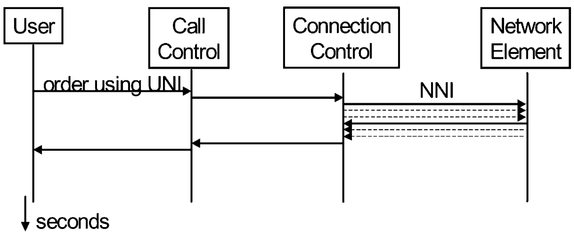


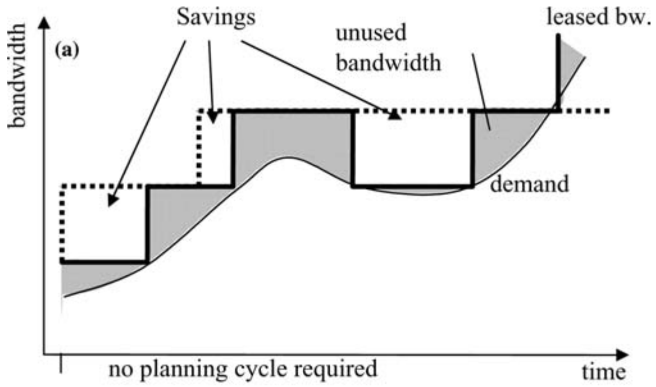
Fig. 7. Message sequence of service delivery with control plane.

7.1 Inbound Logistics

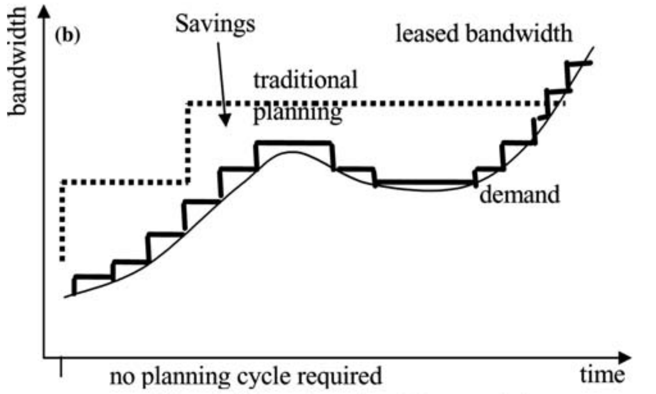
The standardization of the interfaces between network layers simplifies the inbound logistics of a network operator. A typical network operator leases lower layer services as raw materials for their products. Simplifying, automating, and accelerating the procurement process bear the direct advantage of reducing the effort and thus the procurement costs.

Moreover, the fast order and delivery enabled by the standardized user network interface reduces storage costs (see Fig. 8). Traditionally, the process of leasing resources (e.g., wavelengths, SDH connections) requires several days up to months. Therefore, a network operator has to maintain a stock of bandwidth to be able to react in reasonable time to customer bids. With the automation and acceleration of this process, this time can be dramatically reduced to the order of seconds making it obsolete to stock high amounts of bandwidth. Commonly adopted, standardized interfaces (UNI, E-NNI) are a prerequisite for this.

The advantage may even be improved by the introduction of technologies that allow providing bandwidth on fine granularities (Fig. 8b). This again reduces the "storage cost" by relieving the operator from buying and holding bandwidth in large amounts on stock that is only partly used.



with bandwidth on demand.



with bandwidth on demand and finer granularity.

Fig. 8. Reduced bandwidth stock.

Such technologies are on the one hand traditional packet-or cell-based transmission. On the other hand also next-generation SDH approaches like virtual concatenation, Generic Framing Procedure (GFP), or Link Capacity Adjustment Scheme (LCAS) together with automated service delivery using ASON/ASTN control plane technologies will allow a dynamic bandwidth delivery with a fine granularity. As the first step of an introduction of these technologies, proxy agent solutions could intercept the corresponding signaling at system boundaries and forward the messages into network islands still having a centralized network management. This would also allow the integration of legacy equipment with LCAS-capable systems.

A requirement that comes with the introduction of fast service delivery is high quality in the network technology, which makes the measurements of connections at service delivery obsolete. Strong service level agreements (SLAs) are required that underline this requirement with high economic risk in the case of bad quality. This approach has become for example very common in the automotive industries where sub-contractors and suppliers are motivated by the threat of high penalties to deliver just in time the specified quality.

7.2 Operations

Also, in the next step of the value chain, the operations, some improvements can be identified.

The provisioning process that means processing the order of a customer with all currently required steps, like planning paths, checking for availability of bandwidth and configuring the network could be automated reducing the effort and accelerating the process. In today's networks, these processes often require a considerable amount of human effort.

The advantage of automated provisioning becomes even more obvious if services traversing multiple domains are regarded. Even if all domains are in the governance of a single company they may be operated separately, for example, for historical, political, or geographical reasons. Traditionally inter-domain services require a high amount of manual interaction and coordination. This results in high effort and long delivery times. With the introduction of automated service provisioning over multiple domains using defined interfaces like I-NNI (internal network–network interfaces), this process can be automated and accelerated.

Another advantage of the introduction of control planes in transport networks is the possibility to introduce new resilience mechanisms. Such mechanisms have the potential to reduce the required bandwidth for (unused) backup resources, resulting in lowered capital expenses. Some of these resilience mechanisms also allow to realize services requiring high connection availability. Moreover, the automation will ease the offering and provisioning of multiple resilience classes.

Automatic discovery of configurations (e.g.,, neighbor discovery) and distributed data storage of the network state (e.g.,, about resources) can also support operations, since up-to-date management information is available from the network elements themselves. Therefore, for instance, network state data needs not to be retrieved from central and off-line systems storing data, which may be out-dated or erroneous. Moreover, automatic discovery can help to avoid misconnections.

As already shown above, the planning of bandwidth extensions of the network can be simplified. Increasing transport capacity leased from other operators is automated and requires almost no manual interaction. What remains is the negotiation of framework contracts including SLAs for delivery of services on demand with required qualities. What still has to be planned is the extension of the hardware of the network (switches, routers, etc.). Here equipment suppliers may have potential to include functionality in the network management systems that automatically recommend extensions and upgrades. This may even lead to service contracts that include an automatic upgrade.

7.3 Outbound Logistics

The outbound logistics also benefit from a control plane. The delivery of services is automated. Outbound logistics as a part of the typical delivery process of a network operator benefit from the advantages already mentioned above.

In addition, the order processing is simplified and automated. Instead of manual exchange of orders, electronic ordering is introduced. This reduces the effort for both partners, the supplier and the customer (see Section 7.1).

7.4 Marketing and Sales

Marketing and sales are relieved from routine actions like offering and negotiating services for each purchase. Instead, the sales process is widely automated based on framework contracts.

From a marketing point of view, the introduction of service-on-demand offers based on ASON/ASTN technologies may require more effort. The reason is that the simplification of the sales, ordering, and delivery processes increases competition amongst operators by simplifying the opportunity for the customer to choose one supplier for a required service. Bandwidth brokers are a good example where this competition becomes obvious.

7.5 Service

The last step in the value chain is service. Here, the ASON/ASTN approach can help with improved reliability features mentioned above. This reduces manual effort to restore services after a failure occurred. For example, resilience mechanisms can be introduced that address services with low resilience requirements. These services are currently often unprotected and have no automatic backup in the case of a failure. Although sold as unprotected service the customers expect at least a mid-term reaction in the order of 1 hr, which usually cannot be met by repairing physical impairments. Therefore, manual interaction is required to reroute traffic around a failure. The new control plane architectures provide the possibility to introduce novel resilience mechanisms and additional signaling features that simplify error detection and analysis.

8 New Business Opportunities with GMPLS and ASON/ASTN

The introduction of GMPLS/ASON/ASTN also enables new services and, in turn, new business opportunities.

"Service-on-demand" can be offered as a new product and gives the operator competitive advantage to operators that do not offer this kind of services. Besides the operators' cost savings that allow providing bandwidth at very competitive conditions this also gives the customers several advantages reducing their cost. These advantages come mainly from standardization and automation of the interfaces between supplier and customer that have already been described above in detail.

This may even go further, since the possibility to dynamically provide bandwidth to a customer gives this customer in turn the opportunity to generate more business by offering his customers better conditions, like faster service delivery, more flexibility or more competitive pricing.

In [5], this synergetic coexistence of several companies forming an integrated value system is called a virtual company. This structure offers the possibility for covering novel or geographically distinct market segments. Global network operators have to interact with regional ones to reach the end customers. Operators using the virtual-companies approach enabled by standardized ASON/ASTN interfaces can not only deliver fast and flexibly, they also have the possibility to reduce the transaction costs significantly. An important example is end-to-end Layer-1 Virtual Private Networking that allows for a secure and protocol-independent interconnection of customer premises.

Virtual marketplaces will arise where operators sell and lease bandwidth making efficient bandwidth brokerage a new business opportunity. In [9] bandwidth trading is seen as a major trend for network provider and carrier.

Some of the services mentioned above are also feasible using transport network technologies available today. However, with GMPLS/ASON/ASTN these services can be offered rapidly and flexibly using the distributed network control.

The rapid service provisioning and the standardized signaling interfaces offer distinct advantages for customers, carriers, and network operators.

The customers can change more easily from one network provider to another because of better service quality or lower costs reasons. Using the UNI signaling, the existing connections can be torn down and the new connection can be set-up without tedious negotiations and long provisioning times.

The automated interconnection between network domains of the same carrier or between different carriers supports new business models. Two business case studies will be discussed in the following paragraphs.

8.1 Business Example A

The first example (Model A) is for a large, incumbent network operator having its own network infrastructure (see Fig. 9). To extend the network coverage and to be able to offer global interconnection, this network operator has service level agreements and interconnection contracts with several other local and regional network operators.

Currently, to set up an international network connection, a high amount of personal communication by fax and phone and manual configuration is necessary.

Using GMPLS/ASON/ASTN, a connection set-up request is received from a customer via the UNI. The connection set-up request is then forwarded over the I-NNI and E-NNI interfaces to the client destination.

The connection is routed with preference through the network operator's own network. Only where the network coverage is not sufficient, the set-up control signaling is sent via the E-NNI to a cooperating network provider.

8.2 Business Example B

In the second example (Model B), a bandwidth reseller buys large transport capacities wholesale from the network operators and retails these capacities to its customers. Such a connectivity service provider has no own network infrastructure, but cooperates with many interconnected local, regional, and global network operators and carriers. The signaling information to and from

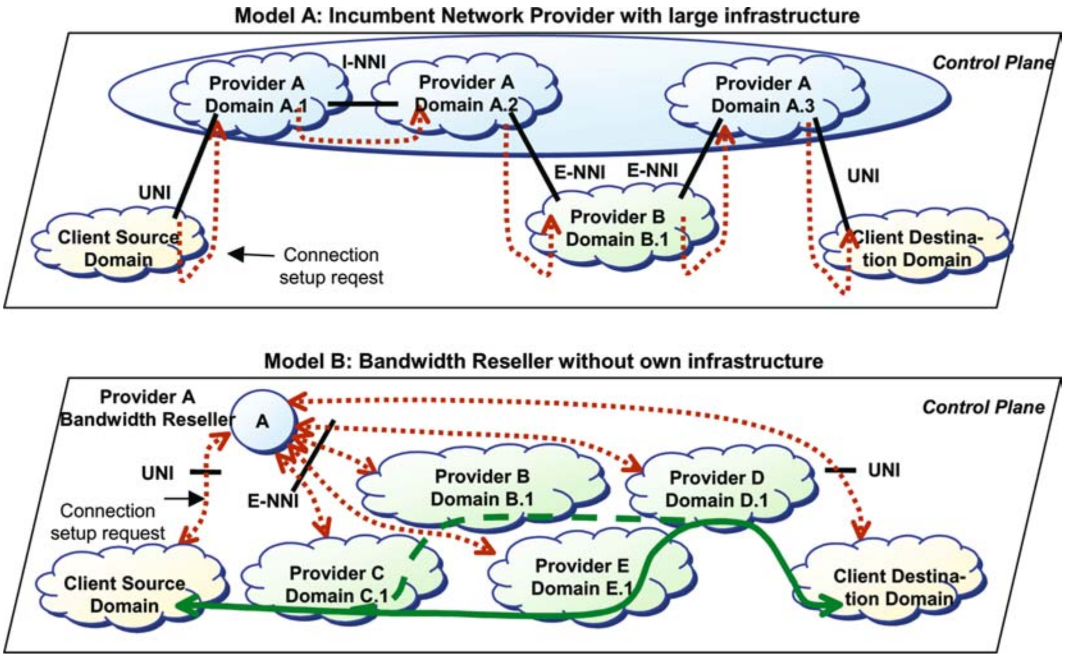


Fig. 9. Network models for two business cases.

the bandwidth reseller is sent out-of-band via an external IP or Ethernet network. The network connectivity must be known to be able to route the connections request to the client destination domain.

Since the bandwidth reseller uses the connection provisioning services of several network operators, he or she can flexibly select the best offer to suit a specific connection request. In Fig. 9 for instance, the indicated connection in Model B is set up through the domains C.1 and E.1 to D.1. An alternative is to set-up the connection through the domain C.1 and B.1 to D.1 (dashed line), if network operator B can offer a better interconnection in terms of cost or quality of service than provider E. The connections established in the transport network planes of the providers B, C, D, and E. These act as carrier's carrier and provide the interconnection to the customer. The customer has only a business relation to the provider A. Comparable models are already established in the civil engineering and energy business, where one company acts as a general contractor. The core competencies of such a general contractor are the customer-relations management and connectivity-service retail.

9 Conclusion

In this paper, we have applied the general value-chain model to network operators and their value system, ranging from transport bandwidth "production" to retailers and end customers. Technologies like GMPLS/ASON/ASTN not only allow the automation of processes within single network operators and between operators leading to corresponding reduction of operational effort. Of great importance is also the idea that the capital requirements of carriers and bandwidth retailers are reduced. They now may obtain bandwidth on demand instead of holding bandwidth on stock for possible customer demands. Finally and perhaps most important, the new technology does not only improve processes and reduce capital requirements but is the starting point for novel business models.

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