Influence of GMPLS on Network Providers' Operational Expenditures: A Quantitative Study

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ABSTRACT

GMPLS is promoted as a major technology for the automation of network operations. It is often claimed to allow the reduction of operational expenses. However, detailed analysis and quantitative evaluation of the changes induced by such technologies is very rare. In this article we quantify the cost reduction potential of GMPLS. We present a detailed analysis and modeling of traditional operator processes. We also develop a model for the expected changed processes when using GMPLS and identify the differences quantitatively. A survey with major telecom operators has been done, and the process models have been verified and parameterized. This allowed quantitative evaluations of the OPEX changes with GMPLS. The results show that, depending on the network operator's processes, different impacts can be expected. As an overall result we could verify that a reduction on the order of 50 percent of OPEX can be expected for most operational models.

INTRODUCTION

In recent years the main focus of transport network evolution has been on increasing transport capacities and introducing data networking technologies and interfaces (e.g., Gigabit Ethernet). This evolution is complemented by ongoing initiatives to reduce the operational effort and accordingly the costs of network operations. Generalized multiprotocol label switching (GMPLS) together with standardized interfaces like user–network and network–network interfaces (UNI/NNI) are automating the operation of telecom networks [1]. They allow services to be provided efficiently and improve the resilience of networks. For service provisioning there is the new paradigm of user-initiated service provisioning (also known as switched connections) where a client can set up connections without operator interaction. This not only speeds up the provisioning process, but also reduces effort for the network operator.

Currently, the approach of using a distributed control plane for network functions like service provisioning, link management, or failure restoration is followed by several initiatives and standardization bodies including the International Telecommunication Union (ITU), Optical Internetworking Forum (OIF), and Internet Engineering Task Force (IETF). In this article we do not distinguish the details of these approaches but generally assume a control plane supporting automation of network operations. We use the term GMPLS to refer to any kind of control plane according to one or several of these standards.

The advantages of GMPLS have been described and discussed controversially in literature and conferences over the last years. However, all these discussions usually lack quantitative investigations of the impacts of such technologies. This results mainly from the difficulties to model operators' processes and to obtain quantitative information about the efforts and costs in these processes.

In this article we evaluate how GMPLS technologies impact network operators' processes, and provide a calculation of the expected operational expenses (OPEX) savings. Based on surveys and interviews with several carriers, we developed a generalized model of traditional network operation processes and potential changes with the introduction of GMPLS. In these surveys and interviews we also collected cost and effort figures for current network operations and extrapolated these to the new GMPLS process model.

In the remainder of this article we first explain our general approach for these investigations, and then present the traditional and new GMPLS-based process models. We then show and evaluate the results of the quantitative anal-

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ysis. In the conclusion we summarize our findings and point out the overall expected OPEX improvements due to GMPLS.

THE APPROACH

The total expenditures of a company can be split in two parts: capital expenditures (CAPEX) and OPEX. CAPEX contribute to the fixed infrastructure of the company and are depreciated over time. They are needed to expand services to customers. OPEX do not contribute to the infrastructure itself and consequently are not subject to depreciation [2]. They represent the cost to keep the company operational, and include costs for technical and commercial operations, administration, and so on.

This article focuses on the impact of GMPLS on the OPEX in an operational network (i.e., one that is up and running) [3]. We therefore do not consider the costs of initial installation or of network extensions. All infrastructures are counted as CAPEX in our model, as suggested in [4].

For the traditional network, we assume it provides end-to-end services. The GMPLS network additionally offers dynamic services.

Network operation comprises all the processes and functions needed to operate a network and deliver services to customers. This includes the sales and marketing processes, the various support functions, as well as provisioning and monitoring of the network and the corporate processes in general. By far, labor costs associated with all of these items account for the majority of a service provider's annual operating expenditures budget (besides other costs of infrastructure like energy, floor space, etc.). The significance of a reduction in OPEX cannot be downplayed.

In this study we want to perform a process-based quantitative analysis of the reductions in operational costs to be expected for network operators using GMPLS. The study is based on the OPEX model defined in [3]. Starting from this very comprehensive model, the idea is to evaluate which operations become more or less expensive when the technology used is GMPLS instead of a traditional static transport network. In extreme cases some operations can even appear or disappear. Apart from operations, particular attention also must be paid to the processes' branches. The probability of each branch of the processes' flow must also be extrapolated when considering the new technology.

Based on this qualitative modeling, quantitative results can be calculated. The normal cost of each operational step is the one assumed in the base OPEX model for the traditional approach. Combining this cost and the qualitative variation, the new cost can be extrapolated. In this way the incremental costs/benefits from using GMPLS can be obtained.

TRADITIONAL PROCESS STRUCTURE OF NETWORK OPERATORS

In general, the introduction of GMPLS will influence the cost structure of network operators in many ways. The next sections describe the processes being affected.

CONTINUOUS AND RECURRING PROCESSES

Continuous Cost of Infrastructure — The cost to keep the network operational in a failure-free situation is the first important cost in this category. We call this the telco-specific continuous cost of infrastructure. It includes the costs for floor space, power, and cooling energy, and leasing network equipment (e.g., fiber rental). Also, right-of-way, that is, the right to put fiber on the property of someone else (e.g., along railways) is part of this cost.

Routine Operations — This is the cost to maintain the network or operate the network should a failure occur. The main actions performed here aim at monitoring the network and its services. Therefore, the actions involved include direct as well as indirect (requested by an alarm) polling of a component, logging status information, and so on. Stock management (keeping track of available resources and ordering equipment if needed), software management (keeping track of software versions and installing updates), security management (keeping track of people trying to violate the system and blocking resources if needed), change management (keeping track of changes in the network, e.g., a certain component goes down), and preventive replacement are also included here.

Reparation — Reparation means actually repairing the failure in the network if this cannot happen in routine operation. Reparation may lead to actual service interrupts, depending on the protection scheme used. The actions involved in the reparation process are diagnosis and analysis, the technicians traveling to the place of the failure, the actual fixing of the failure, and performing the needed tests to verify that the failure is actually repaired.

Operational Network Planning — We distinguish the ongoing network planning activity, which we call operational network planning. It includes all planning performed in an existing network that is up and running, including day-to-day planning, reoptimization, and planning upgrades.

Marketing — By marketing we mean acquiring new customers to a specific service of the network operator. The actions involved are promoting a new service, providing information concerning pricing, and so on.

SERVICE MANAGEMENT PROCESSES

Due to the automation capabilities of GMPLS, service management will be affected to the greatest extent within the process structure of a network operator.

Thus, for our study we investigated the five most technology-dependent processes within the traditional structure of network operators, considering the interactions and operations of the sales department (SD), administration (AM), project management (PM), network operation (NO), and external suppliers (ES) [5].

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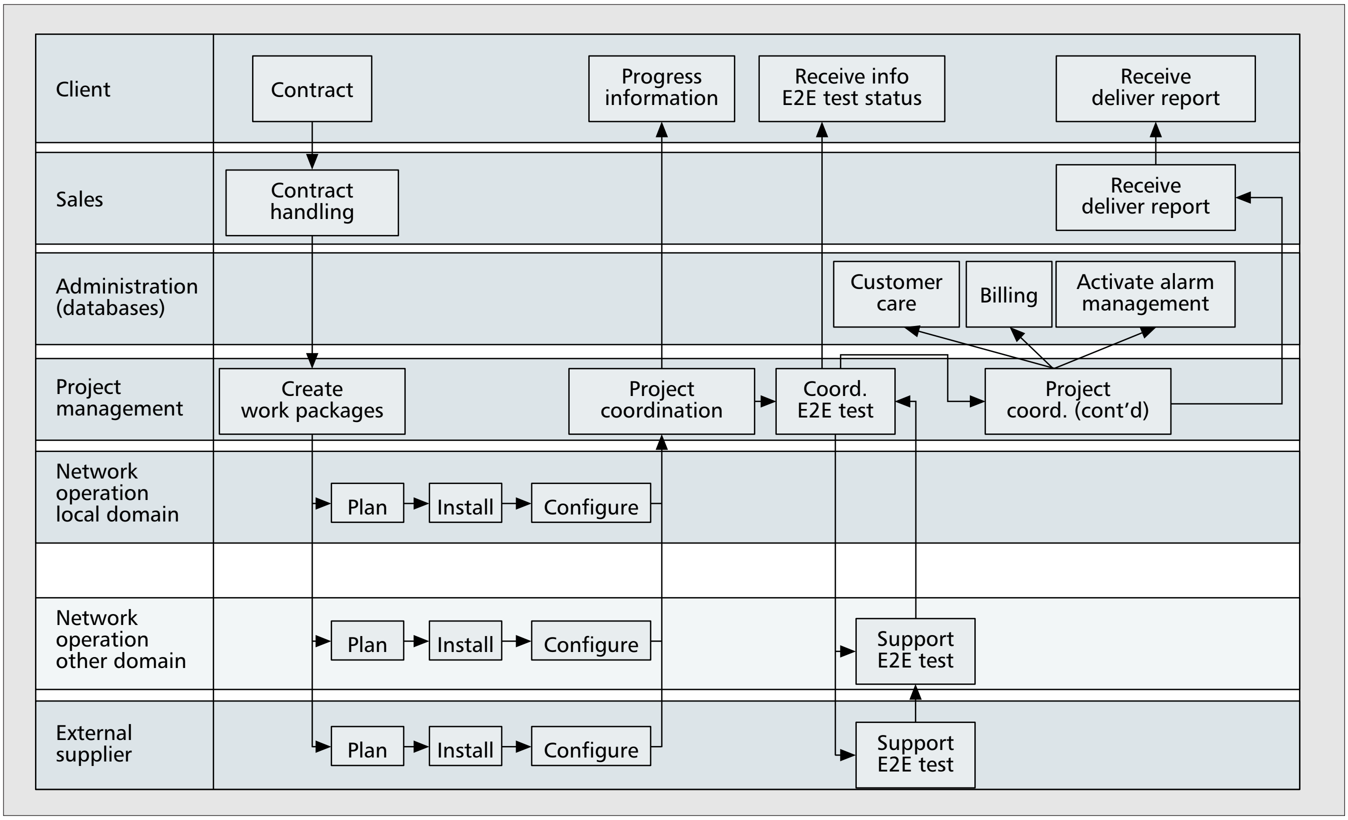


Figure 1. *Typical service provisioning process.*

Service Offer — The sales department negotiates the terms and conditions of the offer with the customer, and does an inquiry as to whether the connection request can be handled by the standard mechanisms and infrastructure. For nonstandard connection inquiries, separate projecting (PM) is triggered for the various domains (local, internal, external), and missing equipment (cards, fibers, etc.) is ordered, causing additional effort and delay. The projected results then define the price calculation (SD), as well as the delay necessary to set up the service. Then the offer is sent to the customer.

Service Provisioning — After the contract has been accepted, the service delivery process starts (Fig. 1). The sales department handles the contract administration and forwards it to the project management that splits it into work packages according to the network domains involved. After providing the connection, an end-to-end test is conducted (PM), and customer care, billing, and alarm management are activated (AM). Finally, a delivery report is issued by the sales department to the customer.

Service Cease — At the end of a contract or upon a cessation request by the customer, the cease process triggers (via PM) the deactivation of the circuits (NO), followed by the recovery of equipment by field technicians (NO). SD is informed about the expected cessation, and the final bill is sent out (AM).

Service Move or Change — Moving or changing a connection is the most complex task since it involves all three previous processes: contract update, new connection setup, and release of the previous connection. The customer's request for change is handled by the sales department as a service offer process, checking again for the availability of resources. The sales department then generates orders for the service provisioning and cease process that are implemented through coordination from the PM department. At the same time the client is receiving updates on the new installation.

The Impact of GMPLS on Operational Processes

From the main operational processes described above, several are impacted by the use of GMPLS.

Continuous and Recurring Processes

Continuous Cost of Infrastructure — The continuous cost of infrastructure will be impacted by the amount and type of network components used. With GMPLS the network usually allows mesh-based restoration, where less backup capacity is required, which in turn leads to fewer network components. The cost to power, cool, and host this equipment will therefore also decrease.

Routine Operations — The cost of routine operation (maintenance cost) also depends on whether the network is automatically switched or not. The use of GMPLS influences the routine operation costs because (re)configuration after replacement of equipment can happen faster.

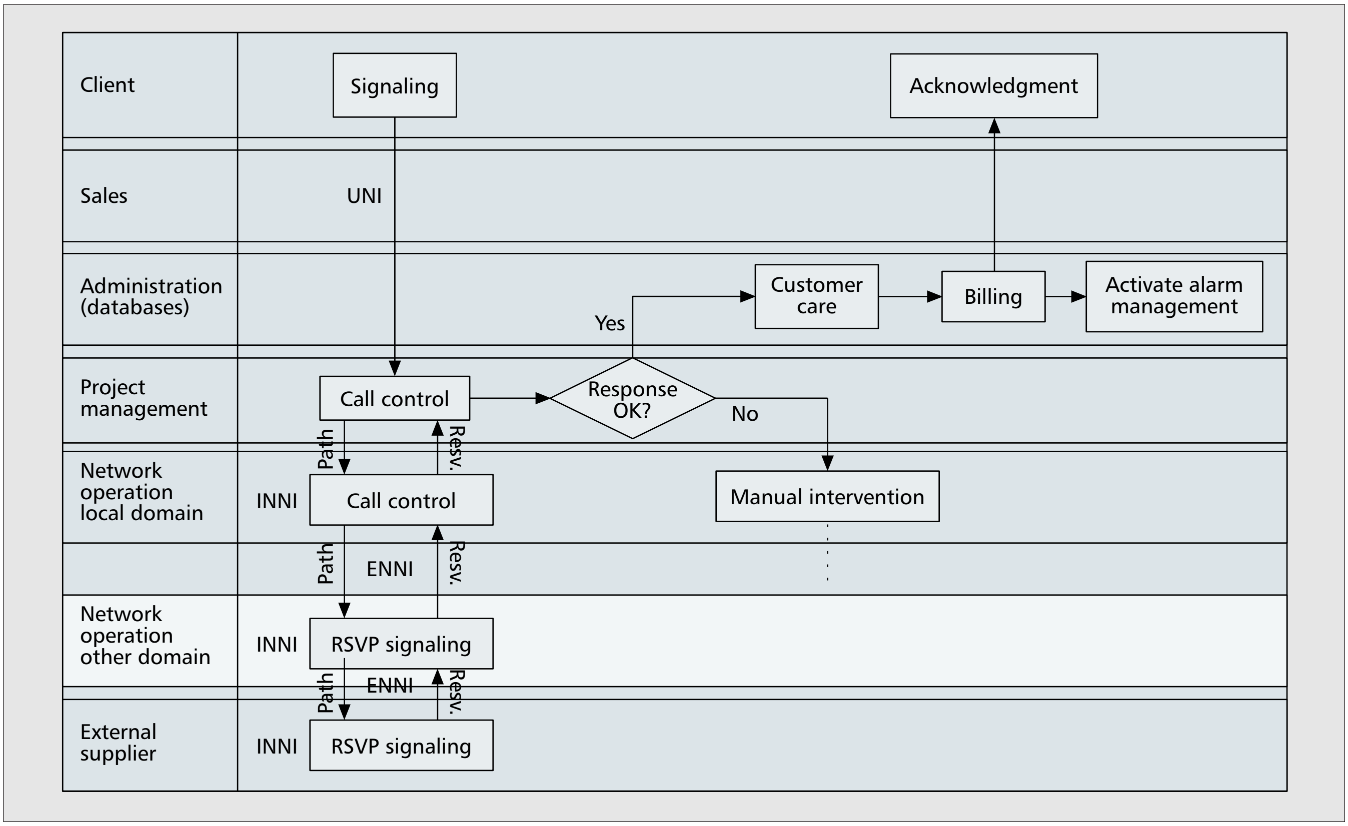


Figure 2. *Service provisioning process with GMPLS.*

Replacements in the routine operation process are only those that can happen in the service window. The service window indicates the time (e.g., at night) during which service interrupts are contractually not considered as downtime. As GMPLS enables faster reconfiguration, more operations can happen during the service window, so the repair process needs to be triggered less often.

On the other hand, monitoring the software and needed software upgrades becomes more expensive in case of GMPLS, because its complexity drastically increases due to the presence of the control plane. In general, we can expect the routine operation cost to increase a bit when GMPLS is used.

Reparation — As a result of using GMPLS, more failures can be fixed from the network operations center (NOC), which could have a beneficial impact on reparation cost. On the other hand, GMPLS leads to more complex network operation, which might be an additional source of failures. Rerouting of traffic happens faster: GMPLS allows for many fast and automated restoration and protection schemes. Isolating a fault gets cheaper when the link management protocol's (LMP's) fault management procedure is available, but LMP is optional in GMPLS [1]. Overall, we expect the cost for the reparation process to decrease with GMPLS. Reference [3] gives an overview of the repair process.

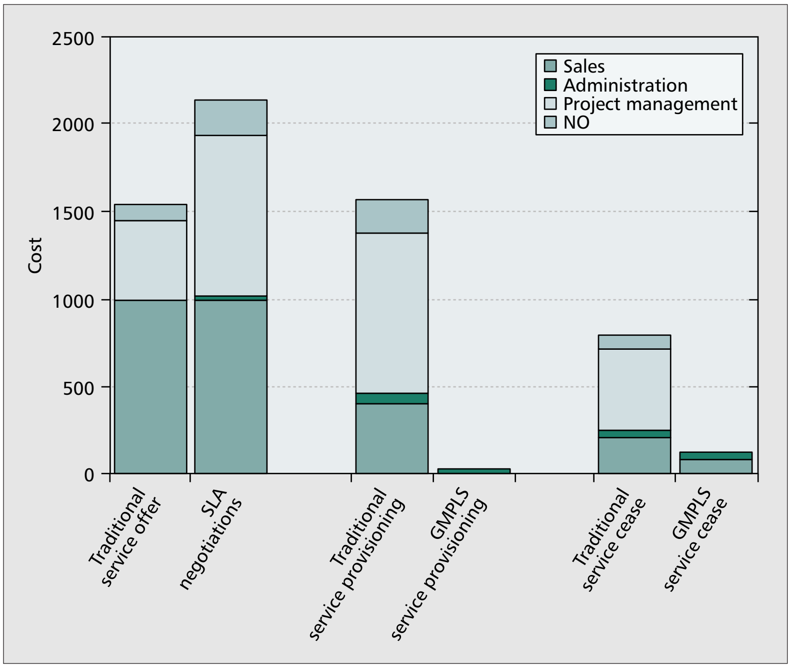
Operational Network Planning — Indirectly, the used network technology will also influence the cost of planning, as more complex systems require greater planning effort.

Marketing — As GMPLS technology allows new services to be offered that are initially unknown to customers, additional marketing will be needed to inform customers. This will lead to higher marketing costs. On the other hand, of course, it may also lead to higher revenues.

Service Management Processes

Finally, technologies automating some of the network operation allow the cost for service provisioning to be significantly reduced, because the signaling can be done via standardized interfaces (UNI and NNI), without requiring manual intervention. This means that the cost of setting up a new connection decreases greatly.

In this case, the service offer and provisioning processes will change fundamentally [6]. Since service delivery will now be automated and executed on the pure machine level, correct agreements and regulations must be negotiated by the sales department, and implemented well before in the form of service level agreements (SLAs). The use of GMPLS technologies and the possibility to offer dynamic services are strongly interconnected issues. The strongest impact of dynamic services is on the pricing and billing process. Fixed price services (e.g., leased lines) will definitely be cheaper in pricing and billing than dynamic services. For dynamic services it is much more difficult (and thus more expensive) to correctly assign costs to customer accounts. Calculating a new price for a new service is more expensive than just applying a traditional pricing scheme. This is elaborated below as negotiations in the service provisioning process.



■ **Figure 3.** *Cost comparison for incumbent.*

SLA Negotiations — The process chain therefore starts with the SLA negotiation process. Before single services are ordered and delivered, a contract framework specifies in detail all sections of a generic service template. Technical aspects like bandwidth (minimum, burst) and its granularity, service availability, and quality of service are specified as well as legal and organizational questions (penalties for requirements not met, compensation, tracking and reporting, etc.). Within the network operator this is accompanied by forecasts (SD), planning (PM), and adaptation of the infrastructure (NO). For new customers, these actions may also involve the order and installation of special hardware (e.g., converters at the customer's premises) and connecting the customer location with the network (including a test of the link).

Service Provisioning — After this framework has been set up, the service delivery process can be simplified due to the introduction of standardized interfaces (Fig. 2). External signaling at the UNI is directly forwarded to the call control (PM) that splits it into Resource Reservation Protocol (RSVP) signaling for each domain (NO). Manual intervention is necessary to set up the connection completely only if no positive responses are received. After database update (AM), customer care is informed, and billing and alarm management are activated. At the end of this process, the client receives the delivery report.

Service Cessation — In the GMPLS case, a cessation request is also received via the UNI. The cease process then triggers the sales department to assess the cessation request, and trigger the billing and confirmation of cessation to the client. On the physical side, the NOC is requested to cease the physical connection. Once the connection is released it is confirmed to the project management, and the order is closed.

Service Move or Change — The GMPLS-modified move and change process is initiated by a customer requesting a move and change. The availability of resources and conformity of this request with the SLA contract are checked automatically. If both have been answered positively, the corresponding cease and provisioning steps are handled directly via the control plane. Manual intervention is only necessary where additional resources have to be deployed in the network or if the request exceeds the SLA framework. Finally, the customer is informed of the results.

Quantitative Results

For each process, costs have been assigned to the process steps (boxes, Fig. 2) and a probability to the branches. We focus on labor costs, expressed in terms of hours required to carry out the task described in the box. Then we calculated the hourly cost[1] of each kind of employee,[2] and multiplied it by the number of hours. Summing up costs for all steps then gives an upper bound estimate of the overall cost of a given process.

The figures on which we based our calculations were obtained by means of interviews and surveys of several network operators.[3] Since the results we present here are based on expert estimations, uncertainty has to be taken into account. However, the standard deviation per process never exceeds 27 percent of the average value. A first analysis of these figures revealed two main types of operators. Indeed, some operators had high number of hours for the sales, administration and project management departments. On the other hand, another group of operators presented lower figures for these departments, whereas the figures for the other departments remained in the same range. We refer to the first type of operators as *incumbent* since they usually have heavier administrative procedures involving larger numbers of employees. By contrast, the second type is referred to as *new entrant*, having less administrative overhead and simpler project management procedures.

Incumbent

In the case of a typical incumbent operator (Fig. 3), the service offer process involves expensive sales and availability check operations. In the end it is nearly as expensive as the service provisioning itself. The cease process involves nearly no work from project management and the NOC, which explains why it is much cheaper. The move and change process is the combination of service offer, provisioning, and cease (in principle, it is a little more expensive since it requires some more coordination).

Looking at the GMPLS-modified processes, we first notice that SLA negotiations are more expensive than the typical service offer. This is normal since the former includes some operations that are usually carried out in the service provisioning process (plan, install, and configure equipment boxes). For a fair comparison, one needs to compare the combination of service offer and provisioning. In the case where

[1] Costs for the company, not only the wages, as suggested in [7].

[2] Each department involved in the processes is composed of one type of employee except the NOC, where engineers, technicians, and field technicians have been considered [7].

[3] For confidentiality reasons the company names of these operators are not disclosed in this article.

GMPLS is used, project management and sales are involved only once — when the SLA is setup — leading to substantial savings. Another advantage is that the same SLA can serve for several services. So once the SLA is in place, provisioning several services with GMPLS costs much less.

New Entrant

For new entrants (Fig. 4), we first see that typical processes are cheaper. This is normal since fewer administrative procedures and less project management are involved, which is balanced by some of these tasks being moved to the NO. Overall, the same tasks are usually carried out, but the split between PM and NO is different. Moreover, we should not forget that this type of operator certainly owns less equipment and infrastructure and thus probably does not provide as many different types of services as an incumbent. Moreover, outsourcing parts of a connection to an external supplier is more frequent (e.g., access lines from a city carrier). In Figs. 3 and 4, the costs displayed do not include the cost of having part of a service going through an external supplier, since this can vary widely and depends on many parameters. But one has to keep in mind that the additional costs it induces (renting, more testing required at interconnection points, etc.) will certainly reduce the cost difference between incumbents and new entrants. In any case, we see that for new entrants GMPLS modified processes are also cheaper and in the same proportion as for the incumbent.

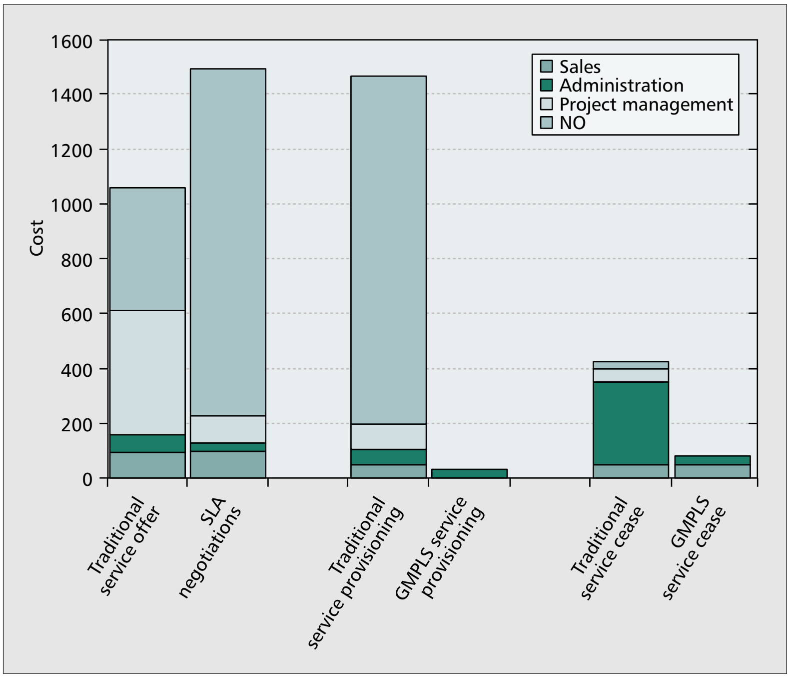


Figure 4. *Cost comparison for new entrant.*

Summary and Conclusion

The investigations for this article include a considerable effort in surveys and interviews with multiple carriers. This allows us to go one step beyond the general claims of GMPLS advantages. Quantitatively substantiated conclusions can be drawn, critically evaluating the real OPEX benefits of GMPLS.

Our studies show that most network operators' processes are similar and can be modeled quite generically. When looking at typical efforts for these processes, there are major differences between incumbent operators and so-called new entrants, which have much lighter business processes but more complex technical processes since they have to resort to external partners more often. This is also the reason why new entrants very often focus on large customers and project business, where customized solutions with more technical efforts are required anyway. Incumbents, on the contrary, have lean technical processes that allow them to provide standard services more easily.

However, interestingly, for both types of operators OPEX effort and cost reductions on the order of 50 percent from traditional operations can be identified when introducing GMPLS.

Based on these results, the introduction of GMPLS can generally be recommended to significantly reduce OPEX. This advantage can even be improved if all network domains and all network layers support interworking GMPLS control planes, and hereby also reduce the operational cost for end-to-end connections across multiple operators' domains.

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Biographies

R. Chahine's biography was unavailable at the time this article was prepared for publication.

Didier Colle received an M.Sc. degree in electrotechnical engineering (option, communications) from Ghent University in 1997. Since then, he has been working at the same university as a researcher in the Department of Information Technology (INTEC). He is part of the research group INTEC Broadband Communication Networks (IBCN) headed by Prof. Piet Demeester. His research led to a Ph.D. degree in February 2002. He was granted a postdoctoral scholarship from the Institute for the Promotion of Innovation through Science and Technology in Flanders (IWT-Vlaanderen) for the period 2003–2004. His research deals with design and planning of communication networks. This work focuses on optical transport networks, to support the next-generation Internet. Until now, he has actively been involved in several IST projects (LION, OPTIMIST, DAVID, STOLAS, NOBEL and LASAGNE), COST actions 266 and 291, and the ITEA/IWT TBONES project. His work has been published in more than 100 scientific publications in international conferences and journals.

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