Influence of a control plane on network expenditures

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ABSTRACT

This paper provides a detailed analysis and modelling of the Operational Expenditures (OPEX) for a network provider. The traditional operational processes are elaborated and the expected changes when using a control plane such as ASON/GMPLS are described. Control planes are promoted as a major technology for the automation of network operations. It is often claimed to allow the reduction of OPEX. However, detailed analysis and quantitative evaluation of the changes induced by such technologies is rare. In this paper we quantify the cost reduction potential of an ASON/GMPLS based control plane. Additionally, we show an important impact of the used resilience scheme on the expenses directly related to continuous costs of infrastructure (floorspace, energy,…) and on the planning and reparation costs. Concerning the service provisioning costs, we show that the introduction of a control plane leads to a reduction in the order of 50% of the OPEX cost compared to the traditional case.

Keywords: OPEX, network management, network operations, business case, GMPLS, ASON

1. INTRODUCTION

This paper presents a quantitative study on the operational expenditures for a transport network operator. We evaluate how control planes such as Automatic Switched Optical Network (ASON) or Generalized Multiprotocol Label Switching (GMPLS) technologies impact transport network operators' processes and costs, when compared to traditional approaches.
During the last years the main focus of transport network evolution was on increasing transport capacities and on 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. ASON, or GMPLS, together with standardized interfaces like UNI/NNI automate the operation of telecom networks[1]. They allow to efficiently provide services and to improve the resilience of networks. For the service provisioning there is the new paradigm of user initiated service provisioning (also known as switched connections) where the client can setup connections without operator interaction. This does not only speed 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 link management, failure restoration, or provisioning services such as leased lines is followed by several initiatives and standardization bodies including ITU, OIF and IETF. In this paper we do not distinguish the details of these approaches but generally assume a control plane supporting automation of network operations. We use the term ASON/GMPLS to refer to any kind of control plane according to one or several of these standards.

2. APPROACH

The total expenditures of a company can be split in two parts: the capital expenditures (CAPEX) and the operational expenditures (OPEX). CAPEX contribute to the fixed infrastructure of the company and are depreciated over time. They are needed to expand the services to the 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 technical and commercial operations, administration, etc. This paper focuses on the impact of ASON/GMPLS on the OPEX in an

operational network, i.e. one that is up and running[3]. We therefore don't consider initial installation and network extension costs. All infrastructure is counted as CAPEX, as suggested in[4]. For the traditional network, we assume that it provides end-to-end services. The ASON/GMPLS network additionally offers dynamic services.
Network operation comprises all the processes and functions needed to operate a network and deliver services to customers. That 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. Thus the significance of a reduction in OPEX cannot be downplayed.
In this study we want to perform a process-based quantitative analysis of OPEX and the reductions expected for operators using ASON/GMPLS in their transport network. The study is based on the OPEX model defined in[3]. Starting from this very comprehensive model, we evaluate which operations become more or less expensive when the used technology is ASON/GMPLS instead of the traditional static transport network. Apart from the operations, particular attention has also to be paid to the processes' branches. The probability of each branch of the processes' flow has also to be extrapolated when considering the new technology.
Based on this qualitative modelling, 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 ASON/GMPLS can be obtained.

3. TRADITIONAL PROCESS STRUCTURE

In general, the introduction of GMPLS as well as the considered resilience scheme will influence the cost structure of network operators in many ways. The next sections describe the processes being affected. A more generic description can be found in[5]. For traditional networks, we consider 1+1 protection (two connections are setup simultaneously, one of them being used as backup).

3.1. Continuous and recurring processes

3.1.1. 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). The continuous cost of infrastructure follows the same trends as CAPEX. Additional network equipment installed as a backup for failures (1+1 protection) leads to higher costs for floor space and energy.

3.1.2. Routine operations

It is the cost to maintain the network or to operate the network in case a failure can occur. The actions involved include direct as well as indirect (requested by an alarm) polling of a component, logging status information, etc. Also stock management (keeping track of the available resources and order equipment if needed), software management (keeping track of software versions, and install updates), security management (keeping track of people trying to violate the system and block resources if needed), change management (keeping track of changes in the network, e.g. a certain component goes down) and preventive replacement are included.

3.1.3. Reparation

Reparation means actually repairing the failure in the network, if this cannot happen in routine operation. Reparation may interrupt unprotected services. The actions involved in the reparation process are diagnosis and analysis, technicians traveling to the failure location, actual fixing of the failure and testing whether it is actually repaired. In a unprotected network, we expect that reparation is more expensive because of the additional effort to reroute the affected traffic.

3.1.4. Operational network planning

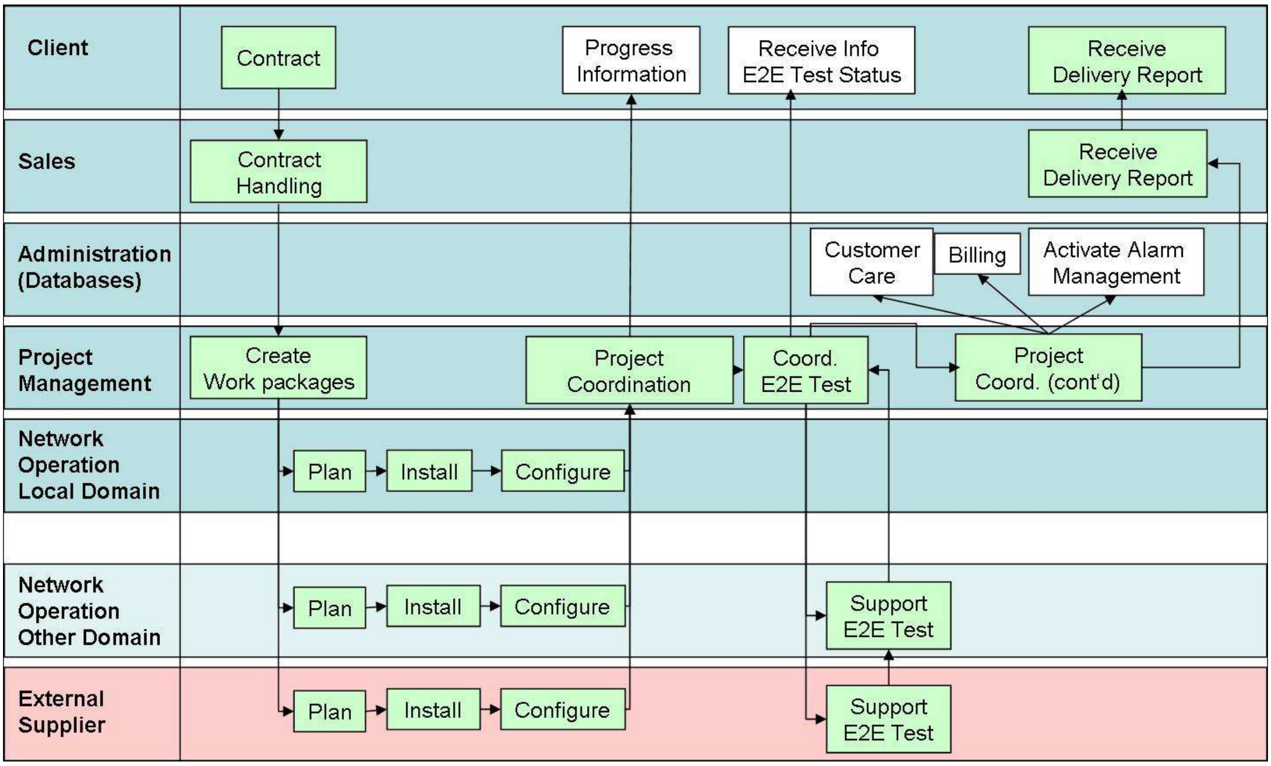

Figure 1 : typical service provisioning process

It is an ongoing task and includes all planning performed in an existing network which is up and running, including day-to-day planning, re-optimization, planning upgrades. The costs for planning are smaller for the unprotected network, because backup scenarios do not need to be planned for. We also assume that the non-ASON/GMPLS network is managed by one standard centralized Nework Management System (NMS) per administrative domain, calculating routes and monitoring alarms but still requiring human intervention to configure the equipment.

3.1.5. Marketing

With marketing we mean acquiring new customers to a specific service of the network operator. The actions involved are promoting a new service, provide information concerning pricing, etc.

3.2. Service management processes

We investigated the five most technology dependant processes within the traditional structure of network operators considering the interactions and operations of sales department (SD), administration (AM), project management (PM), network operation (NO) and external suppliers (ES).

3.2.1. Service offer

The sales department negotiates the terms and conditions of the offer with the customer and checks whether the connection request can be handled by the standard mechanisms and infrastructure. In case of non-standard 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 projecting results then define the price calculation (SD), as well as the delay necessary to set up the service. Then the offer sent is to the customer.

3.2.2. Service provisioning

After the contract has been accepted the service delivery process starts (fig. 1). The sales department handles the contract administration, then the order is split it into work packages according to the network domains involved (PM).

After providing the connection (NO), an end-to-end test is conducted and customer care, billing and alarm management are activated (AM). Finally, a delivery report is issued by the sales department to the customer. In case of 1+1 protection, the cost increases significantly since it is required to setup almost two connections.

3.2.3. Service cessation

At the end of a contract or on 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).

3.2.4. 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 Project Management department. In the same time the client is receiving updates on the new installation.

4. CONTROL PLANE IMPACT ON OPERATIONAL PROCESSES

From the main operational processes described above, several are impacted by the use of ASON/GMPLS. We consider that the use of ASON/GMPLS impacts the processes in two ways: the way connections can be setup and managed, and the wider variety of resilience schemes it promotes. Regarding the resilience schemes, we will now assume that in a ASON/GMPLS network shared mesh protection will be used instead of 1+1 protection. For shared protection, two connections are also planned, but only one is actually provisioned, the second one being provisioned only when the first one has failed. The advantage is that the resources of the latter can be shared among several backup connections, leading to more efficient resource utilisation. This obviously impacts CAPEX, and as a consequence the continuous and recurring processes, which tend to decrease together with CAPEX. Shared protection could also be used in a non GMPLS network, but we consider it is more applicable in the ASON/GMPLS case because the backup path can be provisioned and switched much faster.

4.1. Continuous and recurring processes

4.1.1. Continuous cost of infrastructure

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

4.1.2. Routine operations

The cost of the routine operation (maintenance cost) depends also on whether the network is automatically switched or not. The use of ASON/GMPLS influences the routine operation costs because (re)configuration after replacement of equipment can happen faster. The replacements in the routine operation process are only those that can happen in the service window. The service window indicates the time (e.g. during the night) during which service interrupts are contractually not considered as downtime. As ASON/GMPLS enables faster reconfiguration, more operations can happen during the service window, so that the repair process needs to be triggered less often. On the other hand, monitoring the software and the needed software upgrades becomes more expensive in case of ASON/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 ASON/GMPLS is used.

4.1.3. Reparation

As a result of using ASON/GMPLS more failures can be fixed from the NOC, which could have a beneficial impact on the reparation cost. On the other hand, ASON/GMPLS leads to more complex network operation, which might be an additional source of failures. Rerouting of traffic happens faster: ASON/GMPLS allows for many fast and automated restoration and protection schemes. Isolating a fault gets cheaper when Link Management Protocol (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 in case of ASON/GMPLS. [3]gives an overview of the repair process.

4.1.4. Operational network planning

Indirectly the used network technology will also influence the cost of planning, as more complex systems require a higher planning effort.

4.1.5. Marketing

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

4.2. Service management processes

Finally, technologies automating some of the network operation allow to significantly reduce the cost for service provisioning, because the signaling can be done via standardized interfaces (User Network Interface UNI, and Network to Network Interface NNI), without requiring manual intervention. This means that the cost for setting up a new connection decreases strongly. In this case, the service offer process and provisioning process will be changed fundamentally[6]. Since the service delivery will now be automated and executed on the pure machine level, correct agreements and regulations have to be negotiated by the sales department, and implemented well before in the form of Service Level Agreements (SLAs). The use of control plane technologies and the possibility to offer dynamic services are strongly interconnected issues. The strongest impact of the 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.

4.2.1. SLA negotiations

The process chain therefore starts with the SLA negotiation process. Before the 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, 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, it also involves connecting the customer’s location with the network (which is carried out in the service provisioning process for the non-GMPLS case).

4.2.2. 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 RSVP signaling for each domain (NO). Manual intervention is necessary to set up the connection completely only if no positive responses were 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.

4.2.3. Service cessation

In the ASON/GMPLS case, the 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 network operation centre is requested to cease the physical connection. Once the connection is released, this is confirmed to the project management and the order is closed.

4.2.4. Service move or change

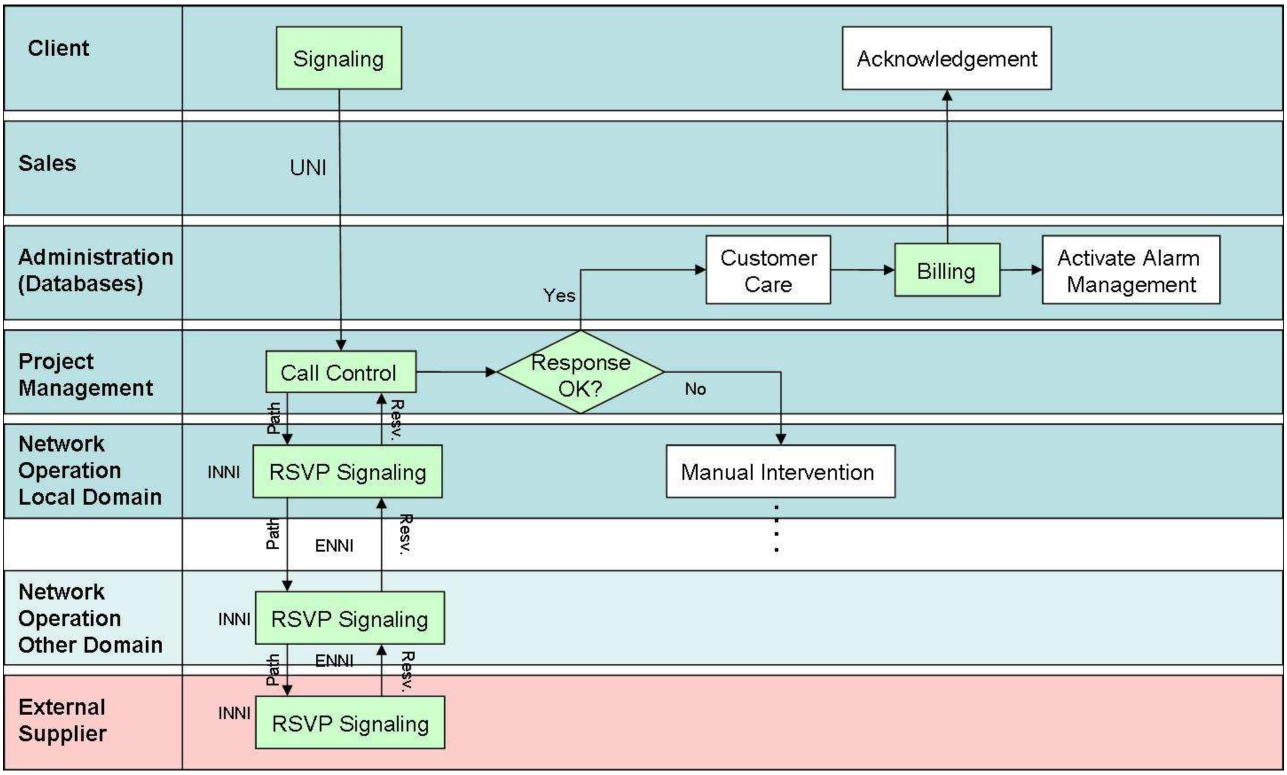

Figure 2 : service provisioning with ASON/GMPLS

The ASON/GMPLS-modified move and change process is initiated by the customer requesting a move and change. The sales department transforms this request directly to check for possibility of request and availability of resources within the framework of the SLA. Once the check of SLA is done, the customer is sent the offer to accept or refuse it. If the customer accepts the sales department generates orders for the service delivery process and cease process that are implemented with coordination from the project management department. At the same time the customer is receiving updates on the new installation.

5. QUANTITATIVE RESULTS

5.1. Service management

For each of the processes described in[3], costs have been assigned to the process steps (boxes in the figure) and a probability to the branches. We focused on labor costs, expressed in terms of hours required to carry out the task described in the box. Then we calculated the hourly fully accounted cost of each kind of employee, and multiplied it by the number of hours. As suggested in[7], we distinguish several personnel categories: sales, administration, engineers and technicians (in the NOC or field technicians). Each department displayed in fig 1 and fig. 2 is composed of one type of employee, except the NOC where engineers, technicians and field technicians have been considered. Summing up costs for all steps gives then an upper bound estimate of the overall cost of a given process. Cost and effort figures for the current network operations were collected based on surveys and interviews with several carriers. From these figures we extrapolated the figures for the new ASON/GMPLS process model.
In the case of a typical incumbent operator (fig. 3), the service offer process involves expensive sales and availability checks 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 network operations center, 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 ASON/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

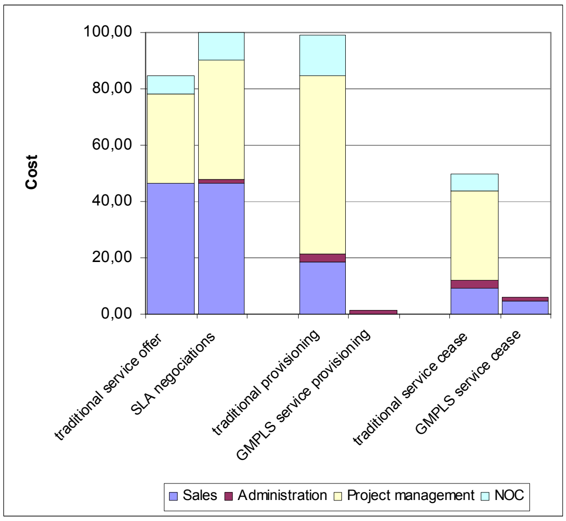

Figure 3 : Normalized cost for a non-standard service

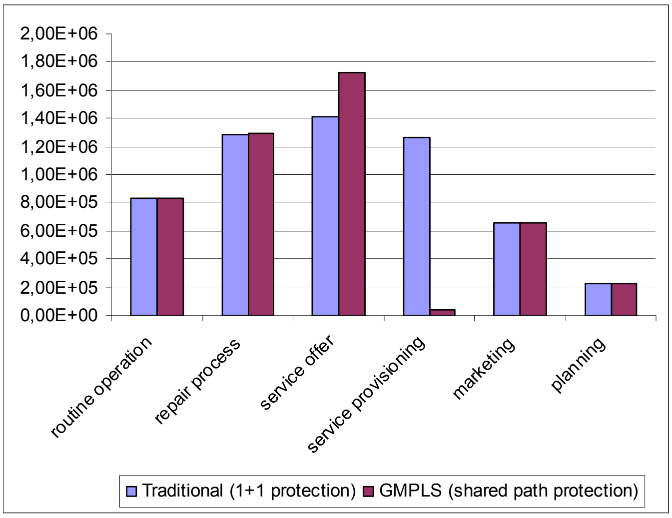

Figure 4 : Yearly OPEX (€) for all processes

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 a control plane 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 ASON/GMPLS costs much less.

5.2. Overview of all operational processes

In order to compare the costs of all processes, a specific case needs to be studied. We consider an optical (WDM) network carrying 2.5 Gbps leased lines and calculate the costs over one year. Although, in a realistic network, leased lines would probably be offered via SDH or OTN over WDM, we focus on this architecture for the sake of simplicity. The topology is the reference German network[8] with 17 nodes and 26 links and the associated traffic for 2004. This traffic leads to 1214 services for one year, 80% of which we assume to be standard services. We also assume that there are no service cessations or move.

5.2.1. Equipment

For each type of equipment (WDM line systems, optical amplifiers, transponders, unequipped OXC itself) we take the following parameters into account: price, and Mean Time Between Failure (MTBF). Detailed values can be found in[9]. The equipment life time is set to 10 years. In order to be able to calculate the yearly capital equipment costs, the total equipment cost obtained from dimensioning is divided by this life time.

5.2.2. Failure probabilities

We assume two types of alarms in the network: preventive alarms and failure alarms. Based on[10], we assume 39% of all alarms to be preventive alarms. Considering failure alarms, we differentiate between CPE problems, external problems (power disruption, etc.), misconfigurations or software failures, and hardware failures (incl. cable cuts). The probabilities of these problems are specific for an optical network[11]. Based on this and the MTBF values, we determined a total of 1171 failures and 749 preventive alarms per year over the entire network.

5.2.3. Estimated yearly OPEX

With the above assumptions, we have been able to estimate yearly costs for this network scenario, as shown in fig. 4. In this respect, we need to point out that our study only considered OPEX for a network which is up and running. Also, including the costs for first-time installation in the process-based costs would have probably changed the picture.
This case study on a specific network scenario allows to compare the process-based costs over one year. We see a significant decrease for service management processes in the ASON/GMPLS case. The other processes' costs remain of

the same order in both scenarios, and could be investigated further. But this case study already allows to have an evaluation of cost reduction that could be awaited from the automation of some processes, and compare it to other OPEX categories.

6. CONCLUSION

this paper we show that most network operators' processes are similar and can be modeled quite generically. When introducing ASON/GMPLS, OPEX cost reductions in the order of 50% compared to traditional operations can be identified for service offer and provisioning together, as shown in fig.3. Based on these results the introduction of a control plane can generally be recommended to significantly reduce OPEX. This advantage can even be improved, if all network domains and all network layers support interworking control planes and hereby also reduce the operational cost for end-to-end connections across multiple operators' domains. When comparing the use of ASON/GMPLS with shared protection capacity to the traditional network without control plane, using 1+1 protection, some other cost effects become clear. The amount of backup capacity in the network has a direct effect on the CAPEX costs and the OPEX part which is directly related to continuous costs of infrastructure (floorspace, energy…) A similar trend is seen for the costs of service provisioning, which is most expensive in case of 1+1 protection (more connections need to be set up). Also planning costs grow with the amount and complexity of failure scenarios that need to be planned for. Finally, also the reparation process is impacted by the dimensioning, because more equipment leads to more possible failures. On the other hand, the availability of backup capacity strongly reduces the time to get the network operational after the occurrence of a failure and therefore reduces this cost.
This paper reports preliminary results, and future work will focus on refining the model and the input data by further questioning network operators.

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