



info

Service cost model and cost comparative studies

Carmen Mas Machuca Øyvind Moe Joerg Eberspächer Monika Jaeger Andreas Gladisch

Article information:

To cite this document:

Carmen Mas Machuca Øyvind Moe Joerg Eberspächer Monika Jaeger Andreas Gladisch, (2009), "Service cost model and cost comparative studies", info, Vol. 11 Iss 3 pp. 19 - 30

Permanent link to this document:

<http://dx.doi.org/10.1108/14636690910954953>

Downloaded on: 22 September 2016, At: 04:12 (PT)

References: this document contains references to 8 other documents.

To copy this document: permissions@emeraldinsight.com

The fulltext of this document has been downloaded 832 times since 2009*

Users who downloaded this article also downloaded:

(2007), "Learning by costing: Sharpening cost image through life cycle costing?", International Journal of Productivity and Performance Management, Vol. 56 Iss 8 pp. 651-672 <http://dx.doi.org/10.1108/17410400710832985>

(2015), "Maintenance cost estimation: application of activity-based costing as a fair estimate method", Journal of Quality in Maintenance Engineering, Vol. 21 Iss 3 pp. 258-270 <http://dx.doi.org/10.1108/JQME-04-2015-0015>

(1998), "Quality cost measurement under activity-based costing", International Journal of Quality & Reliability Management, Vol. 15 Iss 7 pp. 719-752 <http://dx.doi.org/10.1108/02656719810218202>



Access to this document was granted through an Emerald subscription provided by emerald-srm:194764 []

For Authors

If you would like to write for this, or any other Emerald publication, then please use our Emerald for Authors service information about how to choose which publication to write for and submission guidelines are available for all. Please visit www.emeraldinsight.com/authors for more information.

About Emerald www.emeraldinsight.com

Emerald is a global publisher linking research and practice to the benefit of society. The company manages a portfolio of more than 290 journals and over 2,350 books and book series volumes, as well as providing an extensive range of online products and additional customer resources and services.

Emerald is both COUNTER 4 and TRANSFER compliant. The organization is a partner of the Committee on Publication Ethics (COPE) and also works with Portico and the LOCKSS initiative for digital archive preservation.

*Related content and download information correct at time of download.

Service cost model and cost comparative studies

Carmen Mas Machuca, Øyvind Moe, Joerg Eberspächer, Monika Jaeger and Andreas Gladisch

Carmen Mas Machuca is a senior researcher and lecturer at Munich University of Technology, Munich, Germany.

Øyvind Moe is a strategic advisor at Telenor, Fornebu, Norway. Joerg Eberspächer is based at the Munich University of Technology, Munich, Germany.

Monika Jaeger is a senior consultant at T-Systems, Berlin, Germany.

Andreas Gladisch is head of department NGN, T-Systems, Berlin, Germany.

Abstract

Purpose – The purpose of this paper is to propose a service cost model which can be used to evaluate the impact of different management functionalities or network platforms to the service cost.

Design/methodology/approach – Following the validation of the importance that OpEx has on the overall TCO, a classification of the costs is proposed, based on their relation to the network. Two main types of costs have been identified: network based costs and service based costs. Both cost types have been modeled as a set of interconnected processes based on the network and service life cycle respectively. Network and service cost models have been integrated into a single framework. These models have been implemented as Markov chains, which include the dynamic behavior of services. Two different methods for the implementation (analytical versus non-analytical) have been compared from the implementation and computation time point of view. The proposed service model has been used in two case studies: cost comparison of different types of services on different platforms; and impact of the service type distribution on the overall service cost on different platforms.

Findings – This paper finds the utility that the proposed cost model has. It has been shown that the impact on the overall service cost that a particular network platform capability such as the possibility of establishing point to multipoint connections has. The proposed network and service cost models can be used on different types of networks and services.

Originality/value – The paper presents a general service cost model that can be used to study the impact of any management functionality or network platform has on the service cost.

Keywords Financial modelling, Operating costs, Telecommunication services

Paper type Conceptual paper

1. Introduction

One of the main targets of network operators nowadays is to minimize the cost of their networks (i.e. to minimize the total cost of the network ownership (TCO)) in order to maximize their profits. The first techno-economic studies were comparative studies of the investment that was required to build the network, i.e. considering a given network topology and traffic matrix, which were the equipment needed when using one particular technology and/or some management and control capabilities (Sengupta *et al.*, 2003; Verbrugge *et al.*, 2004; Schmid-Egger *et al.*, 2006). This required investment is related to the so-called capital expenditures (CapEx), which deals with the costs of the network infrastructure such as network nodes and ports, optical fiber, buildings, installations, bought and stored equipment, etc. However, these expenditures are not the most important cost of a network. The operation of a network (so-called operational expenditures, OpEx) can be as costly as CapEx. For example, Nokia claims that OpEx will be the 50-80 percent of TCO over ten years and the Metro Ethernet Forum claims 60-85 percent of TCO for OpEx (Evans, 2004). These numbers justify that both OpEx with CapEx studies together should drive the network operator's decisions.

Received 9 May 2008
Revised 16 December 2008
Accepted 20 January 2009.

The OpEx evaluation is quite complex since it covers a huge variety of types of cost such as manpower, time, material, space, equipment configuration, etc. that are required (Mas Machuca, 2006). Our model to evaluate the OpEx of a network distinguishes two types of costs:

1. *Network related costs.* These are the costs related to the maintenance and operation of the network. Costs have been associated to the network processes of the network life cycle, i.e. states of the network and of the services introduced between the start and the end of the network. These network processes are depicted in Figure 1. The costs of some of these processes have been studied in detail: the reparation of a physical failure (Schmid-Egger *et al.*, 2006) and the service migration between different platforms (Shayani *et al.*, 2008).
2. *Service related costs.* These are the costs related to a given service such as the establishment of the service, the release, the restoration, etc.

This study gives first an overview of the cost modeling of network and service costs and then focuses on the service related costs. In particular, the service cost study will be applied to Ethernet services (Gladisch *et al.*, 2006; Jäger, 2006) and the costs associated for supporting these services in different network platforms.

This paper is organized as follows: Section 2 presents the network and service modeling, the relation between both models and a detailed presentation of the cost associated to a service, whereas Section 3 introduces the implementation. Section 4 shows some numerical results and finally, conclusions are drawn in Section 5.

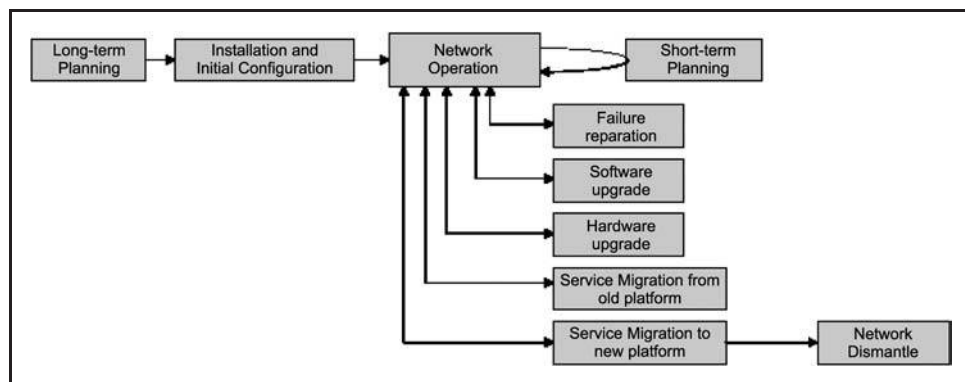
2. Network and service modeling

Providers have traditionally focused their cost evaluation of network and control architectures on up and running networks in normal operation. However, it is understood that set up, migration and tear down of networks significantly contribute to the overall network cost especially since the network life cycles get shorter in time. Therefore our overall cost modeling is based on a life-cycle approach. Furthermore, we distinguish in our approach between network related operational cost and service related operational cost, since it is important to compare the influence of new network architectures and control concepts on the OpEx separately for network and service processes.

2.1. Network processes

The network implementation is started with the long-term planning (shown in Figure 1). After the decision for a certain network architecture and design, the network is installed and initially configured. Then, the network should be in the normal operational mode, circulating between network maintenance, failure reparation, short term planning and upgrades. Before

Figure 1 Network cost model as interconnected processes associated to the network life-cycle



the network is decided to be dismantled, the platform needs to be freed from the services by migrating them to other platforms. The service cost model is invoked by the network more where needed from different network states, e.g. during normal network maintenance, service setup and tear down requests arrive from clients.

2.2. Service processes

The cost of a service has been modeled based on the service life-cycle, which is shown at Figure 2. At a given moment, a service can be in one of the following five processes:

1. *Service establishment.* This process includes the human action of establishing a service as well as the configuration of the network, such as nodes, ports, switches, etc.
2. *Service maintenance.* This process considers the action of maintaining a service, usually by a human person through a graphical user interface (GUI).
3. *Service change.* Any customer may request a change of its service such as a change of the bandwidth or adding a new end-point (in case of a multicast service). This process includes the actions required for the change.
4. *Service restoration.* Some services require a critical restoration time after a failure, which has been agreed on in the Service Level Agreement (SLA) between customer and operator. In order to achieve the requested restoration times, several actions which are considered in this process should be carried out.
5. *Service release.* When the service concludes, several actions should be carried out such as the liberation of resources and the preparation of the final invoice.

This study focuses on Ethernet services. Ethernet services can be point-to-point (P2P), point-to-multipoint (P2MP) and multipoint-to-multipoint (MP2MP). One single service can be mapped into one or several Ethernet Virtual Connections (EVCs)[1]. The mapping rate will depend on the platform being used and the protection scheme required by the service. For example, if an MPLS platform with multicast capabilities is being used, a full protected point-to-multipoint service (i.e. one site connected to N sites) is mapped into two P2MP EVCs; whereas if a traditional SDH platform is used, the service is then mapped into two times N point-to-point VCs.

An EVC can also be modeled based on its life-cycle, which is similar to the service life-cycle (refer to Figure 2). The service is realized by one or more EVCs. Hence, the service processes call EVC processes one or several times appropriately (service establishment calls EVC establishment, etc.).

Both service and EVC processes have been integrated into a single framework, as shown in Figure 3, so that the overall service cost can be computed. This overall service cost includes the cost related to the service itself and the costs related to the associated EVCs.

Figure 3 shows that some service and EVC processes have been merged into a single process as it is the case for the service and EVC maintenance. This merging is justified because both processes (service maintenance and associated EVC maintenance in this

Figure 2 Service and Ethernet virtual connection (EVC) life-cycles

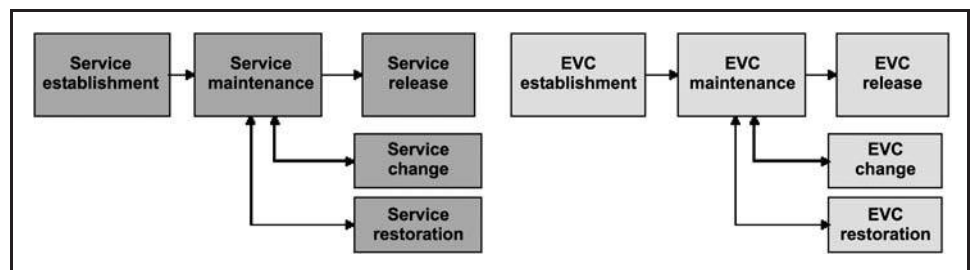
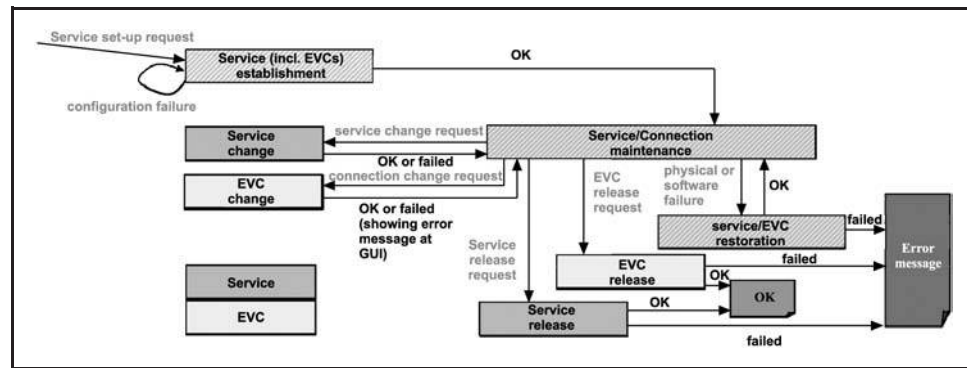


Figure 3 Integration in a single framework of the service and EVC processes

particular example) are usually done by the same persons and therefore, are associated to the same cost. These mergings also help to simplify the model. Figure 3 also shows the events that trigger some of the process calls and transitions. For example, a new service request will start the service configuration process. Another example is the existence of a failure causing a service disruption, which will trigger the service restoration process.

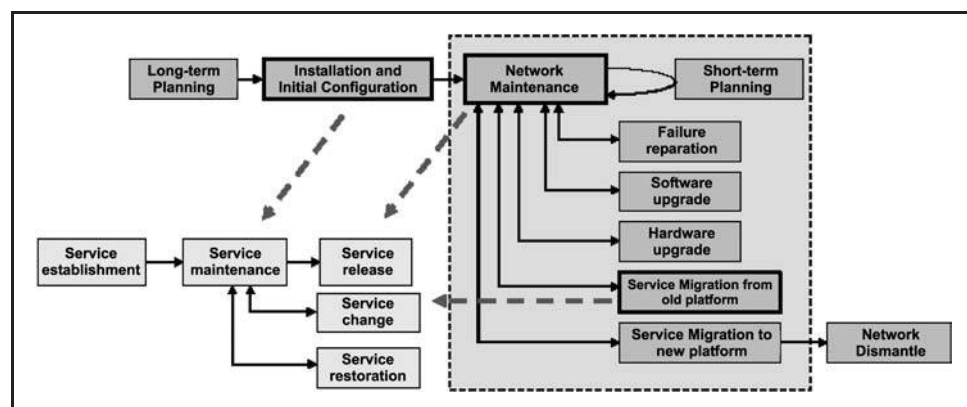
2.3. Integration of network and service costs

Figure 4 shows the network processes that call service costs, which are:

- Installation and initial configuration, where the first services are established.
- Network maintenance, where new services are established and existing services may be changed or released.
- Service migration, where services from old platforms may be established in the studied platform.

2.4. Cost to service process assignment

Each of the processes shown in Figure 3 is associated to one cost, which will obviously depend on the platform being used. All the processes but the service maintenance, are associated to a cost related to the number of parameters that have to be configured and to the way they are configured (e.g. the cost of configuring through a GUI is lower than when configuring it through a command line). The service/EVC maintenance cost is associated to the number of services (and associated EVCs) that are monitored by one person, the time required for this process, the salary this person gets, etc. The salary of this person is an average value that includes the material he needs, the training courses he requires, the

Figure 4 Service model called by network processes

average salary of the people that are monitoring services (services are maintained 24 hours per day and seven days per week), etc. In this section the evaluation of the cost of each process is presented in detail.

Service/EVC establishment. The establishments of the service and its associated EVCs have been integrated into one single process (as shown in Figure 3). The cost of this process has been modeled in two parts: the first considers the cost related to the establishment of the service, whereas the second considers the cost related to the establishment of all the associated EVCs. Depending on the platform, the establishment can be more or less automatic, e.g. it can be done through a GUI or through command lines, which will have an impact on the cost. Hence, a general model has been designed, as shown in Figure 5.

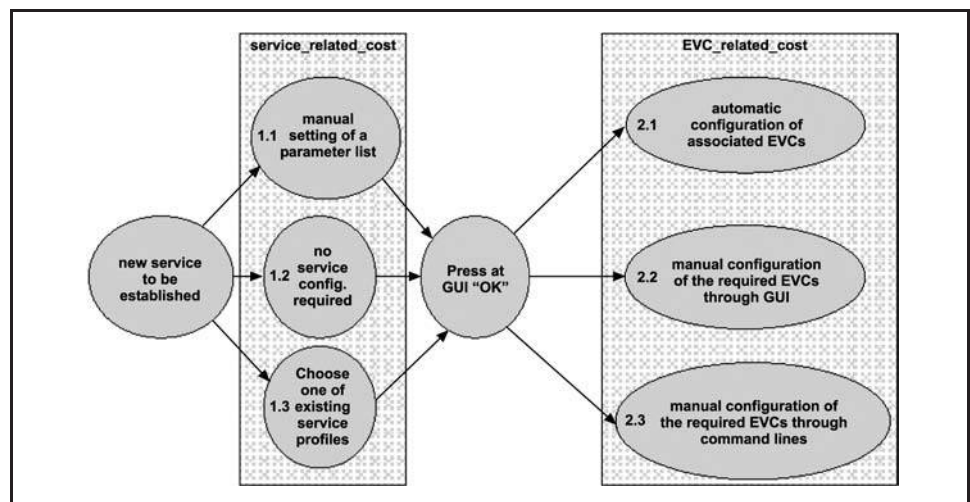
Service/EVC maintenance. The maintenance of EVCs and services are usually done through the same GUI and therefore, they have been integrated into the same process. The cost of this process is proportional to the number of persons required to monitor the service and the lifetime of the service. In this study, we assume that the maintenance cost is the same for all the platforms.

Service change. Some platforms offer the possibility to change one or more parameters of a service through the GUI of the network management system: either automatically releasing the service and establishing a new one with the new characteristics, or by updating automatically the characteristics of the service. The cost of this process is proportional to the number of actions that the operator has to do and the way these actions have to be executed (through command lines, GUI parameters, etc.)

EVC change. Similar to the service change process but applied to the EVC. Some platforms offer the possibility to change some parameters of an EVC without having to change the service (e.g. the UNI of one EVC in a P2MP service).

Service/EVC restoration. In case there is a physical or a software failure, the affected service and/or associated EVCs should be restored. The cost of this process depends on the ability of the control plane to restore the affected EVC and/or service. For example, let us consider a protected (1 + 1) P2MP service. During a failure scenario, some platforms (the ones that associate to a P2MP service multiple EVCs) may restore only the affected EVC, whereas other platforms (the ones that associate to a P2MP service a single EVC) restore the P2MP EVC. Also, there are some platforms that offer the possibility to restore the service through the GUI by rerouting the interrupted service.

Figure 5 Establishment process cost model



EVC release. Some platforms offer the possibility of releasing an EVC without having to release the service. For example, when having a VPN service, it may be possible to remove one site and therefore, releasing the EVCs associated to that site.

Service release. The cost associated to this process is related to the actions to be taken when a service has to be released, i.e. what has to be done to release a service.

3. Implementation

The service model has been implemented as a Markov chain so that it includes the dynamic aspects of a service such as the service and EVC requests that occur during the life of a service, the different failures that may occur, etc. The chain of the service model is shown in Figure 6. The arrows show the possible transitions from one state to another and they have assigned a value which is the transition probability. The transition matrix of this Markov chain is explained in next section.

Two different methods for the implementation have been compared: the non-analytical approach which computes the Markov chain step-by-step, and an analytical approach of solving Markov chains known as Markov Reward Model (MRM). Both methods have been proven to provide results that are realistic in nature and they have a small difference in the implementation simplicity. The main difference between both approaches is the computation time: the second one is more than 10,000 percent faster than the first approach and hence, it was chosen as the final implementation.

3.1. Transition matrix

All Markov chains have associated a transition matrix which gives the transition probabilities from one state to another. In general, cell (i, j) contains the transition probability to go to state j from state i .

Table I shows the transition matrix associated to the Markov chain of Figure 6. The number of states is 9. The sum of all the transition probabilities from one state (i.e. of one row of the transition matrix) is always 1.

Figure 6 Markov Chain associated to the service cost model

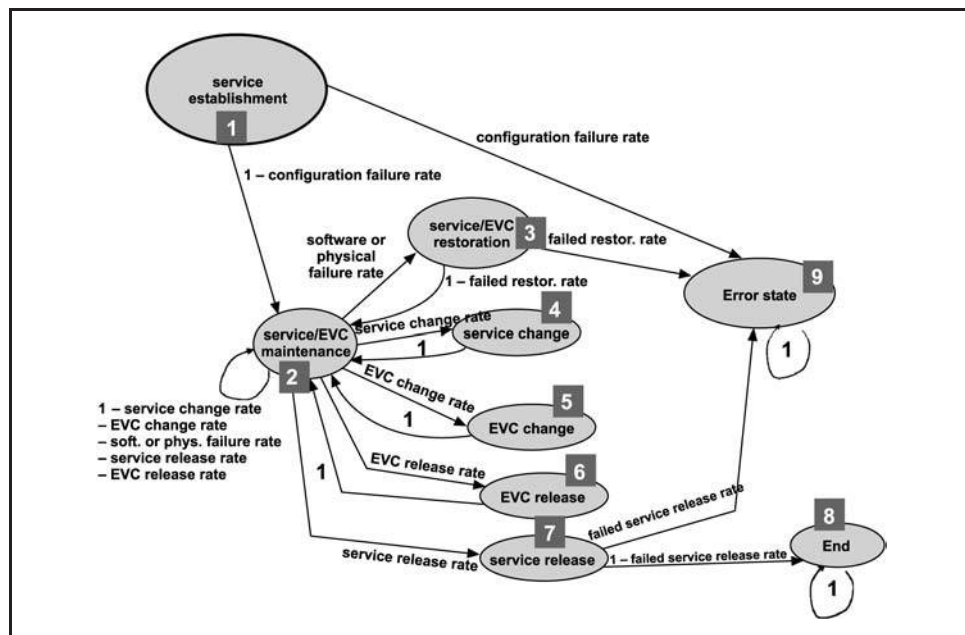


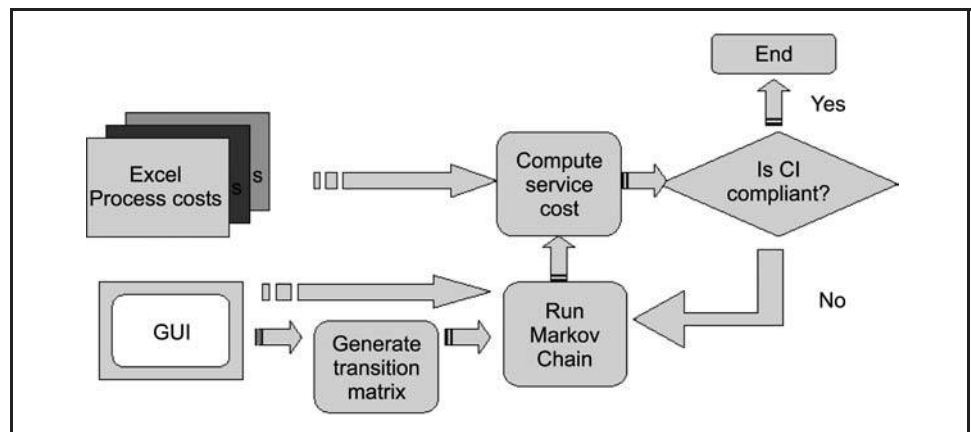
Table I Transition matrix of the service model

	1	2	3	4	5	6	7	8	9
1	0	1-configuration failure rate	0	0	0	0	0	0	Configuration failure rate
2	0	1- Service change rate-EVC change rate-software or physical failure rate-service release rate-EVC release rate	Software or physical failure rate	Service change rate	EVC change rate	EVC release rate	Service release rate	0	0
3	0	1.failure restoration rate	0	0	0	0	0	0	Failure restoration rate
4	0	1	0	0	0	0	0	0	0
5	0	1	0	0	0	0	0	0	0
6	0	1	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	Failed service release rate	1-failed service release rate
8	0	0	0	0	0	0	0	1	0
9	0	0	0	0	0	0	0	0	1

3.2. Model implementation and computation of the total service cost

The overall view of the model implementation is given in Figure 7. A graphical user interface (GUI) allows the user to enter some parameters such as the number of services, the duration distribution of the services, the percentage of each type of services (P2P, P2MP, MP2MP), the platform (E-MPLS, E/SDH, Manual), the different probabilities required to build the transition matrix (as shown in Table I), etc. Based on these parameters, the transition matrix is built and the Markov chain can be simulated. The output gives us the number of visits to each state and the number of instances at each state.

The cost of the service(s) requested at the GUI is computed as the sum of the costs of each of the processes of its life-cycle taking into account the failure rates of the network, the type of service (P2P, P2MP or MP2MP), the service and EVC change request rates, the service duration distribution, etc. Hence, by knowing how often the states were visited, the

Figure 7 Overall view of the service model implementation

cost is computed by multiplying the cost of the process with the number of visits to the process. This applies to all the processes but the maintenance process whose cost is proportional to the time that the service was maintained. It has to be mentioned, that the cost of each process will depend on the platform, and therefore, a database is used for the process costs of the different platforms (as shown in Figure 7). Several simulations are done to establish 95 percent confidence intervals (CI) which are smaller than 10 percent of the average value.

4. Simulations and results

The service model introduced in this article has been used on two case studies that aim at comparing service configuration and operation efforts, allowing to identify service related OpEx for typical next generation L2 services in future packet optimized network architectures. Two different approaches for transporting L2 services can be seen today:

1. Ethernet over existing SDH/OTH based transport networks, which are adopted and enhanced to supporting L2 packet based data transport. New SDH platforms can be equipped with an ASON/GMPLS based control plane (signaling and routing functions) that offer the automatic configuration of VCs.
2. Native Ethernet over static OTN/WDM data transport, using carrier-grade Ethernet network solutions in the aggregation/metro/core network area.

For benchmarking purposes, the configuration of a traditional SDH platform, using only minimum management functions, is also investigated.

Hence three different network platforms with different management capabilities have been assumed in our case studies:

1. First generation SDH with manual configuration capabilities, which is denoted as "Manual". This is the case of the first SDH networks, where every VC had to be established through command lines.
2. Next Generation SDH with Ethernet over SDH (VCAT, GFP, LCAS) support and with automatic configuration capabilities, which is denoted as "E/SDH". However, this platform typically does not yet support multipoint VCs. Therefore, the platform we assume for our case study, as shown in Table I, is assumed to provide point-to-point VCs only.
3. Ethernet with MPLS based control plane, which is denoted as "E-MPLS". There are first implementations of carrier-grade Ethernet solutions which are controlled by MPLS based L2 control functions. Practical configuration experiences with test-bed implementations of the anticipated platforms accompanied our modeling and case studies. Therefore, we specified a second variant of the configuration model in an E-MPLS platform, whose configuration management allows using some pre-defined service profiles of typical services to facilitate and speed up the establishment of new services. Hence, we will distinguish "E-MPLS with profile" and "E-MPLS without profile" platforms.

The mapping of services onto (E)VCs has been shown in Table II. The values used for our study (for a single P2P service) are given in Table III.

	<i>Unprotected service</i>			<i>Full protected service</i>		
	<i>P2P</i>	<i>P2MP</i>	<i>MP2MP</i>	<i>P2P</i>	<i>P2MP</i>	<i>MP2MP</i>
"Manual"	1	N	N(N-1)	2	2N	2N(N-1)
"E/SDH"	1	N	N(N-1)	2	2N	2N(N-1)
"E-MPLS"	1	1	1	2	2	2

Table III Values of the parameters used in the simulation studies

Parameter	Value	Parameter	Value
Multipoint degree N	5	Configuration failure prob.	0.0001
Physical failure prob.	0.0002	Software failure prob.	0.0001
Failed action rate	0.0001	(E)VC release ratio	0.01
Service change ratio	0.01	(E)VC change ratio	0.01
GUI conf. cost	10	Command conf. cost	20

4.1. Case study I

The first case study compares the cost of one P2P, P2MP or MP2MP services for their whole lifetime in the above mentioned network platforms. The lifetime of the service has been assumed to be three years and the multicast degree N equal to 5. Figure 8 shows the cost comparison of the three types of service for the different platforms. It can be observed that “E-MPLS with profile” is the most cost effective, i.e. the most automatic, whereas the “manual” is the more costly due to the higher number of human actions during the different processes of a service life-cycle. It can be also observed that for the “E/SDH” platform case, the cost of a MP2MP service is much higher compared to a P2P service due to the ratio between the service and associated (E)VCs of Table II. This cost difference does not apply to the “E-MPLS” platform where the cost of the three types of services (P2P, P2MP and MP2MP) is comparable, due to the multipoint configuration capability of the platform.

This study also looked into the distribution of the cost among the different processes of a three-years service life-cycle. It was observed that for the “E/SDH” platform, the most costly process for P2P and P2MP services was the *service restoration*, whereas for MP2MP services it was the service establishment. This can be justified by the higher number of (E)VCs that have to be established for a MP2MP service (as shown in Table I) it is $N(N-1)$ if it is an unprotected service.

4.2. Case study II

The second case study compares the cost of a set of 50,000 services for a different percentage of P2P, P2MP and MP2MP services. The service duration was assumed to be between one and five years with a mean of three years. The results are shown in Figure 9. It can be observed that the “E-MPLS” platforms are not sensible to the percentage of the

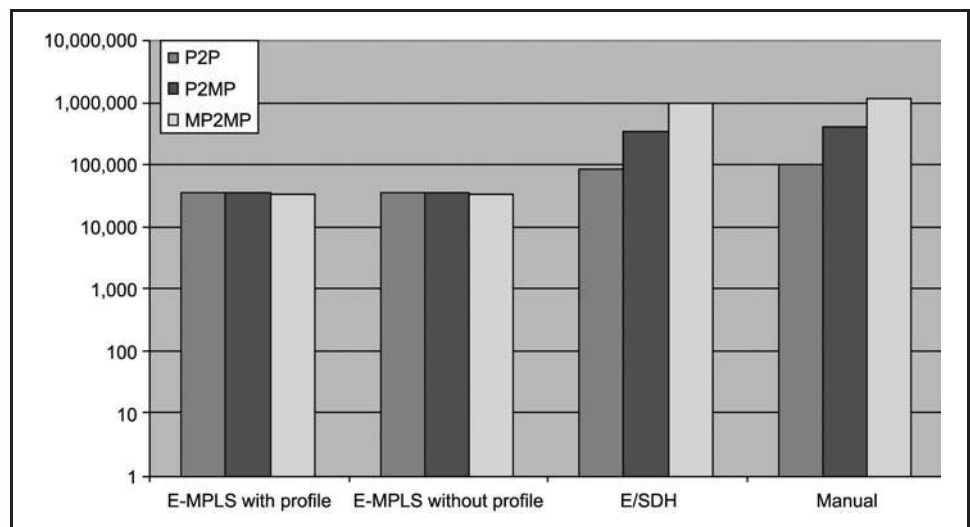
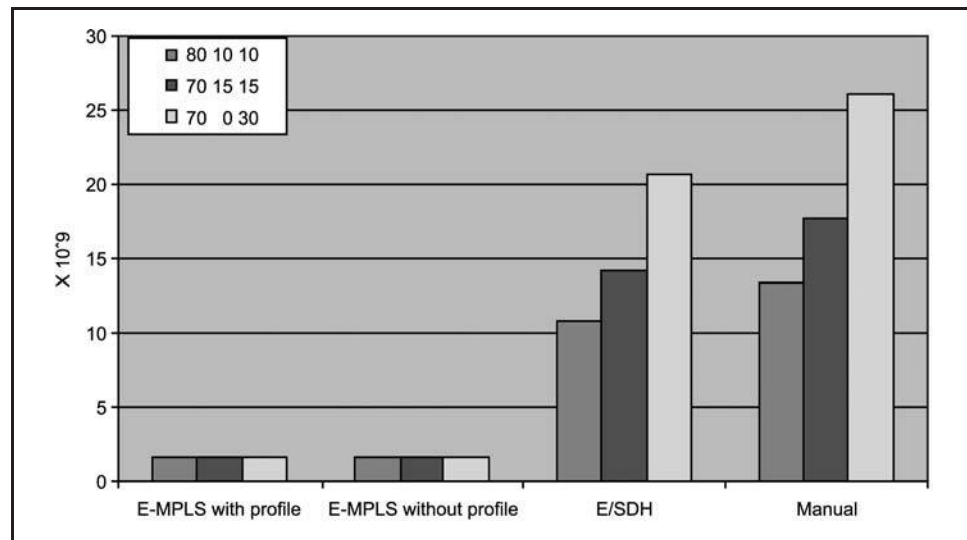
Figure 8 Cost comparisons of different types of services for the different platforms

Figure 9 Cost comparisons of different platforms for a different distribution of services

different types of services, whereas the “manual” and “E/SDH” platforms are sensitive to this percentage and in fact, the overall cost increases with the number of MP2MP (and in less degree with the P2MP) services. This can be justified by the fact that “E-MPLS” platforms are able to establish P2MP and MP2MP EVCs and therefore, it drastically reduces the number of EVCs associated to a service.

5. Conclusions

The interest of network operators has recently focused on operational expenditures as well as the traditional capital expenditures. This paper has presented an overall OpEx model which includes both network and service cost models. In particular, this article has elaborated on OpEx related costs for service configuration of different types of services in different network architecture solutions. We have presented a model to calculate the cost associated to one or more services. This model has been used to compare the cost of different types of Ethernet services (P2P, P2MP and MP2MP) on different platforms. It has been shown that when considering an “E-MPLS” platform with profile capabilities, it is less costly to offer a service, and that the cost of P2P, P2MP and MP2MP services is comparable in the same platform. On the other hand, it has been shown that when using an “E/SDH” platform, the cost of a service depends on the type of service (i.e. MP2MP is more expensive than a P2P service). This paper has also shown the impact that a different percentage on the type of services has on the different platforms. In the next steps of our work, the models will be refined and extended to network related OpEx processes. Case studies will be performed that analyze the overall OpEx of the network over the complete life cycle, and put the results in relation to the CapEx, required for different network evolution scenarios.

Note

1. In this paper the term EVC (Ethernet virtual connection) is used except when referring to SDH platforms where VC (Virtual Container) is more appropriated.

References

- Evans, C. (2004), “Cost justifying the carriers migration to strategy to Ethernet”, *DM & Metro Optical Networking*, July.
- Gladisch, A., Jaeger, M., Dueser, M. and Westphal, J. (2006), “Assessment of network architecture with respect to different service scenarios”, in Won, Y.H., Chang, G.-K., Sato, K.-i. and Wu, J. (Eds), *Network Architectures, Management, and Applications IV. Proceedings of the SPIE*, Vol. 6354.

Jäger, M. (2006), "Network architectures for future optical networks", *ICTON 2006 proceedings, June 2006*, pp. 147-150.

Mas Machuca, C. (2006), "Expenditures study for networks operators" *ICTON 2006 proceedings, June 2006*, pp. 18-22.

Schmid-Egger, A., Kirstädter, A. and Eberspächer, J. (2006), "Ethernet in the backbone: an approach to cost-efficient core networks", in Kern, E.-M., Hegering, H.-G. and Brüggel, B. (Eds), *Managing Development and Application of Digital technologies*, Springer Verlag, Heidelberg, pp. 195-212.

Sengupta, S., Saha, D. and Kumar, V.P. (2003), "Switched optical backbone for cost-effective scalable core IP networks", *IEEE Communications Magazine*, June.

Shayani, D., Machuca, C.M., Jager, M. and Gladisch, A. (2008), "Cost analysis of the service migration problem between communication platforms", *IEEE/IFIP Network Operations and Management Symposium (NOMS) 2008*.

Verbrugge, S., Colle, D., Pickavet, M. and Demeester, P. (2004), "Capex comparison between link-by-link and end-to-end grooming in a European backbone network" *Networks 2004 proceedings, June 2004*.

About the authors

Carmen Mas Machuca (M'00) received the Telecommunications Engineering degree from the Universitat Politècnica de Catalunya (UPC), Barcelona, Spain, in 1995 and the PhD degree from the Swiss Federal Institute of Technology, Lausanne (EPFL), Switzerland, in 2000. In 1996, she became a Research Assistant at the Institute of Computer Communications and Applications, EPFL, where she also was a Teaching Assistant. In January 2000, she joined Intracom S.A, Greece, as Project Coordinator, where she participated and lead various tasks in several IST and Eurescom projects. In October 2002, she joined the Athens Information Technology (AIT) Center, Athens, Greece, as a Research Scientist and in January 2004, she became Assistant Professor. Since December 2004, she is with the Institute of Communication Networks at Munich University of Technology (TUM) and researcher and lecturer. She is author and coauthor of more than 25 publications related to optical and mobile communications and techno-economic studies. Carmen Mas Machuca is the corresponding author and can be contacted at: cmas@tum.de

Øyvind Moe works for the Telenor group, the world's 7th largest mobile operator, as a strategic advisor focusing on network infrastructure. He earned a MSc in Communication Technology from the Norwegian University of Science and Technology. Øyvind Moe wrote his Master Thesis at the Institute of Communication Networks, Technische Universität München. In relation to this work he has been co-author on several published papers.

Joerg Eberspächer received a Dr.-Ing. degree at the University of Stuttgart in 1976. From 1977 to 1990 he was with Siemens AG, Munich, Germany, where he was responsible for R&D in high speed networks. Since 1990, he has been full professor at the Technische Universität München (TUM) and head of the institute for communication networks. He is one of the directors of the Center for Digital Technology and Management (CDTM). His research interests are next generation internet, advanced mobile communication, network planning and interdisciplinary techno-economical issues. He is senior member IEEE and member VDE.

Monika Jaeger is a senior strategic consultant in the department of "Next Generation Broadband Networks" at T-Systems in Berlin, since 2007. She consults Deutsche Telekom and T-Com units in developing visions and strategies of network evolution and migration of DT network platforms. In 1999, Monika Jaeger joined the Research Institute of Deutsche Telekom as Senior Scientist, and she has held different positions within the DT-Group since then. Her current research interests are in the area of cost efficiency in IP/optical transport networks. She has been involved in the EC IST FP7 funded project NOBEL II and she participates in the federally funded project Eibone. In 1995 Monika Jaeger became a research staff member at the Fraunhofer Institute for Open Communication Systems in Berlin. From 1992 to 1994 she worked as Software Engineer for DeTeWe AG in Berlin. She graduated in Electrical Engineering from Munich University of Technology, Germany in 1992. She has authored and co-authored more than 50 publications related to IP/optical

communications and techno-economic studies. She has served in Technical Committees of international workshops and conferences. Monika Jaeger is a member of IEEE.

Andreas Gladisch received his Dipl.-Ing. degree in 1986 from the Technical University of Ilmenau in "Theory of Electrotechniques". From 1986 to 1990 he was engaged in research on coherent optical communication and optical frequency control at Humboldt University Berlin, where he received the PhD in Optical Communication. He joined the Research Institute of Deutsche Telekom in 1991. In 1996 he became the head of the research group "Management and Control of Optical Networks" and in 1999 he got the responsibility for the department "Network Architecture". Since 2007 he is head of the unit "Next generation Broadband Systems" of T-Systems ES. He was involved in several European Research Projects about optical and multi layer networks (for example Photon, Meton, Moon, Lion). He is project manager of projects dealing with the migration of Deutsche Telekom transport network especially the migration of SDH and WDM, including the development and assessment of different network scenarios and technologies. Andreas Gladisch is member of ITG and IEEE and he has authored or co-authored more than 90 national and international technical conference or journal papers.

To purchase reprints of this article please e-mail: reprints@emeraldinsight.com
Or visit our web site for further details: www.emeraldinsight.com/reprints