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From the Exploration-Programmes of Corporate Technology (8)

# NETPLAN: A Framework for the Development of Network Planning, Design and Optimization Applications

In today's competitive environment, a successful network operator must offer networks that meet the quality requirements of the customer at minimal costs. Planning and optimizing are two important processes in the attempt to build new and cost-efficient networks. Although there exist numerous commercial tools for network planning and optimization, they are often non-extendible and built for a restricted set of network architectures and problems. For this purpose, we built a flexible, object-oriented software framework for the development of integrated network planning and design tools.

The framework NETPLAN implements several reusable components that are essential to network planning and design, such as a generic network model, graphical user interfaces, algorithm and controller components. It also provides standard interactions between these components, hence allowing an application programmer to integrate new applications into a framework application easily.

## Introduction

With the upcoming worldwide liberalization of the telecommunication market on the one hand and the increasing demand for a variety of communication services on the other hand, planning, design and management of telecommunication networks has become a vital issue for network operators and service providers. Telecommunication networks must be designed considering both installation costs and required capacity. Although there exist numerous commercial tools for these tasks, they all have one major disadvantage. To an application programmer, they present themselves as a black box. While they offer a certain range of solutions to problems such as backbone design, clocking analysis, etc., they cannot be adapted to integrate new optimization algorithms or special analysis methods. Hence, an open, object-oriented system for the development of

ATM and IP based networks support various applications such as audiovisual and data applications with very different traffic patterns. To make best use of network resources and at the same time guarantee the requested network quality, the Exploration Programme\* "EP97-8 Traffic Management" investigates traffic control mechanisms, real time traffic management, routing, network dimensioning and network optimization for these networks.

\* Exploration Programmes are commissioned by the Swisscom Board of Directors and executed in Corporate Technology. The activities have a mean to long term time horizon (2-7 years) depending on the area.

Box "Software Frameworks"). In this paper, we present the framework NETPLAN [7] and a number of applications that have successfully been built on top of it. NETPLAN is

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planning, design and optimization applications is needed.

One possibility to build such a system is to create a set of program libraries containing various planning, design and optimization methods, similar the well-known mathematical libraries in FORTRAN. New applications are then built by calling functions contained in the program library. However, this approach limits reuse of program code to single function calls. The interaction between objects in the program must be designed for each application from scratch, hence, making the integration of applications in a standard environment very difficult. This, however, is crucial in a problem domain where individual applications share a large number of standard features. For example, most applications dealing with networks require the possibility to query, display, and modify the network configuration data. Using only a program library, the application programmer would have to rewrite the basic editing features of the application every time. Frameworks are an elegant and increasingly popular way of solving these problems [6, 3] (see

based on object-oriented technology and extensively uses the paradigm of design patterns [1]. So far, we have made the experience that NETPLAN facilitates the development of new, tailor-made network applications and, in particular, allows the integration of these new applications, resulting in a high degree of acceptance by the application users. Based on NETPLAN, prototypes for different network planning tools have been developed successfully.

## The NETPLAN Framework

Whether the concept of a framework is applicable to a certain problem domain strongly depends on the structure and the shape of the applications that come from this domain. That is, if each application in a domain would require completely different data structures and unique processing steps, it would make little sense to build a framework for this domain, as only few common structures can be reused. The domain of network planning and optimization, however, is a well structured area, in which most applications share a large number of common features. For example, most applications in this domain need to build a network model, save and retrieve net-

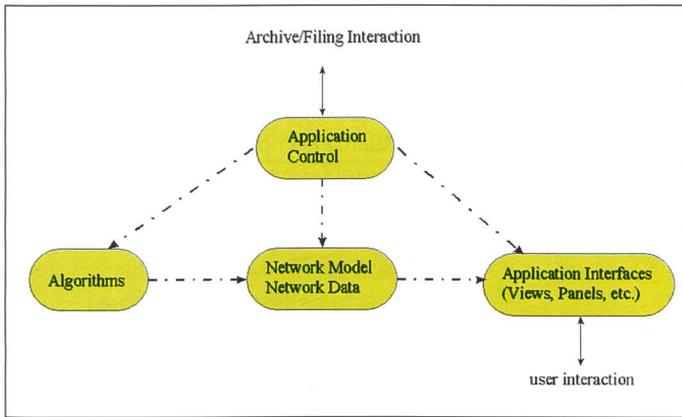


Fig. 1. Basic components of a network planning and optimization application.

work data, visualize the network components, provide the interactions between the model and the graphical user interfaces, and so on. It was one of the major objectives of the project to build a framework which incorporates all of the above mentioned features as well as some additional sophisticated components that help in building customized network applications in a fast, reusable and extendible manner.

Basically, there are four components in every network planning or optimization application, namely an application control, a set of algorithms, the network model and the user interfaces such as a network editor. In Figure 1, the four components and their mutual interactions are displayed.

The NETPLAN framework provides for each of these components a corresponding framework structure, which already implements a number of standard features. Furthermore, the interactions between the components are also provided for by the framework. For example, NETPLAN contains a generic network model, which supports the concepts of nodes, links, demands, connections, subnetworks and network interfaces. Network aspects which are specific to an application can then be added by associating network data to these predefined network objects. Also, the interactions between the network and the graphical user interfaces (operations such as move, select, zoom, add and delete) are already implemented. In Figure 2, the framework components along with the embedded user application components described in Figure 1 are shown.

It is important to note that unlike a library of function calls, the framework itself represents a complete application, the so-called standard framework application. This standard application contains

various features such as a version tree editor, an advanced network editor, archiving functionality for the created networks, basic traffic routing and route optimization schemes and an algorithm management facility. User-defined application with specific behavior such as the ones described later in section 3, can then be built by either inheriting from framework components or by registering new application components with the framework (see also Box "Software Frameworks").

The most important advantage that results from using the framework, is that user-defined applications are created as add-ons to the standard framework application. Hence, all of the above mentioned features are automatically available in the user-defined application. As a consequence, the time spent in developing new applications can be reduced substantially. Furthermore, each component of a new application that is plugged into the framework conforms to the general framework rules of inheritance and composition. Therefore, modules that are created for one application may easily be reused for another application. For example, if a new algorithm is implemented that computes the delay of

IP packets for an application that analyzes HTTP delay behavior, then that same IP delay algorithm may later be reused in a new application that studies Internet telephony. In general, the reuse of components is strongly encouraged by the framework and helps to reduce redundancies in development projects.

Clearly, all of the above mentioned characteristics of NETPLAN would be of minor interest if the framework would not be open, fast, extendible and also portable onto different operating system platforms. For this reason, NETPLAN was realized and implemented using C++ and the commercial graphical user interface library ILOG Views. Thanks to ILOG Views, it was possible to create a framework that is both completely portable between Unix and Windows 95/NT platforms while at the same time it offers sophisticated graphical user interfaces. In order to develop new applications based on NETPLAN, the following prerequisites are required: the NETPLAN C++ Source code, a C++ compiler (MSVC++ 5.0 or GNU CC), an ILOG Views 2.3 along with the ILOG Views libraries and some experience with C++ application development.

For the purpose of demonstrating the applicability and usefulness of NETPLAN, some sample applications are briefly described in the following section.

### NETPLAN in Action: Sample Applications

In order to see the diversity of applications that can be written on the basis of NETPLAN, we present three different prototypes that were created during the past 2 years by a number of different NETPLAN users. For each of these prototypes, we briefly describe the purpose, the basic structure and the functionality of the prototype application.

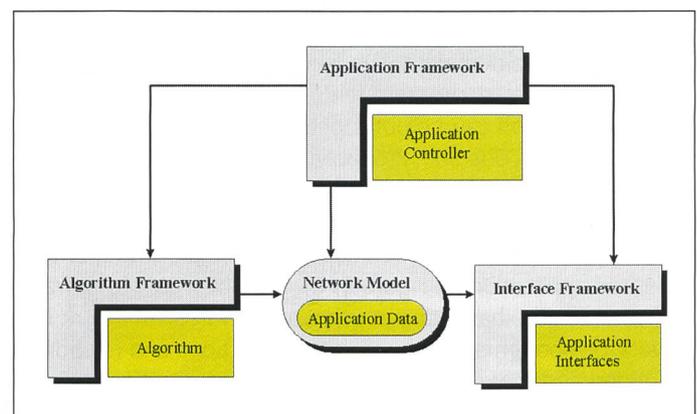


Fig. 2. Overview of the framework structure.



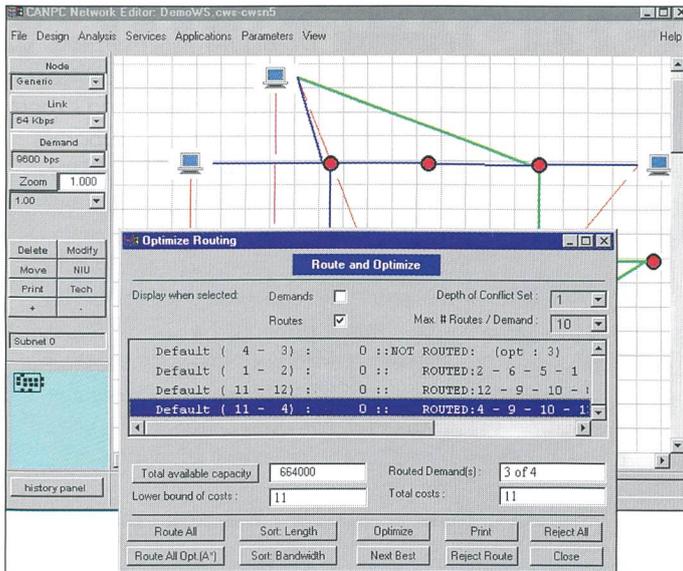


Fig. 4. Routing application panel and corresponding highlighted route (in the network editor).

mands can be satisfied. This is best ensured if the goal in routing is to reduce the usage of bandwidth in the network. However, although the problem of optimally routing a set of traffic demands in a network is easily described, it is difficult to find solutions for this problem for large networks. In fact, this problem requires in the worst case a number of computation steps that grows exponentially with the size of the network. Hence, in practice, due to limited computation time it is close to impossible to compute an optimal routing configuration for a set of traffic demands. Most routing methods in today's networks therefore lead to non-optimal and, possibly, very costly solution. Assuming that, at some point in time, it is possible to recompute certain routing decisions and initiate rerouting of certain demands, it was decided to develop a heuristic algorithm which starts from a non-optimal routing configuration and tries to gradually improve the configuration. The algorithm was designed and developed together with the University of Bern. Due to the fact that a network model, a network editor and a basic shortest path routing scheme was already implemented in the framework, it was possible to fully concentrate on the intrinsic of the new optimization algorithm. In Figure 4, the application panel that was explicitly designed for the routing optimization application is shown (partially hiding the regular network editor displaying a simple network). Notice that the panel offers such functionalities as routing all demands, optimizing a configuration, or displaying the total available

bandwidth in the network for the current configuration. Because all of the components in the new application were inherited from existing framework classes, it was decided to make this optimization application part of the standard framework application. Hence, the new features can also be applied and reused by other, yet to be written, applications that are based on the framework.

**Resource Reservation**

In the past, renting constant bit rate services has been the main possibility for companies to satisfy their internal traffic

requirements. With the increased promotion of ATM services, however, the interest in services that match the complex traffic patterns of companies better than a simple constant bit rate solution, has been growing steadily. One such service, for example is the temporary constant bit rate service (TCBR). With this service, the customer can specify a traffic profile, which consists of a set of traffic activations. Each such activation is described by a start and an end time and a required bit rate that remains constant over the specified time span. The activations may be subject to a repetition mode that is either daily, weekly or monthly. Clearly, with such TCBR traffic descriptions, it is possible for a customer to tailor its telecommunication contracts much better according to its actual needs than with a simple CBR service. For the operator, on the other hand, the routing and allocation of these TCBR requests and the management of the available bandwidth profile is far from being a trivial task. For example, the routing of a TCBR request requires during the search for a route that the activations in the TCBR request are compared with the available bandwidth of the links based on a time schedule. That is, for each link, a profile of accumulated TCBR profiles must be maintained, such that new TCBR requests can be fitted into the remaining pattern of yet unallocated bandwidth of a link. It is easy to see that

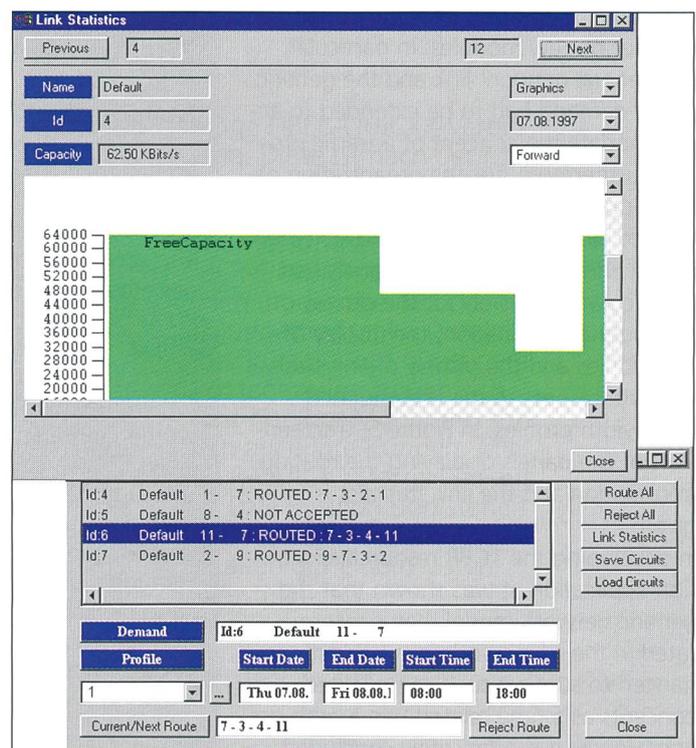


Fig. 5. Application panels for the display of link statistics and routing information.

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without the help of a sophisticated software tool, the allocation of TCBR requests in a medium size network becomes an impossible task. In order to gain experience, a prototype was built on the basis of NETPLAN. While it was possible to reuse components such as the basic network model, the network editor and the shortest path algorithm, it was also necessary to add a number of new modules. In particular, the generic network link and the generic traffic demand had to be extended to accommodate the concept of a traffic profile. Furthermore, for the organization of these profiles, a new controller was needed along with an archiving scheme. Finally, three new graphical panels had to be created, namely for the display of the routing information, the display of the profiles and the display of link statistics with respect to the accumulated bandwidth profiles. In Figure 5, a screenshot of the panels displaying the routing information and the link statistics is given. In developing the TCBR resource allocation application, it was shown that the generic network model that is incorporated in the framework, can be easily enhanced to support such complicated concepts as a time related bandwidth usage. Hence, it can be safely concluded

that the model is general enough to support a variety of future network extension.

## Conclusions

Based on the experiences from the previously mentioned projects, it can be concluded that there are three major advantages in using the framework:

- The framework is well suited for the fast development of prototypes which can then be used to further develop a productive version. Hence, the time lost on coding that is often experienced when using languages such as Visual Basic for prototyping does not occur when a framework like NETPLAN is applied.
- It is easy to integrate different applications within a master application. Hence, a user may analyze, optimize or merely study the same network in conjunction with applications that were developed by different parties without having to switch applications and keep copies of the network in each of these applications.
- The facilities provided by the ILOG Views library make the framework truly portable. This is particularly important for applications that must run both in a backoffice environment such as a Unix system and also on the customer front, where Window-based platforms are more popular.



**Dr. Bruno T. Messmer** is an artificial intelligence and software engineering expert working for the Corporate Technology Unit of Swisscom. Before joining Swisscom in 1996, he received a doctoral degree from the University of Berne for his work in the area of pattern recognition and graph matching. He has an ongoing interest in object-oriented technologies, Java and C++, Internet applications and, in general, the application of AI techniques in the telecommunication domain.

The benefit that results from using NETPLAN has also been recognized outside of Swisscom. Consequently, the commercialization of the framework is currently under investigation. Furthermore, a demo version of the NETPLAN standard application will be integrated on the demo CD-ROM of ILOG as a successful project in the Telecom area. The demo CD-ROM from ILOG is distributed worldwide, hence, wide reaching positive publicity is guaranteed. For more information on NETPLAN, contact the author or visit the project homepage <http://canpc.vppt.ch>. 9.4

## Zusammenfassung

### Framework NETPLAN

Im heutigen liberalisierten und hart umkämpften Telekommunikationsmarkt muss ein erfolgreicher Netzbetreiber Netzwerke und Dienste betreiben und offerieren, die einerseits die Qualitätsansprüche der Kunden befriedigen, andererseits aber auch kosteneffizient sind. Die Planung und die Optimierung von Netzen sind in diesem Zusammenhang zwei unerlässliche Werkzeuge. Obwohl es verschiedene kommerzielle Softwarepakete für die Planung und Optimierung von Netzwerken gibt, ist festzustellen, dass die meisten dieser Programme nur für klar definierte, beschränkte Problemstellung oder für proprietäre Netzwerkarchitekturen geschaffen wurden und sie keine offenen Schnittstellen, die Erweiterungen ermöglichen würden, unterstützen. Aus diesem Grunde haben wir ein Objekt-orientiertes, flexibles Software Framework entwickelt, welches dazu dient, Netzwerk Planungs- und Optimierungsapplikationen zu implementieren. Das Framework NETPLAN stellt verschiedene wiederverwendbare Komponenten, wie einen Netzwerk-Editor und ein generisches Netzmodell, zur Verfügung, die wichtige Bestandteile jeder Planungs- und Optimierungsapplikation sind. Dank dieser vordefinierten Module kann die Entwicklungszeit für neue Softwareapplikationen im Netzplanungsbe- reich erheblich reduziert werden. Ausserdem ist es möglich, neue Komponenten auch für andere Applikationen wiederzuverwenden, da das Framework die Interaktionen zwischen den Komponenten vordefiniert und standardisiert.

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