Global
Communications
Newsletter

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Inatel: 37 Years of Experience Teaching Telecommunications

The Instituto Nacional de Telecomunicações (Inatel) was created in 1965. Located in Minas Gerais, Brazil, Inatel is the main source of professional formation in the region, which is an information technology cluster, as well as in the country.

Pioneering in teaching telecommunications in Brazil, Inatel offers an electrical engineering degree with emphasis on electronics and telecommunications, as well as specialization programs on telecommunications systems and network engineering, and a telecommunications master's degree.

Manpower for Engineering

The main mission of Inatel is to guarantee technical and human education for its students. To achieve this, Inatel develops technical, scientific, and cultural programs, contributing to the social integration between future engineers and the local, regional, and national community. Among these programs are the Technological Fair of Inatel (FETIN), an academic program to stimulate students to apply their knowledge in the development of new products to meet the demands of society, and the Technological and Scientific Initiation Seminar (INCITEL), where students present their scientific projects showing their initiative, talent, and entrepreneurship skills.

The Post-Graduation Program Follows Market Demand

The telecommunications systems and network engineering specialization course offers up-to-date knowledge on telecommunications networks and systems, satellite communications, mobile and optical communications, local and metropolitan computer networks, ATM, SDH, and access networks.

The telecommunications master's program focuses on telecommunications research, development, and teaching activities, and stimulates scientific and technological researchers for society's development.

The master's program research lines are optical communications, telecommunications networks and systems, telecommunications energy systems, and high-frequency voice recognition devices.

Always seeking technological development, Inatel has research and scientific initiation groups working in the areas of digital signal processing, telecommunications networks and systems, microwave and optical communications, and telecommunications energy systems.

Inatel and Regional Development: The Technological Pole of Santa Rita do Sapucaí

By preparing specialized engineers for the market, Inatel plays an important role in the process of changing an agriculture-based economy into a technological pole.

Numerous technology-based companies have started their activities at Inatel. Today, they assist multinational companies, thus generating hundreds of jobs and stimulating the region's economy.

Inatel executes the International Cooperation Agreement ABC-GTZ to consolidate the Technological Pole of Santa Rita do Sapucaí. Inatel also takes part in the Cresce Minas Project, from Federation of Industries of the State of Minas Gerais (Fiemg), which sets the cluster of information technology in the cities of Santa Rita do Sapucaí, Pouso Alegre, and Itajubá.

Companies and Projects Incubation Program

Inatel's Incubation Program was designed to stimulate students, teachers, and entrepreneurs to create their own business plans and develop their projects at the Inatel campus. Many companies have already passed through this program and today supply technology developed during their incubation time to multinational companies. There are over 20 of these companies, generating 400 jobs in a small town and stimulating the region's economy.

Inatel Competence Center: Partnership for Technological Solutions

Besides graduation and post-graduation programs, Inatel has a specialized service center, the Inatel Competence Center, offering training, consultancy, and project development services such as contracted training services, training programs, open and "in company" courses, specialized consultancy, software and hardware development, and equipment essay and calibration. Inatel is also an institution able to receive incentives under the Law of Informatics, which can finance projects on information technology, training programs, consultancy, and products tests and essays. Among Inatel partners are Ericsson Telecommunications, Motorola, Nortel Networks, Benchmark Electronics, and Harris Brazil.

The Inatel Competence Center provides its members with

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INTERMIP Project Results

By Georges Fiche and Guy Pujolle, France

The context, organization, and objectives of the project have already been presented in a previous article [1]. This article presents the main findings of the project, which has proved to be very promising at both the theoretical and the industrial level. The aim of this three-year project was to suggest rules for multiservice IP network traffic engineering.

This National Telecommunications Research Network (RNRT)/Multiservice IP Network Evaluation and Traffic Engineering (INTERMIP) research project has brought together various representatives of the telecommunications sector such as equipment manufacturers, operators, software manufacturers, and small and medium-sized businesses. Major companies such as Alcatel and France Telecom R&D, academic institutions such as the Scientific Research Council (CNRS) LIP6 Laboratory and the National Telecom Institute (INT), and small businesses such as Delta Partners were all involved in the project. This combination of resources and different viewpoints was an important factor in obtaining the fundamental and practical results presented below.

Outline of the Problem

The rules for telephone network traffic engineering are well known. However, in a multiservice network, the problem of defining such rules is much more complex. Furthermore, there is still no accepted theory for devising traffic engineering rules for IP networks. In these networks, quality of service (QoS) is generally ensured (in those cases where it is ensured) by reactive dimensioning or overdimensioning following traffic observation. Despite the major normalization work of the Internet Engineering Task Force (IETF), work on specifications for IP differentiated services is yet to be completed, and the support mechanisms for these differentiated services are still being developed.

Anxious to obtain real results and feasible solutions that could be quickly implemented, the INTERMIP project took a global approach to the problem. As a result, the project has dealt successively with the following:

- Identifying the traffic characteristics and QoS requirements of the different applications to be supported by multiservice networks. The problems of characterizing the traffic flows in terms of rate, rate variability, and self-similar characteristics, and identifying real-time constraints, are the key points of this part of the study.
- Identifying the IP service categories that support these different applications. The problems of defining QoS and flow aggregation form the basis of this study. In particular, the protocols being defined by the IETF to support individual or aggregated traffic flows should be taken into account.
- Determining the traffic management mechanisms for controlling the aforementioned IP service categories. This deals with the problems of reserving suitable resources to carry the flows offered to the network with the required QoS, and controlling the admission of requests (which consists of only accepting new requests if the QoS of flows that have already been accepted is still respected).
- Evaluating the routing policies that allow QoS constraints to be respected and resource occupation to be optimized. The underlying problem in this study is the relative effectiveness of different routing algorithms used in the IP field regarding network protection and especially the results of the preceding study.
- Determining the network resource dimensioning rules according to the traffic anticipated. Here the problem consists of establishing dimensioning formulae which ensure that QoS is respected, and take into account the fundamental characteristics of the flows to be carried, both with and without real-time constraints, and integrating both types of flow without increasing complexity too much.
- Developing a tool for evaluating and dimensioning multiservice networks. This study is concerned with the evolution of network performance evaluation and dimensioning tools available in the market. A small number of basic ATM or IP models have been proposed that respond poorly, if at all, to the problems posed. The development of a tool incorporating models from previous studies allows the results of the project to be effectively applied and meets the needs of network providers.

Results

Following a survey of existing standards and developments in this field, and regarding the problems outlined above, the tasks carried out over the course of the project have given rise to a number of deliverables that are not detailed here but whose overall results are presented.

Regarding traffic categories, a distinction is made between elastic traffic and real-time traffic. Elastic traffic is traffic controlled by TCP and constitutes the majority of Internet traffic today. It has no real-time constraints or severe packet loss. However, the packet loss rate must be reasonable since it causes retransmission. The essential performance criterion is the rate actually reached or useful rate. In terms of services, it includes various applications such as email, file transfers, and Web pages.

Real-time traffic is supported by UDP. The delay, transfer time, and jitter requirements are all important. The packet loss requirements are also important but only if perceived at the user level. Some services like speech and video are fairly tolerant. This traffic is also described as streaming traffic.

In both cases, it is useful to distinguish between the call or session, stream, and packet levels. Particular emphasis is placed on the stream level; the successive objects of a session such as the speech in a conversation or the pages in a Web session. The results are based on observations taken from France Telecom networks. The outcome of these results is that, if at the call level it is reasonable to consider that arrivals will follow a Poisson process, this is not the case at other levels, in particular at the packet level where complex characteristics such as self-similarity are observed. At the stream level, a Poisson process cannot be accepted in the strict sense, insofar as the distribution of intervals between incoming streams is optimally adjusted using the Weibull or gamma laws, and where some correlation, albeit weak, is observed between the successive inflows. As for statistical stream length distribution (expressed as packets, octets, or duration), Pareto's Law provides a good representative model of the distribution queues and, where the length is expressed as packets, of the entire distribution. The main outcome of the analyses was to highlight the insensitivity properties, which allowed the performance of both elastic and streaming flows to be evaluated as described next.

Elastic flow performance. Investigations concerning the statistical sharing of link bandwidth produced the following important results:

The self-similarity phenomena observed at packet and stream levels can be explained by the interaction between the traffic characteristics and the way the link shares its

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bandwidth (influence of TCP and length according to Pareto's Law). It has been shown, in particular, that the long-term dependence correlation between the stream input processes is due to the way the number of flows per session is distributed.

Regarding the statistical performance of a shared bandwidth with perfect fairness, it has been shown that performance in terms of useful rate is not affected by the number of streams per session, stream size distribution, and so on. The distribution of the number of streams in progress depends solely on the total link load, so it is easy to find the average transfer rate. Applying the resulting model to dimensioning allows us to determine the load and capacity to be reserved for carrying elastic traffic at the minimum required rate.

Streaming traffic performance. The analysis of streaming traffic characteristics shows that each stream can be seen as a succession of bursts at peak rate c, interspersed with periods of silence. As with elastic traffic, it has been shown that the distribution of the number of bursts in progress does not depend on the specific traffic characteristics (number of bursts per stream, distribution of bursts and silent periods, etc.). Performance only depends on the total demand and peak rate. Specifically, the distribution of the number of bursts in progress is simply Poisson's Law applied at burst level. In this way, the congestion probability can be evaluated by taking into account the maximum link capacity using Erlang type formulae. It can then be shown that as long as the link congestion probability is negligible, the delay of the packets is less than that if following a Poisson type input process. The packet transfer time can also be evaluated. The previous results can be extrapolated for bursts of different rates by applying equivalent Erlang multirate formulae. Applying this model to dimensioning allows us to determine the capacity to be reserved for carrying streaming traffic.

Integrated traffic performance. Various integration strategies were investigated. Here, network performance where elastic streams and real-time streams share the same resources was studied. As detailed above, it is assumed that a nonpreemptive priority is applied to the real-time stream packets on each network node. Analysis shows that elastic stream performance depends heavily on the traffic characteristics and, in particular, on the average duration of the real-time streams. The need to stabilize the elastic traffic has also been shown, and in order to achieve this, a sufficient ratio of the residual bandwidth must be almost permanently assigned to it to prevent congestion. A performance gain is obtained, in relation to nonintegration, when the probability of this ratio being exceeded by the real-time traffic is relatively low (10^{-3}). Applying this model to dimensioning allows us to determine the capacity that must be reserved for carrying a combination of elastic and streaming traffic.

On this basis, a traffic management strategy can be considered. As the IETF has shown, the above results suggest processing streaming flows as a priority. Performance can then be guaranteed by integrating the packets into an expedited forwarding (EF) class in nonpreemptive priority queues. The above results show that real-time flows are guaranteed to be subject only to limited delay, when relatively effective use of the links is allowed (up to 80 percent when the link has a capacity greater than 155 Mb/s). In case of overload, the real-time flow QoS is maintained, as long as the corresponding demand is not too high. However, elastic flow performance is badly affected. With that in mind, several investigations have suggested that admission control could be beneficial at the flow level to control overloads. In other words, a new flow would only be accepted if there are sufficient available resources to ensure continued good performance of flows already accepted.

Concerning routing, simulations have been carried out to compare elastic flow performance. This has also allowed analysis of the impact of admission control on the performance of known algorithms such as Widest Shortest Path and several new adaptive routing algorithms such as Maximum Utility Path, the aim being to identify an effective stream strategy. The importance of preserving network resources for high traffic has led to the suggestion that the logical equivalent of the circuit reservation technique for routing elastic streams should be applied. Integrating this technique into the two previous algorithms significantly improves their performance.

Finally, the project has led to the development of an engineering software package made up of a main package and a prototype package. The main package, developed from an existing tool, introduces performance evaluation formulae such as those mentioned above, which allow evaluation of the network resources necessary to guarantee the required QoS. The software allows us to submit complex networks, at both the access and core network levels, to select the chosen route management strategies (MPLS, etc.) and to set the traffic levels in terms of the number of users, servers, and characteristic services at both session and stream levels, and in terms of service delivery to the end user. The tool generates the equipment necessary to obtain the required QoS (node capacity, link capacity, etc.). A prototype written in agent language was developed at the same time. This software, open to the introduction of new components and dynamic algorithms controlled by intelligent agents, has, for example, allowed investigation of the effectiveness of QoS management algorithms.

Conclusion

The INTERMIP project has made a significant contribution to better understand the requirements of and possible solutions for multiservice IP network traffic engineering. The results of the project have been shared through numerous journal publications and conferences within the traffic engineering field. Finally, the integration of traffic requirement characterization methods and associated performance evaluation formulae in a tool, using the notions of session and stream, offers network providers an effective solution to their dimensioning needs.

The INTERMIP project has shown the importance of an initiative like the RNRT. Thanks to its flexible structure, it has enabled effective cooperation between various partners in the telecommunications field such as universities, telecommunications companies, equipment manufacturers, and small and medium-sized businesses. The various participants and their research teams were represented in the project by Guy Pujolle for CNRS/LIP6, Gérard Hébuterne for the INT, James Roberts for France Telecom R&D, Georges Fiche for Alcatel, and Pierre Bacquet for Delta Partner.

The public description of the project is available at http://www-rp.lip6.fr/intermip/.

Reference

[1] G. Fiche and Guy Pujolle, "The INTERMIP Project", GCN, *IEEE Commun. Mag.* May 2002, http://www.comsoc.org/pubs/gcn/ gcn0502.html

Inatel: 37 Years of Experience (cont'd)

sophisticated laboratories and a scientific technological information center where the most recent national and international research data on telecommunications and information technology are available.

Training

Inatel offers open courses in the areas of telecommunications systems, computer networks, mobile systems, TV signal distribution systems, and telecommunications tests and measurements. "In company " courses are also available at the Inatel campus and are completely adapted to customers' needs. Professionals can also act participate a contracted service basis, part- or full-time, for training, academic research, course development, and technical translation services. Corporate training programs are organized in stages such as analysis of needs, application, and evaluation through special performance indicators.

Software and Hardware Development

The Inatel Competence Center has a team of specialists fully dedicated to the development of software and hardware projects, supported by Inatel professors and the most advanced technologies. National and international technical and scientific cooperation agreements established by Inatel allow constant technical upgrading of the professional team, besides being an excellent opportunity to enrich their work experience.

In the software design area, the Inatel Competence Center is able to develop systems, tools, methods, and techniques to increase a company's market performance. Projects are designed according to CMM level 2 orientation (Capability Maturity Model). Active areas are object-oriented technology, Java, C++ and C#, OOAD, distributed object technology, CORBA, COM, COM+ and DCOM, EJB and JavaBeans, case tools, software inspection, and UML and usage cases.

The Hardware Development Group stays close to the market by designing circuits, equipment, and systems in areas such as communication systems, telephony, telemetry, microprocessor digital systems, digital signal processing, data acquisition and storage systems, measurement systems, automation and control, and power packs.

Specialized Consultancy

A specialized consultancy team develops new projects, and performs system specifications, proposal analysis, field problems detection, and other activities. They work in the telecommunications area (analog and digital communication, antennas and propagation, switching, access networks, wireless, optical communications, digital video, computer networks, telecommunication management systems, and data communication) and in the software design area (object orientation, programming languages, case tools, distributed objects, processing, and quality of software). In addition, Inatel Competence Center professionals are able to meet companies' specific needs.

Essays and Calibration

Working together with several certifying organizations assigned by the Telecommunications National Agency (Anatel), the Inatel Competence Center offers product and prototype trials and calibration services, using modern precision instruments and pattern tracing. It is possible to perform trials on products such as digital transmission, radios, switching equipment, antennas, and power supply, as well as tests of temperature and humidity variation. Calibration services test multimeters, oscilloscopes, counters, function generators, spectrum analyzers (up to 2 GHz), level meters, power meters, and other equipment.

Inatel II International Telecommunications Meeting – October, 2002

The Telecommunications International Meeting of Inatel takes place every two years at the Inatel campus in Santa Rita do Sapucaí, MG, Brazil. It brings Brazilian and foreign researchers together in a three-day seminar. During 21–23 October 2002, specialists from Brazil, Germany, England, the United States, and Japan discussed current telecommunications technologies. Information is available from imprensa@inatel.br

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