Analysis and Design of Advanced Multiservice Networks Supporting Mobility, Multimedia, and Internetworking

COST Action 279 Final Report

José Brázio, Phuoc Tran-Gia, Nail Akar, Andrzej Beben, Wojciech Burakowski, Markus Fiedler, Ezhan Karasan, Michael Menth, Philippe Olivier, Kurt Tutschku, Sabine Wittevrongel (Eds.)

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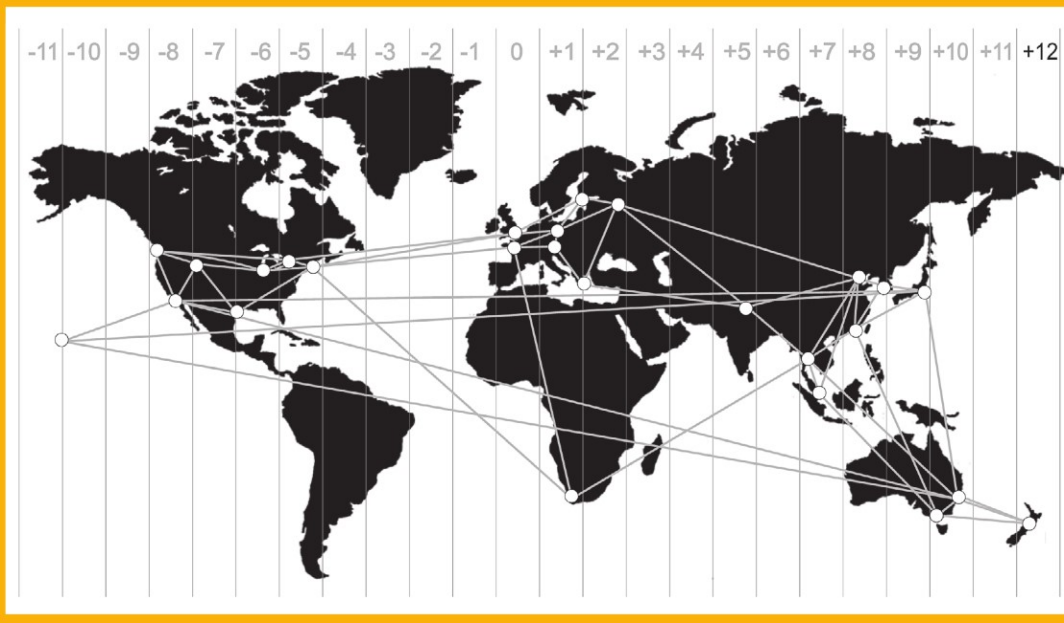

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ANALYSIS AND DESIGN OF ADVANCED MULTISERVICE NETWORKS SUPPORTING MOBILITY, MULTIMEDIA, AND INTERNETWORKING

Analysis and Design of Advanced Multiservice Networks Supporting Mobility, Multimedia, and Internetworking

COST Action 279 Final Report

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Preface

This book constitutes the Final Report of COST Action 279, *Analysis and Design of Advanced Multiservice Networks supporting Multimedia, Mobility, and Interworking*, a guided tour of the state-of-the-art work on diverse aspects of modern telecommunications networks design developed within this Action during the four years of its operation, started on July 1, 2001, and ended on June 30, 2005.

As stated in its founding charter, its Memorandum of Understanding, the work area of COST 279 is the analysis, design, and control aspects of present-day networks—quite a wide scope. Behind the unifying façade put on by the Internet Protocol (IP) network layer, todays networks hide a mess of heterogeneity: heterogeneity at the level of applications, both concerning the traffic they produce and the network Quality of Service (QoS) they require, and heterogeneity at the level of network component subsystems, in particular an increasingly important mobile/wireless access segment. A common ground for the treatment of this disparate set of topics was given by the strong methodological component contained in the approach followed in COST 279, with importance placed on the development and application, whenever possible, of analytical techniques and models for the mathematical understanding of the systems under study. The results expected from the Action ranged thus from mathematical models and algorithms as entities of own interest to the understanding of system behavior via their application. Explicit value was also given to contributions to progress in basic issues, such as queueing theory and estimation and identification in stochastic models, in recognition of their status as key elements for the understanding of the behavior of networks and for their design.

During its period of operation, COST 279 was a crucible for a very fruitful interaction among a sizeable group of European researchers exhibiting a remarkable diversity across a number of dimensions: with origins from both telecom operators and universities, with backgrounds in mathematics, computer science, and engineering, and with experiences ranging from basic re-

search to applied engineering. The competences available in this group thus matched quite well the diversity accommodated within the scope of the Action.

The current book summarizes the work contained in the internal technical documents, officially designated *Temporary Documents*, presented in the meetings held during the lifetime of COST 279. The work in some of those TDs has since been published in the peer-reviewed literature, but the work in some others, especially the more recent ones, has not. In the text of the following chapters, references are made to the open literature publications, whenever possible. When only the internal TDs are available, a reader looking for further details is asked to have the kindness of contacting directly the authors for the materials of his interest. The list of author contacts and TDs produced, together with their abstracts, is available at the Action web site, at `http://www.lx.it.pt/cost279/`.

Given its origin and purpose, the present publication is not a textbook. It is rather an annotated bibliography on a body of state-of-the-art work done on a related set of topics on network design, and it has an intrinsic value as such. However, a reader wanting to get an overall picture of the state-of-the-art in a specific sub-area within the scope of COST 279 can most likely do so by systematically exploring the numerous references given in the text.

The book starts with a short *Introduction* to the COST Research Framework and to COST Action 279 itself. The rest of the book, containing the technical material proper, has a hybrid organization. The first technical chapter is on *IP-Based Networks*, and deals essentially with issues relevant to end-to-end QoS. The following two chapters are of a horizontal nature, the first on *Queueing Models*, and the second on *Traffic Measurement, Characterization, and Modeling*. The last three chapters are technology-specific, and cover *Wireless Networks*, *Optical Networks*, and *Peer-to-Peer Services*. The book contains, as Appendices, an extensive *Bibliography*, the *List of Temporary Documents*, and the details on the *COST 279 Management Committee* and the *COST 279 Participating Institutions*.

Because of the hybrid structure of the book, the study of specific topics may fit naturally into more than one chapter, particularly so when both a basic, methodological part, and a system study part are involved. In such cases, the option made was to include references to the work in both chapters, with appropriate cross-references. In this way, chapters are, as much as possible, self-contained.

This book would not have been possible without the contribution of an enthusiastic and hard-working team of people. First and foremost, there are all the members of COST 279, the people who did the technical work reported, and who are indeed the reason for its existence. A large debt is next owed

to Michael Menth, from the University of Würzburg, Germany, who single-handedly coordinated the organization of the *COST 279 Mid-Term Report*, upon which this book is based, together with the fine team of technical chapter editors and contributing members listed at the beginning of each chapter. The overall operation of COST 279 had the wise guidance of its Management Committee and the support of the COST Program Technical Committee for Telecommunications and Information Science and Technology and the COST TIST Secretariat.

In the course of the year 2003 we had the sad news of the passing away of Prof. Olga Casals, MC member from Spain. COST 279 remains indebted to both her technical contributions and personal enthusiasm.

Even though COST 279 ended at its normal four-year term, the ensemble of its members possesses high enough cohesion and momentum to allow itself to materialize in the future, given appropriate conditions, into a similar initiative. We remain in anticipation of its outcome.

June 2005

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Phuoc Tran-Gia
Vice-Chairperson

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Introduction

The COST Program

COST 279 is one of the Actions of the European COST Program, an intergovernmental framework for European Co-operation in the field of Scientific and Technical Research allowing the co-ordination of nationally funded research on a European level. COST Actions are launched on a "bottom-up" approach, with the initiative for the creation of Actions coming from the scientists and technical experts themselves and from those with a direct interest in furthering international collaboration. According to the general spirit of flexibility of COST, country participation follows an *à la carte* principle.

The COST framework provides means for the setting up of regular meetings among researchers of the participating countries, for the purpose of technical exchanges, discussion of research directions, and organization of common initiatives. The resulting co-operation and interaction among researchers is intended to help Europe hold a strong position in the field of scientific and technical research. Its experience has shown very beneficial to the research community: besides helping keep its cohesion, it has allowed advanced students and young researchers in the beginning of their careers to get in touch with the latest research developments and integrated into the community, and it has potentiated the start up of research groups in environments where previous research tradition in an area did not exist. In addition, COST provides mechanisms for the transfer of its research results to the surrounding society, and examples abound of related "success stories. Detailed information on the COST Program can be obtained via the Web at the URL `http://www.cordis.lu/cost/`.

COST Action 279

COST Action 279 belongs to a distinguished lineage of COST Actions (COST 201, 214, 224, 242, and 257) that, since 1979, have fostered cooperation

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