Preface

The area of communication and computer networks has become a very active area of research by the Control Systems community in the last few years. The recent special issues in journals (e.g., *IEEE Transactions on Automatic Control*, Vol. 47, No. 6, June 2002, *Automatica*, Vol. 35, December, 1999, and *Control Engineering Practice*, Vol. 11, 2003) and the many special sessions in control conferences certify to this strong interest (see, for example, the plenary sessions of T. Basar and of F. Kelly in the IEEE 2003 Conference on Decision and Control, and the 2003 European Control Conferences, respectively, as well as the more than 15 sessions in the IEEE 2003 Conference on Decision and Control). As described in a special issue of IEEE Control Systems Magazine (vol.21, no.1, February 2001), the area of communication networks is of great interest to control researchers because its challenging problems fall within the scope and background of systems and control engineering. Furthermore, the increasing need to control dynamical systems via communication networks provides fertile grounds for control theorists as well as practitioners.

As a result, both analysis and synthesis approaches by the control community have appeared in the context of network control. Tools from convex optimization and control theory are playing increasing roles in efficient network utilization, fair resource allocation, and communication delay accommodation. On the other hand, as feedback control systems become increasingly distributed and dependent on shared networks for their efficient operation, the field of Networked Control Systems (NCS) is fast becoming a mainstay of control systems research and applications. In what follows, the term “communication control networks” will refer to both networks under control *(control in networks)* as well as networked control systems *(control over networks)*.

The complexity in the design and operation of communication/control networks, along with their real-time requirements, severely limit the ability to obtain accurate mathematical models. Such models are usually hybrid (containing both time-driven and event-driven dynamics), uncertain due to intentional simplification (fluid model approximations), or to parametric inaccuracies (uncertain delays), or still from the presence of additive disturbances (disruptive loads and congestion). Furthermore, in all practical situations, the network devices and systems are limited in their range of operation (limited queue lengths and rates) and therefore are subject to amplitude and rate saturation. Hence, large amplitude disturbances or uncertainties may drive the states and/or the controls into saturation where the system may operate in a mode from which it may be difficult to preserve performance or even stability requirements. Finally, the inherent presence of packets loss, delays, and the limited-capacity communication medium are important features that need to be taken into account to guarantee the performance and stability of such networks.

Our objective in editing this book with solicited contributions from experts in the various areas of communication/control networks, is to present interesting and complementary techniques that treat problems arising in the control of networks as well as in control across networks. We also see this book as a modest attempt to reverse the trend of fragmentation and specialization of the related fields of control, communication, and computing. The book had its genesis in a multidisciplinary collaborative effort between France and the USA, under the auspices of CNRS and NSF, concerning problems in stability, stabilization, and optimization for time-delay systems and related applications including the control of communication networks. Hence, the developments proposed in the sixteen chapters are *interdisciplinary* as they cover various research fields including *Controls*, *Communications*, *Applied Mathematics*, and *Computer Science*.

The book is organized as follows.

- Part 1 is devoted to Fluid/Flow Models and consists of chapters 1 through 5.
- Part 2 is devoted to Congestion and Nonlinear Systems and consists of chapters 6 through 10.
- Part 3 is devoted to Load Balancing and Teleoperation and consists of chapters 11 through 13.
- Part 4 is devoted to "Emerging Control Theory and Information Complexity" and consists of chapters 14 to 16.

Note that this partition is somewhat arbitrary as most of the chapters are interconnected, and mainly reflects the editors' biases and interests.

We hope that this volume will help in claiming many of the communications and networking problems for controls researchers, and to alert graduate students to the many interesting ideas at the boundary between communications, computing, and controls.

Acknowledgements

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in Autom atic Control in existence since 1995. However, we also invited researchers outside these research teams in order to provide a deeper and more balanced representation of the areas.

First and foremost, we would like to thank all the contributors of the book. Wit hout their encouragement, enthusiasm, and patience, this book would have not been possible. A list of contributors is provided at the end of the book. Professors S.I. Niculescu and K. Gu in particular have contributed more than their share to the birthing of this volume. Next, we would like to thank CNRS and NSF, and more specifically our program man agers Claire Giraud, Jean-Luc Clément (CNRS), Rose Gombay and Kishan Baheti (NSF) for funding the joint research which made this book possible. We would also like to thank Luis Farinas Del Cerro (DRI-CNRS). Thanks also go to *GDR Automatique* (France), *MENRT* (France) and the laboratory *LAAS-CNRS*. Finally, thank also Isabelle Queinnec (LAAS-CNRS) for her help regarding latex problems.

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