PhD dissertation evaluation

Title of the dissertation

A Comprehensive Optimization Model for Multi-hop Wireless Networks with Multicast Traffic

Author

Bartłomiej Ostrowski

Summary and contributions

The thesis addresses the modeling of wireless networks based on Time Division Multiple Access (TDMA) subject to multicast traffic. The thesis is structured in 9 chapters; Chapters 3-thru-9 propose mathematical programming formulations to optimize wireless networks under multicast traffic giving emphasis to different aspects and objectives including throughput maximization, energy consumption minimization, and data delivery delay minimization. The thesis often takes a constructive incremental approach starting from a basic formulation of the reference optimization problem and then adding up complexity and new features. Chapter 1 and 2 are used respectively to introduce the addressed topic and review the related state of the art.

A more detailed summary of the contributions is reported hereafter.

In Chapter 2, the thesis reviews the state of the art in the field of optimization of multicast traffic in wireless networks critically commenting both on the different reference wireless communication technologies, and om the main body of work dealing with the optimization of such technologies under multicast traffic.

Chapter 3 is dedicated to introducing the basic mathematical programming formulation which is then used as a reference in developing the more advanced formulations of the following chapters. The Basic Optimization Model (BOM) is thoroughly described in the two cases where the routing paths of multicast traffic are/are not subject to optimization themselves. The Chapter serves as for introducing the notation which is then largely used throughput the thesis.

Chapter 4 and Chapter 5 focus on formulations targeting the throughput maximization. Chapter 4 extend the BOM by including the optimization of the Modulation and Coding Schemes (MCSs) used by the wireless transmissions; two variants are discussed in this regard: a static case where MCSs are optimized by fixed throughout network lifetime, and a dynamic case in which MCSs can be optimally set on a finer time scale. Chapter 5 further introduce the possibility of optimizing the transmitted power of wireless transmission, which is a common feature of most of the reference wireless communication technologies. Also in this chapter, two alternative situations are considered where (i) the transmission power can vary continuously in a range or (ii) it is adjustable according to a fixed set of transmission power levels.

Chapter 6 brings in the optimization problem the energy issue by introducing formulations which tend to minimize the average energy consumption out of the multicast traffic service and/or target the throughput maximization under energy consumption constraints. The proposed formulation leverage a consistent energy consumption model which reflect the real behavior of wireless communication transceivers.

Chapter 7 further extends the work by targeting the objective of minimizing the packet delivery delay. The Chapter also proposes a heuristic mechanism based on Simulated Annealing (SA) to get sub-optimal solutions of the proposed delay-oriented formulation in short computation time.

Chapter 8 and Chapter 9 complete the work by introducing an alternative formulation (Chapter 8) and adding the problem of selecting the destination node for the multicast traffic which were considered as fixed and given in the previous chapters.

Assessment

What scientific/research issue is considered in this dissertation (the aim and thesis of the dissertation) and was it formulated by the author in a comprehensible way?

As reported in the previous part of this report, the research problem addressed in this thesis is the optimization of multicast traffic across wireless networks. The addressed problem is timely and relevant as multicast traffic is pervasive is most of the currently available wireless networks and will play a central role also in future technologies (e.g., 5G/6G). The scientific playground of the thesis is clearly described and expressed by the Candidate with convincing motivations on its timeliness and relevance.

Does the dissertation include appropriate analyzes of past work, including world literature, state of the art, and industrial applications?

Chapter 2 of the thesis is dedicated to commenting on state of the art and potential practical impacts of the proposed models and algorithms. The thesis highlights the most relevant past contributions in the research field clearly commenting on the main differences with respect to the proposed solutions. I did also appreciate the effort in spotting and commenting on real and realistic networking scenarios which could benefit from the proposed mathematical programming formulations and algorithms.

Has the author solved the research issues defined in the dissertation, did he use an appropriate method and are the assumptions justified?

The thesis addresses the reference problem with a rigorous modeling-oriented approach. All the mathematical programming formulations introduced throughout the technical chapters are correct and technically sound. The simplifying assumptions which are inherent of such type of modeling works are well justified and thoroughly commented. I particularly appreciated the effort of addressing a vast range of different sub-problems within the field of multicast traffic optimization in wireless networks; in this respect, the thesis provides a powerful toolbox to help network operators and managers optimizing their network architecture according to the specific goals.

The adjective "comprehensive" is often used in titles of scientific works even if many times the work itself is not such comprehensive. In the case of this thesis I really believe that the adjective is right on target: the thesis is really "comprehensive" in modeling multicast wireless networks providing a vast corpus of mathematical programming formulations for the problem at hand.

Thus, even of the general problem of optimizing wireless networks has a long scientific lifetime, the thesis has the high merit in proposing a comprehensive yet coherent set of mathematical programming formulations which encompass multiple practical aspects of real TDMA-based multicast wireless networks. The proposed formulations have great scientific value *per se* often providing mathematically elegant ways out to problems like the mathematical representation of the interference constraints based on the Signal to Interference Noise Ratio (SINR).

The thesis is well written and motivated in all its parts. Even if the main contributions is in the proposed mathematical programming formulations, each chapter covering a specific optimization problem/objective includes also a numerical performance evaluation section which is used to assess the quality of the planned wireless networks in realistic network scenarios which helps in strengthening the scientific consistency of the work.

Given all the above, I believe that the scientific contribution of the PhD thesis is **outstanding**.

Matteo Cesana, Full Professor
Dip. Elettronica, Informazione e Bioingegneria
Politecnico di Milano
Matteo.cesana@polimi.it

Signature:

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