Performance limits of delay constrained communication systems

Classical results in information theory focus on coding theorems which provide sharp guarantees for reliable communication and data compression when one allows for arbitrary delays for achieving a desired probability of error. But in real systems such as multimedia communication systems, delay constraints are fundamental and non-negotiable. For such delay constrained systems, except in rare cases, determining the optimal system performance is a highly intractable problem. Prior to our work, performance limits were derived using disparate techniques and arguments. What was perhaps unsatisfactory was the lack of a common framework whereby these bounds could be derived, understood and then generalised.

We attacked this problem using a novel combination of techniques from optimisation theory and provided a linear programming (LP) based framework to obtain these bounds. Our results showed that all previous approaches were subsumed in our LP based framework, and improved on earlier bounds. Moreover, it provided the first systematic generalisations to networked problems, where such bounds were particularly hard to obtain.

Our work has yielded an illuminating optimisation-theoretic understanding of the performance limits of delay constrained communication systems. It holds the promise of a unified theory of the performance limitations of such systems and a clearer understanding of delay constrained information flows on networks. Our work will appear soon in the prestigious IEEE Transactions on Information Theory [3], where a reviewer called it 'a truly valuable contribution to the Transactions'. Further work will be presented at the IEEE Information Theory Workshop [4] in Taiwan.

Our earlier results in this line of work were presented at the IEEE Conference on Decision and Control [1] in Japan (2015), and at the National Conference on Communications in Chennai (2017) where we received the Best Paper Award [2].

[1] Sharu Theresa Jose and Ankur A Kulkarni. A linear programming relaxation for stochastic control problems with non-classical information patterns. In 2015 *54th IEEE Conference on Decision and Control (CDC)*, pages 5743-5748. IEEE, 2015

[2] Sharu Theresa Jose and Ankur A. Kulkarni. A linear programming based channel coding strong converse for the bsc and bec. In *Proceedings of the National Conference on Communications*, 2017

[3] Sharu Theresa Jose and Ankur A. Kulkarni. Linear programming based converses for nite- blocklength joint-source channel coding. to appear in *the IEEE Transactions on Information Theory*, 2017

[4] Sharu Theresa Jose and Ankur A. Kulkarni. Linear programming based converses for some network- like problems. In to appear in the *Proceedings of Information Theory Workshop*, 2017

Prof. Ankur Kulkarni, Systems and Control Engineering, kulkarni.ankur@iitb.ac.in