Report on paper "The Capacity Region of a Class of Three-Receiver Broadcast Channels with Degraded Message Sets", by Chandra Nair and Abbas El Gamal, IEEE Transactions on IT, Vol. 55, No. 10, pp. 4479-4493, Oct. 2009.

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Theme: This paper establishes the capacity region of a class of three-receiver broadcast channels with two degraded message sets and shows that it can be strictly larger than the simple extension of the Kőrner-Marton region that yields capacity in the two-receiver case.

Results: This paper uses the new and clever idea of "indirect decoding" to show that conventional superposition is not sufficient to maximize the throughput of information on a three-receiver broadcast channel, when all receivers are interested in a common message and one of them is to receive a private message. The idea that superposition could be optimal in this case had been conjectured by researchers. The paper disproves the conjecture and shows alternatives that are optimal in a class of nontrivial channels. The paper also argues that finding the capacity region of the three-receiver broadcast channel with degraded message sets is as hard a problem as finding the capacity region of the two-receiver broadcast channel with common and private messages.

The broadcast channel is one of the most basic models in multiple user information theory. It has resisted all attempts to solve its capacity region in the general discrete memoryless case, ever since it was originally proposed by Cover in 1972. The main tools that have been used to establish the solution in a number of special cases have been superposition coding and Marton`s mutual covering (random binning) strategy. The incorporation of the new technique contributed in this paper, indirect decoding, has allowed the formulation of new achievable regions for some broadcast channels, which are strictly larger than the regions obtained by extensions of the superposition and random binning techniques. Indirect decoding makes use of additional auxiliary random variables to superimpose part of the private message onto the "cloud center", and part in the satellite codeword. These additional random variables also yield the establishment of new inner and outer bounds on the capacity region of the general three-receiver broadcast channels with two and three degraded message sets, one of the most promising developments in this problem in many years.

Paper: The paper is well written and gives a good account of the problem and its history. The special cases in which the new achievable region is optimal are illustrated with very clear examples. Discrete memoryless and Gaussian cases are exemplified, showing strict gains with respect to the straightforward extension of conventional superposition. The paper also alludes to a general procedure for the definition of achievable regions that apply in any set of

messaging requirements, extending the usefulness on the methods beyond the degraded message set cases. Some astute techniques are also employed to establish that certain regions described by different expressions turn out to be identical.

Impact: This paper has been referenced by 27 articles, according to Google Scholar, a sizeable number of citations, considering it was published only 19 months ago. The introduction of the indirect decoding strategy has opened up new avenues for establishing rate bounds in connection to the broadcast channel. I would argue that this is one of the most important contributions to the broadcast channel problem since the initial breakthroughs of the 1970`s.

Conclusion: This paper introduces a new strategy, named indirect decoding, for communicating over broadcast channels with three or more receivers. It creates new possibilities for developments in this very hard problem. These contributions merit ample recognition and make this paper a very strong candidate for the 2011 Information Theory Paper Award.