On the Design of Universal Schemes for Massive Uncoordinated Multiple Access

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The wireless landscape is changing rapidly, and in no small part due to legions of unattended devices that seek to disseminate information sporadically. This paradigm shift is important because it may impact the operation and efficacy of currently used protocols. Specifically, the change in landscape requires the design of multiple access schemes whereby a massive number of wireless devices need to access the Internet in an uncoordinated fashion. To address this issue, many researchers are shifting their interest from connectivity-based resource allocation algorithms and scheduling schemes to random access protocols.

One of the flagship multiple access schemes is slotted ALOHA, which was originally designed for wireline networks. This research is inspired by ALOHA and other similar algorithms, and it seeks to extend basic notions from random access to future wireless infrastructures. Existing results on improving the performance of slotted ALOHA assume that the number of users is known at the transmitters in order to implement the random access strategy. In our work, we focus on a single round of transmissions and consider the important question of whether it is possible to design universal, adaptive massive uncoordinated random access schemes that are agnostic to the number of users in the network. We propose a novel formulation of the slotted multiple access problem with successive interference cancellation, in which the access point does not need to estimate the number of devices and the number of time slots can be determined dynamically. This research also seeks to explore further novel formulations of the slotted multiple access problem with successive interference cancellation. In particular, we wish to explore the situation in which there exist two access points that may share some common subscribers, and how the sharing of decoded packets can deliver performance improvements.

A recent breakthrough in analyzing the performance of random access schemes showed that graphical representations traditionally employed in iterative decoding extend to wireless systems with successive interference cancellation. This connection between coding theory and multiple access offers new means to construct access strategies and analyze their performance. One aspect of the problem that has not received much attention is the fact that the structure of the ensuing bipartite graph is heavily influenced by the antenna characteristics of the access points. For instance, in the scenario with two access points, we wish to explore the effect of different partitions of users on the graph structure and thus on the overall performance of the protocol. In turn, the findings can be used to inform antenna design objectives for similar use cases. Numerical results currently show a substantial performance increase over traditional ALOHA for the slotted multiple access problem with successive interference cancellation. It provides protocols that seek to perform well in a rising use case that is not currently served well by deployed protocols.