Multi-Dimensional Coexistence: Extending the Concept of the Spectral Mask to Include Transmitter Transmission Pattern for Spectrum Sharing

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This presentation demonstrates how the concept of a spectral mask can be extended to include antenna radiation pattern as an additional dimension of constraint. This extension provides a framework under which users of wireless spectrum can jointly adjust their spectral and spatial transmission parameters to ensure coexistence within a shared environment. The joint constraints generated under this framework can provide goals for optimization algorithms, such as those for ambiguity function generation via an alternating projections method explored by Latham and Eustice.

Given knowledge of the location and interference power levels of other wireless spectrum users in a shared geographic environment, the Friis transmission equation is used to determine a transmission power constraint for each frequency in each direction of transmission. Essentially, this provides a multi-dimensional map of the constraints requiring transmitter compliance to avoid causing harmful interference to other devices.

Many presently deployed wireless devices have a fixed antenna radiation pattern that cannot be controlled or adjusted to provide adjustable directional transmission. In cases such as these, the known antenna radiation pattern can be applied as a series of weights to the relevant subset of the joint spectral-spatial constraint map to generate an intelligent spectral mask that accounts for other users in an environment, as well as the limitations of the device's transmission properties. Compared to a traditional spectral mask, this spectral mask provides a more precise representation of the actual limitations placed on the available spectrum for the device compared to a traditional spectral mask.

In the event a device is able to adjust its transmission pattern in real time, such as a radar transmitter or fifth-generation (5G) wireless device using a phased array, a new spatial dimension of optimization is available to avoid interference with other users. Assuming a specific spectral signal is desired, this signal can be applied to the joint spectral-spatial constraint map to generate an angular transmission-pattern mask that would dictate a limit of transmittable power for every angle. Such a device would then need to adjust its transmission pattern to avoid violating this mask.

Finally, if a device has freedom in its objectives such that it is not limited to a specific transmission pattern or signal, then both the spatial and spectral dimensions of the constraint map can be used during optimization. For example, given a radar with desired ambiguity function and target direction, the transmission pattern can be adjusted in such a way that more bandwidth is available in the direction of the target, relaxing the constraints placed on the waveform needed to achieve a certain ambiguity function. This is demonstrated using a simulation featuring a radar with sweeping transmission direction coexisting with nearby communication handsets. As handsets move and the radar sweeps, new constraints are determined, and the radar waveform is continually optimized using alternating projections to provide a desired ambiguity function without producing interference.