Radio Flexibility at the PHY layer

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Abstract

In response to the demand for increasingly flexible radio systems from industry (operators, service providers, equipment manufacturers, chip manufacturers, system integrators, etc.), government (military communication and signal-intelligence systems), as well as various user demands, the field has grown rapidly over the last twenty years or so, and has intrigued and activated R&D Departments, academia, research centers, as well as funding agencies. It is now a rapidly growing field of inquiry, development, prototyping, and even fielding. Because of the enormity of the subject matter, it is hard to draw solid boundaries that exclusively envelop the scientific topic, but it is clear that such terms as Software Radio, Software Defined Radio, Reconfigurable Radio, Cognitive/Intelligent/Smart Radio, etc., are at the center of this activity. Similar arguments would include work on flexible air-interface waveforms and/or generalized (and properly parameterized) descriptions and receptions thereof.

Among the many factors that seem to motivate the field, the most obvious seems to be the need for multi-standard, multi-mode operation, in view of the extreme proliferation of different, mutually-incompatible radio standards around the globe (witness the analog-to-digital-to-wideband-to-multicarrier evolution of air interfaces in the various cellular-system generations). This is the desire for "legacy-proof" functionality, i.e., the ability to handle existing systems in a single unified terminal (or single infrastructure access point), regardless of whether this radio system is equipped with all the related information pre-stored in memory or whether this is software-downloaded to a generically architected terminal. In a similar manner, "future-proof" systems would employ flexibility in order to accommodate yet-unknown systems and standards with a relative ease (say, by a mere re-setting of the values of a known set of parameters), although this is obviously a harder goal to achieve. Similarly, economies of scale dictate that radio transceivers employ reusable modules to the degree possible ("modularity"). Of course, truly optimized designs for specific needs and circumstances lead to "point solutions", so that flexibility of the modular and/or generic waveform-design sort may incur some performance loss. In other words, the benefit of flexibility may come at some cost, but hopefully the trade-off is still favourable to flexible designs.

The presentation will focus rather narrowly on the physical-layer aspect of radio flexibility and will provide a brief description of various research fronts at that layer, with particular emphasis on the digital baseband and the algorithms/tasks that this portion may perform in the service of flexibility. It will start by identifying the various goals of flexible radio and then provide some definitions for a systematic sorting out of the related concepts. It will delineate the various research sub-areas that have recently been identified as central to promoting the relevant research methodology, namely:

- Flexible baseband digital signal processing algorithms.
- Flexible digital platforms and architectures.
- Flexible Link-Centric QoS management concepts.

For each sub-area, various open issues and knowledge gaps will be identified. In addition, a generic framework for the description and taxonomy of the various flexibility mechanisms will also be presented, including a discussion of the various related metrics and cost functions.

Finally, the presentation will present *dynamic signal design* as an example of a mechanism that empowers such flexible transceiver architectures, providing for mode-selection algorithmic designs that incorporate these concepts and thus represent an instantiation of the radio flexibility framework.