Comment to ET Docket No. 03-108
NPRM FCC 03-322

Facilitating Opportunities for Flexible, Efficient, and Reliable Spectrum Use Employing Cognitive Radio Technologies

The purpose of this comment is to offer to the Commission information on related research that may be helpful in considering technical aspects of cognitive radio systems. In specific this comment suggests that additional technical functionality may need to be considered to maximize the flexibility of cognitive radio systems.

Paragraph numbers below refer to paragraphs in the NPRM

1. Note one to this paragraph presents a description of cognitive radio as "adaptive awareness." Part of the research this comment deals with is a concept termed adaptability. Adaptability is the means to change system behavior based on system inputs. The concept of adaptability assumes a multi-mode functionality (the availability of multiple modulation and/or protocol layers) using SDR or a similar technology. Adaptability can be divided into two major functional areas: selection and negotiation. Selection is a single ended process and negotiation is a two or more ended process. This comment addresses only negotiation, as selection (using spectrum sensing or geographic location monitoring) is more technically straight forward. Full negotiation requires a bi-directional transfer of information between two or more devices describing the available capabilities of each device and then using a methodology (predefined, negotiated or accessed) to make a selection of the common capabilities sufficient to support the communications capabilities desired. If such common communications capabilities are not available, it is also very desirable to notify the higher layers of the communications system of the exact issue. This is considered an aspect of adaptability.

20. This paragraph suggest that "…a cognitive radio could negotiate cooperatively with other spectrum users…" and "…could also be used to facilitate interoperability between or among communications systems…" The use and value of negotiation is also noted in para 23. From these paragraphs it appears that negotiation is considered a desirable capability for cognitive radio systems.

In a communications system, a communications channel must exist to support negotiation. This is quite problematic when the purpose of such negotiation may be to select a communications channel (and related technology). This is one argument of several that strongly suggest that an independent channel used solely for the purpose of negotiation is necessary to support a fully flexible channel (or other protocol layer) selection. Further arguments include:

The control channel in many cellular communications systems is more reliable (greater signal to noise ratio) than the main/data channel. This makes practical a controlled fall-back to a different channel or lower transmission rate in the event the existing main channel performance is not acceptable. A failing main channel cannot reliably negotiate its own fall-

back. In multi-mode cellular systems there is no common control channel to support this capability, as existing cellular control channels use similar technology to the main channel. An independent communications channel is necessary for such negotiation if multi-mode fall-back is desired.

Multi-layer time-independent communications protocols are quite complex; testing of all states is not practical in many such communications systems. When revisions are made to one or more layers of the protocols it is sometimes the case that backward compatibility is not maintained in all operational cases. This may seem far-fetched, but modern communications systems are long lived (20-50 years) with thousands of different implementations and multiple revisions of each standard (often 20 - 30 standards are used). Communications systems such as data modems or facsimile machines are widely used (+100 million users) and support multiple (approaching 10) older communications protocols. This vast combinatorial range allows even small incompatibilities to impact applications-to-applications communications somewhere. For this reason it is sometimes necessary to negotiate even among revisions of protocols for application-to-application compatibility. To support such a capability an independent channel (when different revisions/implementations of the main channel are not compatible) with single tree structured protocol (which is guaranteed to be a super-set of its previous revisions) is required.[1]

An *etiquette* is the name for an independent communications channel/protocol used only for the purpose of negotiating the main channel or other protocols layered on the main channel. Several long term successful communications systems use an etiquette. ITU-T V.8 is the etiquette used in almost all existing telephone data modems. ITU-T T.30 is the etiquette used in all Group 3 facsimile machines. In all DSL systems standardized in the ITU-T, an etiquette termed G.994.1 is used.

The author of this comment respectfully suggests that the FCC consider the need to specify an etiquette that would allow negotiation among all the possible communications protocols that are foreseen in each band (or sequence of bands) that support cognitive radio. The standards for this etiquette could be developed in an independent standardization committee.

[1] Further discussion of this point is in Fundamental Nature of Standards: Technical Perspective, published in IEEE Communications Magazine, Vol. 38, #6, June, 2000, p. 70 available at http://www.csrstds.com/fundtec.html