1. **Final publishable summary report**

The WiCoding project was a Marie-Curie action for retraining of Prof. Erdal Arıkan of Bilkent University, Turkey and Prof. Garik Markarian of Lancaster University and CEO of Rinicom Ltd acted as the project coordinator and scientist in charge.

The technical aims of the WiCoding project were the development of novel techniques targeting specific aspects of next generation wireless broadband access systems. More specifically, the project focused on advanced signal processing and coding techniques for improving the performance of wireless systems, as exemplified by the current WiMAX system. WiMAX is an international standard for wireless broadband access—a network with a cellular structure consisting of base-stations and fixed or mobile user terminals. Some of the main technological innovations that came out of the project are described below.

*Pre-distortion in OFDM:*

OFDM stands for orthogonal frequency division multiplexing. It is a means of allowing multiple users to share a common communication electromagnetic spectrum. OFDM has become the air-interface of choice for modern wireless systems—being adopted in standards such as WiFi, WiMAX, and DVB-T. Despite its many advantages, OFDM suffers from a PAPR problem which makes OFDM systems costly to implement. PAPR is an abbreviation for “peak to average power ratio.” In OFDM systems, the PAPR of transmitted signals tends to be high and this prevents the high power amplifier at the OFDM transmitter to be operated efficiently. To mitigate this problem, an effective method is to use a “pre-distorter” which compensates for the non-linear behaviour of the power amplifier when it is driven into saturation by a strong input signal. In WiCoding, a novel hybrid pre-distortion algorithm for OFDM systems was developed. A prototype of the pre-distorter has been prepared and showcased at the ICT Mobile Summit 2009.

*Pre-distortion for MIMO OFDM:*

As a continuation of the above work on pre-distortion, WiCoding initiated work on pre-distortion for MIMO OFDM systems. In MIMO systems, there are multiple amplifiers, one for each transmit antenna. The novel idea in the MIMO case is to take advantage of the additive nature of the atmospheric transmission to compensate for the non-linearities in a joint fashion. This work is still in progress and is likely to result in entirely new techniques for dealing with this very important problem of wireless communications.

*Low-complexity coding schemes for MIMO OFDM:*

A main research goal of WiCoding was to develop advanced techniques to reduce the complexity of the PHY layer processing in MIMO OFDM systems. An entirely new coding method called “polar coding” was used towards this end. Polar codes, discovered recently by Prof. Arikan, are a class of codes that achieve the Shannon limit with low-complexity encoding and decoding algorithms. The work in WiCoding on polar coding aimed at taking polar coding from a theoretical idea to practice—an aim consistent with the fact that both Profs. Arikan and Markarian have a long professional background in coding theory and applications. Indeed, this collaboration has resulted in several publications already. Initial work in this area consisted of a critical assessment of polar codes as a potential competitor to existing coding schemes that are used in the WiMAX system. The results of this initial study were encouraging enough to continue the work in the direction of designing coding, modulation, and space-time coding schemes based on the polar coding paradigm. This work is still continuing. We expect several more publications on this subject.

*Real-time video distribution over WiMAX:*

Real-time video distribution over broadband wireless systems presents special challenges since video coding schemes are developed for wireline systems which can transmit data at a steady rate and more reliably. Wireless channels are subject to fading that causes the transmission rate to fluctuate and they are more error prone. Video distribution is further complicated by the heterogeneous set of networks the video stream encounters end-to-end. Prof.. Arikan took part in the preparation of two research proposals by Rinicom on this very challenging subject of video distribution. One proposal dealt with intelligent video analytics so that the camera system has sufficient intelligence to minimize the data sent to a central location. The second proposal addressed the cross-system cross-layer optimisation issues as video traffic passes from one wireless system to another in an end-to-end connection consisting of several different types of networks, wireless as well as wireline. Another outcome of this work was the setting up of a WiMAX system with video equipment at Prof. Arikan’s home institution, Bilkent University, which is now used for hands-on training of students and as a research testbed.

*Cognitive radio:*

The wireless networks of the future are envisioned to consist of a set of intelligent radio devices equipped with multiple sensors, designed to sense the radio environment, and accordingly take actions so as to maximize the overall utilisation of the scarce spectral resources. The radios of the future are also expected to be “green”—emitting as little energy as feasible to carry out the communication task. The set of techniques required to make this vision a reality are collectively called “cognitive radio,” which was a theme explored under WiCoding. A concrete result obtained as a result of these studies has been the entrance of Rinicom into a consortium of companies to a new EUREKA (CELTIC) project on cognitive radio. Rinicom’s role in this project will be mainly the design of cross-layer optimized PHY and MAC layers for a cognitive radio platform.