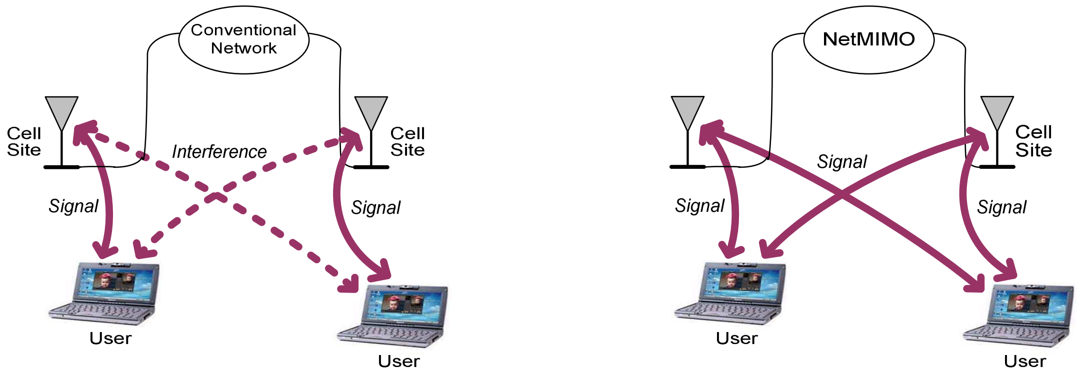
1. Final Publishable Summary Report

In the traditional *modus operandi* of cellular systems, a user is assigned to a cell site on the basis of certain criteria (e.g., signal strength) and it then communicates with that cell site while causing interference to all other sites in the system. The key tenet of *NetMIMO* is that, in the uplink specifically, intercell interference is merely a superposition of signals that were intended for other cell sites, i.e., signals that happen to have been collected at the wrong place. If these signals could be properly classified and routed, they would in fact cease to be interference and become useful in the detection of the data they bear. (A dual observation can be made about the downlink.) This insight naturally leads to the conclusion that, ultimately, the goal should be to serve all users through all the sites within their range of influence. While challenging, this is theoretically possible by virtue of the fact that the cell sites are connected by a powerful backbone network. This ambitious idea leverages the almost unlimited bandwidth available in optical-fiber wireline networks to transcend the burden of wireless intercell interference. With *NetMIMO*, in fact, the notion of a cell gets blurred once users are no longer assigned to specific sites. Ultimately, there is a network of sites serving a population of users. While this is a conceptually simple proposition, it poses numerous hurdles and challenges that this project aims to resolve.



(a) Conventional System. (b) NetMIMO.

This final report complements the first period report by covering the final 24 months of the project. Allocated to this second phase are Tasks T3-T7. The objectives of these tasks are as follows:

- T3: Evaluate the performance of uplink and downlink techniques under various channel estimation policies. Show that *NetMIMO* can operate with realistic fading estimates.
- T4: Design reference signal structures specifically tailored to the channel estimation needs of *NetMIMO*. Determine the bandwidth and power overhead relative to a traditional system.
- T5: Develop calibration mechanisms to warrant channel reciprocity in TDD systems.
- T6: Quantify tolerance to latency and delay jitters. Organize backbone network to guarantee delivery of data and channel estimates within such tolerance.
- T7: Determine the size of the coordination clusters in which *NetMIMO* should be organized.

Summary of Work and Results for Task T3:

The receive and transmit structures developed in T1 and T2 provided a good level of performance with manageable complexity under ideal knowledge of the channel fading coefficients at each time instant and at each frequency (the so-called *genie conditions*). A key point in the success of the project, however, is to ensure that the performance remains satisfactory when the system operates on the basis of realistic channel estimates. A reference-signal (a.k.a. pilot-signal) time-frequency-space grid was devised. Using this grid, the performance was tested and it was verified that the degradation was indeed acceptable.

SUMMARY OF WORK AND RESULTS FOR TASK T4:

In contrast with single-user settings, where the reference-signal overhead is modest (typically ranging between 5% and 15%), in coordinated settings it explodes with the number of users and the number of antennas therein, with the danger of cannibalizing most of the coordination gains. What we proposed in this task was a variable-density scheme that matches the overhead to the power level and degree of mobility separately for each individual user. Given the disparity in received powers and in degrees of mobility, this often results in large reductions in overhead relative to a baseline that applied worst-case overheads to all users involved. In turn, this allows preserving a larger share of the theoretical gains.

SUMMARY OF WORK AND RESULTS FOR TASK T5:

The calibration necessary to ensure reciprocity between uplink and downlink turned out not to be a serious obstacle. Calibration algorithms borrowed from the intelligent antenna literature were adapted to the problem at hand without excessive difficulty. The results were satisfactory.

SUMMARY OF WORK AND RESULTS FOR TASK T6:

Latency and delay jitters turn out to be one of the principal hurdles in the operation of *NetMIMO*. It is necessary to have delay guarantees of no more than 1 ms for the degradation relative to ideal (no-delay) conditions not to be substantial. The current preference for flat network architectures complicates this milestone as it eliminates hierarchical network elements that could facilitate the coordination. Distributed schemes whereby every cell coordinates a subset of the available channels were devised and tested successfully.

SUMMARY OF WORK AND RESULTS FOR TASK T7:

Using the results derived in earlier tasks, it was determined that the optimal size for the coordination clusters, in terms of fundamental performance limits, ranges between 3 and 12 sectors depending on the location of the users within their respective sectors. This corresponds to cooperation clusters spanning between 3 and 7 cells, each of them in general only partially (i.e., some but not all sectors participate in the coordination).

The *NetMIMO* project falls squarely within the IST thematic priorities for FP7. Specifically, the research objectives are directly relevant to the IST thematic area of *Information & Communications Technologies (ICT)*. The project has addressed several of the seven ICT challenges identified, and in particular the aim of transforming today's Internet into a higher fidelity medium delivering rich and immersive experience to mobile users. Although the gains obtained through collaborative transmission and reception do not by themselves suffice to make this a reality, they can be one of the ingredients contributing to it.

For further details on *NetMIMO*, or to access the publications and other dissemination activities, please visit the project's website at http://www.dtic.upf.edu/~alozano/netmimo/index.html