A Complex Baseband Platform for Spatial–Temporal Mobile Radio Channel Simulations

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***Abstract*—Recently, joint spatial–temporal signal processing has been recognized as the key to reducing the effects of the intersymbol and cochannel interference seen in very high bit-rate mobile radio communications systems. Developing hardware simulators that can simulate mobile radio propagation scenarios in time and space domains is essential for evaluating the real-time performance of spatial–temporal signal processing schemes. This paper outlines a complex baseband platform developed for spatial–temporal mobile radio channel simulations. The platform consists of a complex baseband fading/array response simulator, a digital signal processor (DSP) board, and a general-purpose parameter estimator that uses systolic array implementation of the recursive least square (RLS) algorithm. Results of experiments conducted using the developed platform are presented to confirm the proper operation of the system.**

***Index Terms*—Adaptive array, broad-band mobile communications, parameter estimation, recursive least square (RLS) algorithm, space/time-equalizer, systolic array.**

I. Introduction

MANY research papers have been published in the field of mobile multimedia communications; all target the technological breakthroughs that would enable very high bit-rate, say higher than 10 Msymbols/s, signal transmission over mobile radio channels [1], [2]. The main hurdles are the severe intersymbol interference (ISI) and cochannel interference (CCI) imposed on the received signals, due, respectively, to multipath propagation and the reuse of the same frequency in adjacent cells. Since the complex envelope of each propagation path varies as the vehicle moves, the ISI and CCI are both time-variant.

Joint space/time (S/T-) domain signal processing techniques have been recognized as effective in achieving spatial signal isolation, thereby reducing the effects of both ISI and CCI [3], [4]. Adaptive array antennas and adaptive equalization techniques, which have long been considered as constituting independent technology areas, are being combined in a unified concept that is sometimes referred to as space/time equalization [5].

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To develop S/T-equalizers and evaluate their performance, hardware simulators that can simulate spatial and temporal radio wave propagation scenarios in real-time are needed. The temporal structure of the propagation scenario can be characterized by the received signal's delay profile, and the spatial structure by the angular profile. The former can be simulated by dividing the transmitted signal into several path components corresponding to the multipaths, and weighting them appropriately. The angular profile can be simulated by rotating the signal phases of the path components received by the antenna array in accordance with their direction of arrival (DOA).

Instead of measurements in which the system to be tested, including antenna and RF/If circuitry, is placed in an anechoic chamber, the performance of time/space signal processing itself can be more conveniently evaluated by using a channel simulator connected directly to the S/T-equalizer. Since performance evaluations using such a channel simulator are not affected by the imperfections inherent within the antenna and/or RF/IF sections, higher efficiency can be expected in evaluating the performance of S/T-signal processing algorithms and optimizing their implementation.

In general, the problems inherent within S/T-equalization are twofold: one is parameter estimation, the other is sequence estimation. Parameter estimation includes problems in determining optimal weights on elements for the adaptive antenna as well as replicating received composite signal for time-domain equalization. Sequence estimation is the problem of estimating, from the S/T-equalizer output, the information sequences transmitted by the desired users.

This paper describes a hardware platform developed for spatial–temporal mobile radio channel simulations. The platform consists of a complex baseband fading/array response simulator, a DSP (Analog Devices SHARC ADSP-21 060) board, and a general-purpose parameter estimator [6] that uses systolic array implementation of the recursive least square (RLS) algorithm. The parameter estimator, which can estimate the optimal values of up to 23 parameters for S/T-equalizers, works as an adjunct to the DSP board. Obviously, the parameter estimation time is much shorter using the estimator than running the RLS algorithm on the DSP board. Data input logic configuration depends on the type of S/T-equalizer [7], so the input logic was made programmable.

The developed platform works completely in the complex baseband domain. The fading/array response simulator simulates the temporal and spatial radio wave propagation scenarios in broadband mobile communication channels in real-time. The temporal structure of the received signals can be approximated by adjusting path strengths, and the spatial structure by adjusting their DOAs.