A heterogeneous device technology reconfigurable logic fabric is proposed which leverages the cooperating advantages of distinct magnetic random access memory (MRAM)-based look-up tables (LUTs) to realize sequential logic circuits, along with conventional SRAM-based LUTs to realize combinational logic paths. The resulting Hybrid Spin/Charge FPGA (HSC-FPGA) using magnetic tunnel junction (MTJ) devices within this topology demonstrates commensurate reductions in area and power consumption over fabrics having LUTs constructed with either individual technology alone. Herein, a hierarchical top-down design approach is used to develop the HSC-FPGA starting from the configurable logic block (CLB) and slice structures down to LUT circuits and the corresponding device fabrication paradigms.

An orthogonal dimension of fabric heterogeneity is also non-determinism enabled by either low-voltage CMOS or probabilistic emerging devices. It can be realized using probabilistic devices within a reconfigurable network to blend deterministic and probabilistic computational models. Herein, consider the probabilistic spin logic “p-bit” device as a fabric element comprising a crossbar-structured weighted array. Programmability of the resistive network interconnecting p-bit devices can be achieved by modifying the resistive states of the array’s weighted connections. Thus, the programmable weighted array forms a CLB-scale macro processing element with bitstream programmability. This allows field programmability for a wide range of classification problems and recognition tasks to allow fluid mappings of probabilistic and deterministic computing approaches. In particular, a Deep Belief Network (DBN) is implemented in the field using recurrent layers of processing elements to form an n-m1-m2-…-mi weighted array as a configurable hardware circuit with an n-input layer followed by i hidden layers.