

Bio-inspired computing systems: the Embryonics project

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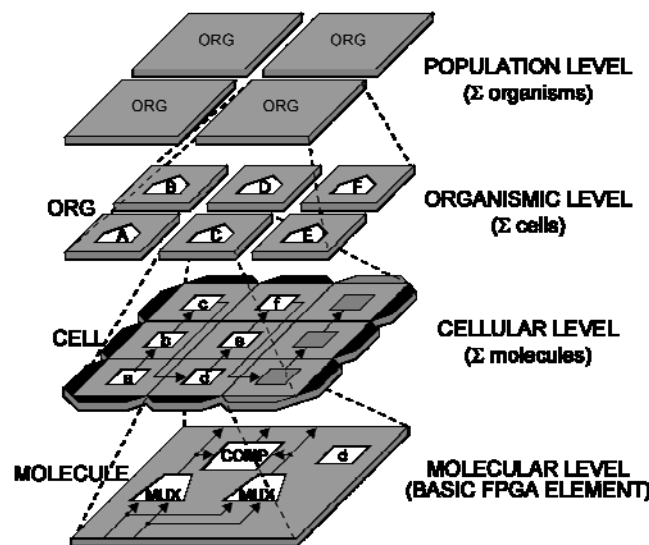
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A human being consists of approximately 60 trillion (60×10^{12}) cells. At each instant, in each of these 60 trillion cells, the *genome*, a ribbon of 2 billion characters, is decoded to produce the proteins needed for the survival of the organism. This genome contains the ensemble of the genetic inheritance of the individual and, at the same time, the instructions for both the construction and the operation of the organism. The parallel execution of 60 trillion genomes in as many cells occurs ceaselessly from the conception to the death of the individual. Faults are rare and, in the majority of cases, successfully detected and repaired. This process, remarkable for its complexity and its precision, relies on completely discrete information: the structure of DNA is a sequence of four bases, usually designated with the letters A (adenine), C (cytosine), G (guanine), and T (thymine).

Our *Embryonics* project (for *embryonic electronics*) is inspired by the basic processes of molecular biology and by the embryonic development of living beings. By adopting certain features of cellular organization, and by transposing them to the two-dimensional world of integrated circuits, we try to show that properties unique to the living world, such as *self-replication* and *self-repair*, can be applied to artificial objects (integrated circuits).

Our approach is based on four hierarchical levels of organization (see figure):

- (1) The basic primitive of our system is the *molecule*, the element of a programmable logic circuit.
- (2) A finite set of molecules makes up a *cell*, essentially a small processor with the associated memory, executing a program that finds a biological equivalent in the *genome*.
- (3) A finite set of cells is an *organism*, an application-specific multiprocessor system.
- (4) The organism can itself replicate, giving rise to a *population* of identical organisms.



Keywords: Embryonics, computer system design, fault-tolerance, self-replication.