

Multi-objective Intrinsic Evolution of Embedded Systems (MOVES)

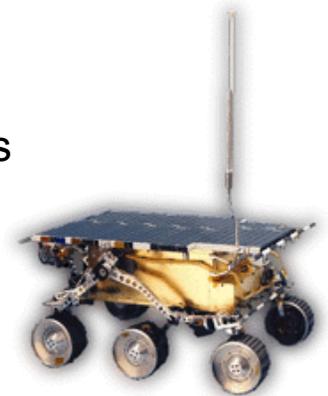


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- goal
 - ◆ investigate intrinsic evolution as a mechanism to achieve self-adaptation and –optimization for autonomous embedded systems

- an embedded system ...
 - ◆ adapts to slow changes by simulated evolution
 - ◆ adapts to radical changes by switching to pre-evolved alternatives
 - ◆ requires intrinsic evolution for autonomous operation



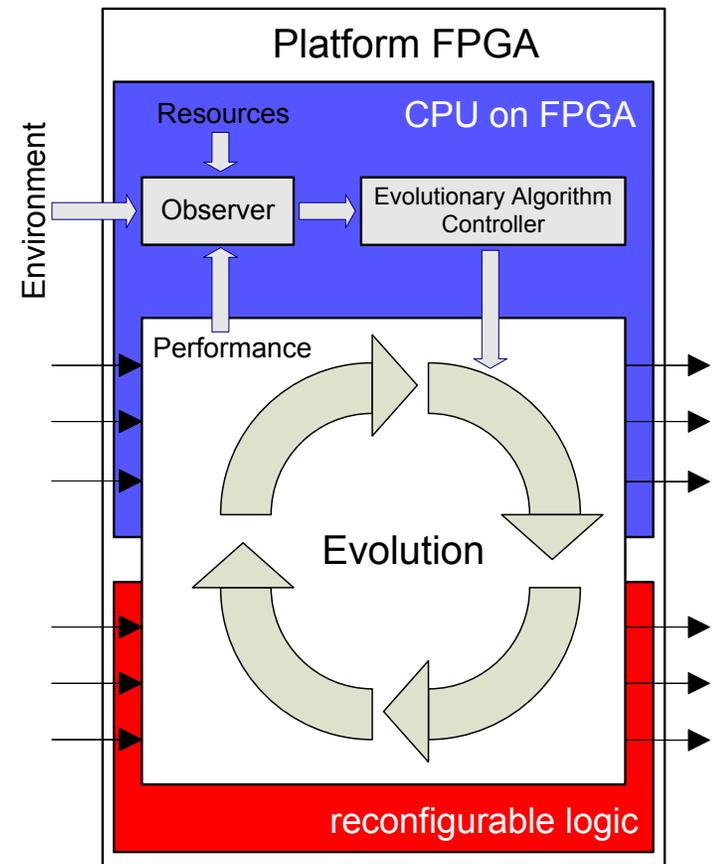
OC Architectures

■ physical architecture: "organic" system-on-chip

- ◆ prototyping work on platform FPGA, eg. Xilinx Virtex-II Pro/Virtex-4
- ◆ on-chip evolution in hardware and software, self-reconfiguration
- ◆ evolved functions differ w.r.t.
 - functional quality
 - required hardware resources
 - computation time
 - power consumption

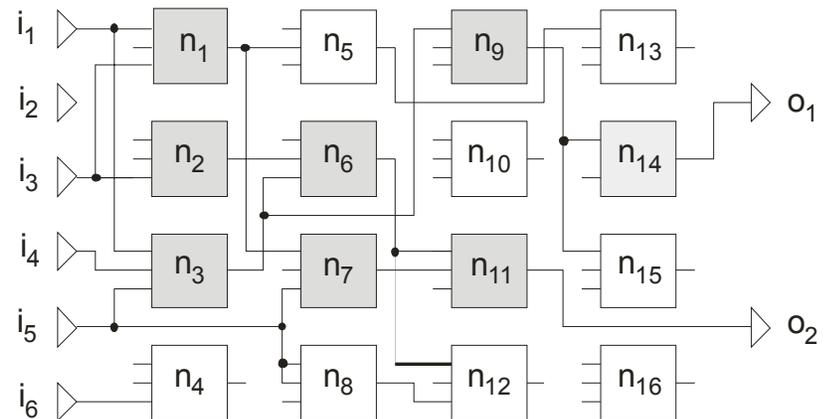
■ logical architecture: controller-observer

- ◆ observer monitors
 - system performance
 - available resources
 - environmental changes
- ◆ controller initiates
 - re-evolution or
 - switch to pre-evolved alternatives



Aspects of Self-organization

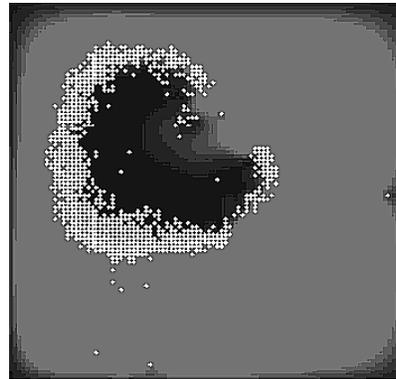
- evolutionary algorithms inherently provide
 - ◆ self-optimization
 - ◆ self-adaptation
- evolutionary algorithms can be used to implement self-recovery
 - ◆ re-evolution triggered by a detected faulty behavior
 - ◆ recovery is enabled by the inherent redundancy in the evolved circuits
- evolvable hardware \equiv self-organizing hardware
 - ◆ if "organization" is interpreted as the structural arrangement of logic elements and interconnect (?)



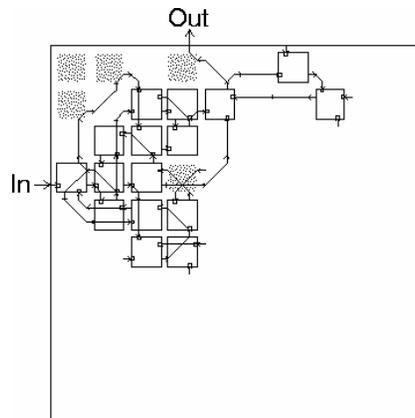
Emergence Phenomena

- might arise from the interaction between several embedded systems
 - ◆ cooperation between individually evolved systems projected for the 2nd and 3rd SPP phases
- other emergence phenomena in evolvable hardware (not part of our project)

- ◆ multi-cellularity
[RothermichMiller02]



- ◆ unconstrained evolution (?)
[Thompson96]



Nature-inspired Methods Used

- evolutionary algorithms
 - ◆ applied at the hardware/software level

- issues
 - ◆ multi-objective evolution
 - ◆ intrinsic evolution, ie. the fitness of a circuit is evaluated on the target system
 - ◆ online evolution, ie. the circuit is evolved while being operational

- challenges
 - ◆ scalability: evolve "complex" vs. "complicated" solutions
 - ◆ robustness: evolve useful circuits from an engineering perspective
 - ◆ validation: evolve correct circuits, even provable correct circuits?