Preface

A new computing model, extends the von Neumann stored program control (SPC) computing model to program and execute self-configuring, self-monitoring, self-healing, self-protecting and self-optimizing (in short, self-managing or self-*) distributed software systems. As opposed to self-organizing systems that evolve based on probabilistic considerations, this approach focuses on the encapsulation, replication, and execution of distributed and managed (regulated) tasks that are specified precisely. Its innately parallel architecture (non-von Neumann), and its architectural resiliency of cellular organisms, are ideally suited to exploit the many-core architecture and low-latency bandwidth networks emerging in the new generation of data centers to improve the price/performance of IT infrastructure by orders of magnitude.

The new computing model (known as the Distributed intelligent managed element (DIME) Network Architecture) consists of a signaling network overlay over the computing service network and allows parallelism between the control (setup, monitoring, analysis and reconfiguration based on workload variations, business priorities and latency constraints) and the computing functions of the distributed software components. A workflow is implemented as a set of tasks, arranged or organized in a directed acyclic graph (DAG) and executed by a managed network of DIMEs. These tasks, depending on user requirements are programmed and executed as loadable modules in each DIME. The distributed software components along with associated profiles defining their use and management constraints are executed by DIMEs endowed with self-management and signaling-enabled-control architecture. The profiles are used as blueprints to setup, execute and control the down-stream DAG at each node based on global and local policies which depend on business priorities, workload fluctuations and latency constraints. A new class of distributed systems with the architectural resilience of cellular organisms are possible using the DIME network architecture with signaling to monitor and regulate the execution of computational workflows with self-* properties.

We describe two proofs-of-concept implementations; one using a new native operating system called Parallax which is specially designed using the DIME computing model to monitor and control multi-core and many-core processors in an Intel processor based server; another using a conventional operating system (Linux) to encapsulate a process as a DIME. The results suggest that the service management can be decoupled from the underlying hardware infrastructure management by utilizing signaling based dynamic configuration of DIME network architecture, and potentially reduce the layers of management software in developing next generation highly-scalable, parallel, distributed virtual service creation, delivery, and assurance platforms.

The purpose of this research brief is to introduce some new ideas based on the study of cellular organisms, human organizational networks and telecommunication networks to improve the resiliency, efficiency and scaling of distributed systems executing various computational workflows. The ideas extend the current von-Neumann computing model by separating the services management from services execution exploiting the parallelism and performance offered by the new class of many-core processors.

The DIME network architecture is a departure from conventional wisdom currently being pursued by the universities and corporate research & development. It adds monitoring and control to each Turing computing node and a parallel signaling enabled network to implement the management of temporal behavior of workflows executed as directed acyclic graphs using a network of managed Turing machines.

The concept of a parallel signaling channel is foreign to the current generation of IT professionals, except for those with telecommunications or voice over IP experience, who are by now either retired or dead. Signaling allows establishing equilibrium patterns and monitor and control exceptions system-wide. It allows contention resolution based on system-wide view and eliminates race conditions and other common issues found in current distributed computing practice. In systems with strong dynamic coupling between various elements of the system, where each change in one element continually influences other element's direction of change, signaling in the computational model helps implement system-wide coordination and control based on system-wide priorities, workload fluctuations and latency constraints.

We have demonstrated the feasibility of this approach using two prototypes. However, in order to take these concepts to practical application in mission critical environments, the DIME network architecture requires its validation and acceptance by a larger community. This research brief presents the concept and the results for such validation and analysis.

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