In this dissertation, we focus on multiple levels of optimized resource management techniques. We first consider a classic resource management problem namely the scheduling of data-intensive applications. We define the Divisible Load Scheduling (DLS) problem, outline the system model based on the assumption that data staging and all communication with the sites can be done in parallel, and introduce a set of optimal divisible load scheduling algorithms and the related fault-tolerant coordination algorithm. The DLS algorithms introduced in this dissertation exploit parallel communication, consider realistic scenarios regarding the time when heterogeneous computing systems are available, and generate optimal schedules. Performance studies show that these algorithms perform better than divisible load scheduling algorithms based upon sequential communication.

We have developed a self-organization model for resource management in distributed systems consisting of a very large number of sites with excess computing capacity. This self-organization model is inspired by biological metaphors and uses the concept of varying energy levels to express activity and goal satisfaction. The model is applied to Pleiades, a service-oriented architecture based on resource virtualization.

The self-organization model for complex computing and communication systems is applied to Very Large Sensor Networks (VLSNs). An algorithm for self-organization of anonymous sensor nodes called SFSN (Scale-free Sensor Networks) and an algorithm utilizing the Small-worlds principals called SWAS (Small-worlds of Anonymous Sensors) are introduced. The SFSN algorithm is designed for VLSNs consisting of a fairly large number of inexpensive sensors with limited resources. An important feature of the algorithm is the ability to interconnect sensors without an identity, or physical address used by traditional communication and coordination protocols. During the self-organization phase, the collision-free communication channels allowing a sensor to synchronously forward information to the members of its proximity set are established and the communication pattern is followed during the activity phases. Simulation study shows that the SFSN ensures the scalability, limits the amount of communication and the complexity of coordination. The SWAS algorithm is further improved from SFSN by applying the Small-worlds principles. It is unique in its ability to create a sensor network with a topology approximating small-worlds networks. Rather than creating shortcuts between pairs of diametrically positioned nodes in a logical ring we end up with something resembling a double-stranded DNA. By exploiting Small-worlds principles we combine two desirable features of networks namely high clustering and small path length.

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