Immune-inspired networked service delivery

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The expansion in distributed computing capabilities has led to a need to deliver services at different locations in networks, where demand is unpredictable. Giving all nodes in a distributed system the potential to deliver any service is likely to be a waste of resources, while extreme specialization on the part of individual nodes is likely to incur large overheads in terms of messaging and service transmission across the network. Other Computer Science researchers have drawn inspiration from one of real life's most adaptable distributed systems, the vertebrate immune system, to attempt to solve problems in a variety of different application areas (de Castro et al., 2003, Soft Comp., 7, 526). We describe an immune system-inspired method for service management in a distributed network services scenario. Each node in the network runs our system and the actions of all these local instances mesh together to provide overall service management.

The self/non-self theory of activation of the vertebrate immune system suggests how it can generate a response to non-self entities, protecting the organism concerned. Our system uses an analogous activation sequence system to respond to requests arriving unpredictably at different nodes in a network, and enables the efficient delivery of responses to the requesting node without requiring complete specialization of capabilities in each node. In our system we have focused on the network of stimulatory interactions amongst antigens, antibodies, T-Cells and B-Cells. Requests for services are represented by antigens which interact with elements (nominally representing T- and B-Cells) in a two stage activation process to produce fully activated B-Cells. The fully activated B-Cells are monitored by Service Runners to indicate the level of demand in the system. The activation of B-Cells also releases antibodies which act as adverts for services. We believe that reproducing the logic of this interaction network, along with biologically plausible parameters for longevity and diffusion rates of the various cell types, give us an artificial system which can adapt to service demand patterns in the same way that the immune system adapts to patterns of antigenic challenge. A key issue is the level of complexity in our system. It aims to be useful, with some of the advantages of the analogous natural system, without attempting to model it slavishly. Our simulations show that an adequate level of complexity was chosen, as simpler incarnations lost some desirable properties, whereas more complex implementations would have led the system more towards modelling the immune system than focusing on service delivery.

In the simple network simulations described here some of the major issues for distributed systems are successfully counteracted. Unevenly distributed demand (which would otherwise result in excess demand on particular nodes) is balanced across suitable processing nodes. We see a memory effect whereby nodes can build up a more rapid response to requests based on their history of responses, allowing nodes to become specialists at dealing with particular request types. The diffusion of 'cells' deals with the issue of locating a suitable node to satisfy a request, even across several network hops. The large number of cells in the network originating from many different nodes, provides a level of fault tolerance, directing requests to alternative nodes in the event of node failure. We look forward to testing the system in larger, and more realistic, distributed network services scenarios.