Load Balancing Telecom Networks

An Approach Using Ant-like Agents

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Load Balancing

- Calls made between two points are routed through a number of intermediate nodes of limited capacity.
- If a node is full, calls that try to pass through it fail.
- Congestion and call failure can be avoided by distributing call traffic over the system using load balancing.
There are two primary load balancing methods:

- Static load balancing fixes a set of “good” routes, which it maintains regardless of variations in congestion.
- Dynamic load balancing changes which routes are “good” as a function of previous and current congestion.
- This research focuses on dynamic load balancing, which is in widespread use.
Routing Organization

- A call originating from node A can be assigned a route to node Z at its outset.
- A call from node A can be tagged with destination node Z. The route taken is determined by individual nodes along the way.
- Routing tables at each node store information used to make these decisions, and must contain a valid route for every possible call in the network.
Centrally Controlled Routing

Controlling dynamic routing schemes centrally has numerous disadvantages:

- Needs a large amount of current knowledge about the network
- Scales very badly
- Failure of the controller usually leads to failure of the entire system.
Proposed an alternative to central control which used two species of mobile agents.

Load management agents form the lowest level of control
- Launch from source nodes and move around the network, finding the current best paths using an adaptation of Dijkstra’s shortest path algorithm.
- Update the routing tables accordingly

Parent agents form the second level of control
- Travel over the network, gathering information about which nodes are congested
- Goes to those nodes and launches load agents
Ant Abilities

- Ants exhibit simple behaviors, but collectively perform complex tasks through the use of stigmergy.
  - Ants produce specific actions in response to stimuli in the local environment.
  - If an ant’s action affects the local environment, it in turn affects the actions of other ants at that location.
Ant systems are exceedingly robust, and are unperturbed by changes in colony size, habitat disturbances, or variations in food supply.

Telephone networks, like any colonies, can be thought of as collections of competing activities.

A balance between these competing activities can be reached by using simple agents that interact with traces left by each other.
Selects a random node excluding the node from which it just moved (or originated)

Upon arriving at a new node, the ants influence the entry at the node with the reciprocal of its age plus a constant and then normalizes the entries.

This approach can cause tables to become very unbalanced with one path dominating all others, so a noise factor, $f$, is introduced.

$f$ represents the probability that an ant will choose a completely random node, rather than $1-f$ odds of continuing on the pheromone trail.
Schoonderwoerd, Holland, Bruten used a synthetic network topology identical to the British Telecom structure.

Each node was given a capacity of 40 calls.
At each time step an ant was released from each node with a random destination. All pheromone tables were initialized with equal probabilities. Two different trials were executed, one with no noise and one with 5% noise. 10 different call-distributions were randomly generated to simulate congestion. Limit the number of load agents to 1 per node, to avoid cyclic behavior.
Ants outperformed *improved* mobile agents.

*Improved* mobile agents all performed better than the original.

All dynamic load balancing produced better results than no dynamic load balancing.

With constant call probabilities ants without noise performed better.
Ants without noise performed better on constant call probability than varied call probabilities.

Stopping launching ants performed worse than continually launching them.

Stopping launching load agents performed worse than continually launching them.
Discussion

- Ants performed load balancing better than the mobile agents and far better than static methods.

- Ants were more successful at rerouting through a topology with varied call statistics than mobile agents.

- Both ants and agents responded well to changes in the call traffic patterns:
  - Agents changed their routes slightly faster than ants, but often for the worse.