Load Balancing Telecom Networks

An Approach Using Ant-like Agents

Alice Forehand
Robert Pienta

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

Types of 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 of failure of the entire system.

Appleby and Steward's Mobile Agents

- 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

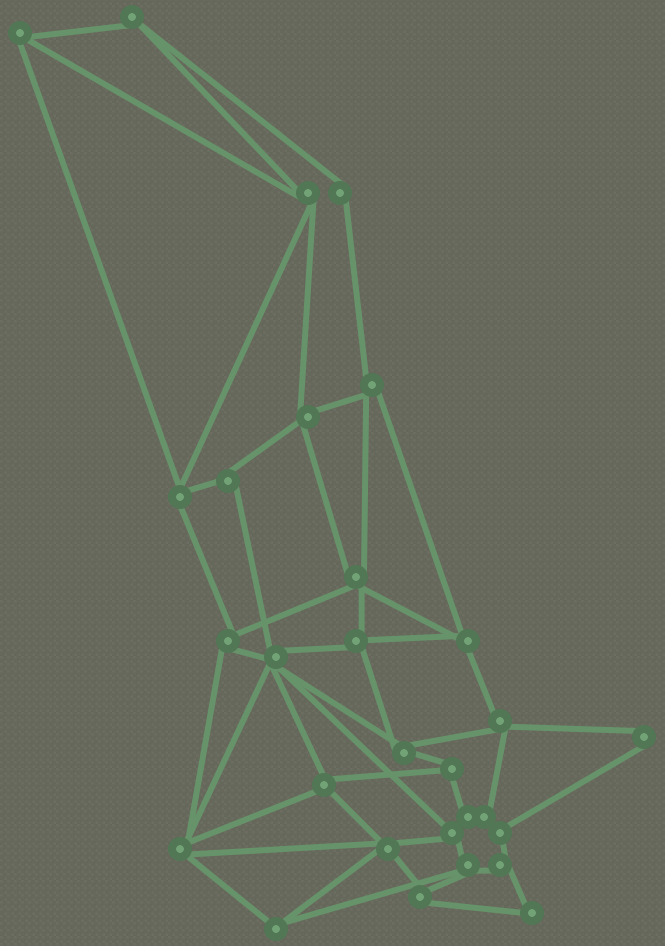
Ant Colonies and Telephone Networks

- 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 though 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

Ant-like Mobile Agents

- Selects a random node excluding the node from which it just moved (or originated)
- Upon arriving at a new node, the ants influences 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

Modeling Network Topology



- Schoonderwoerd, Holland, Bruten used a synthetic network topology identical to the British Telecom structure
- Each node was given a capacity of 40 calls

Experimental Design

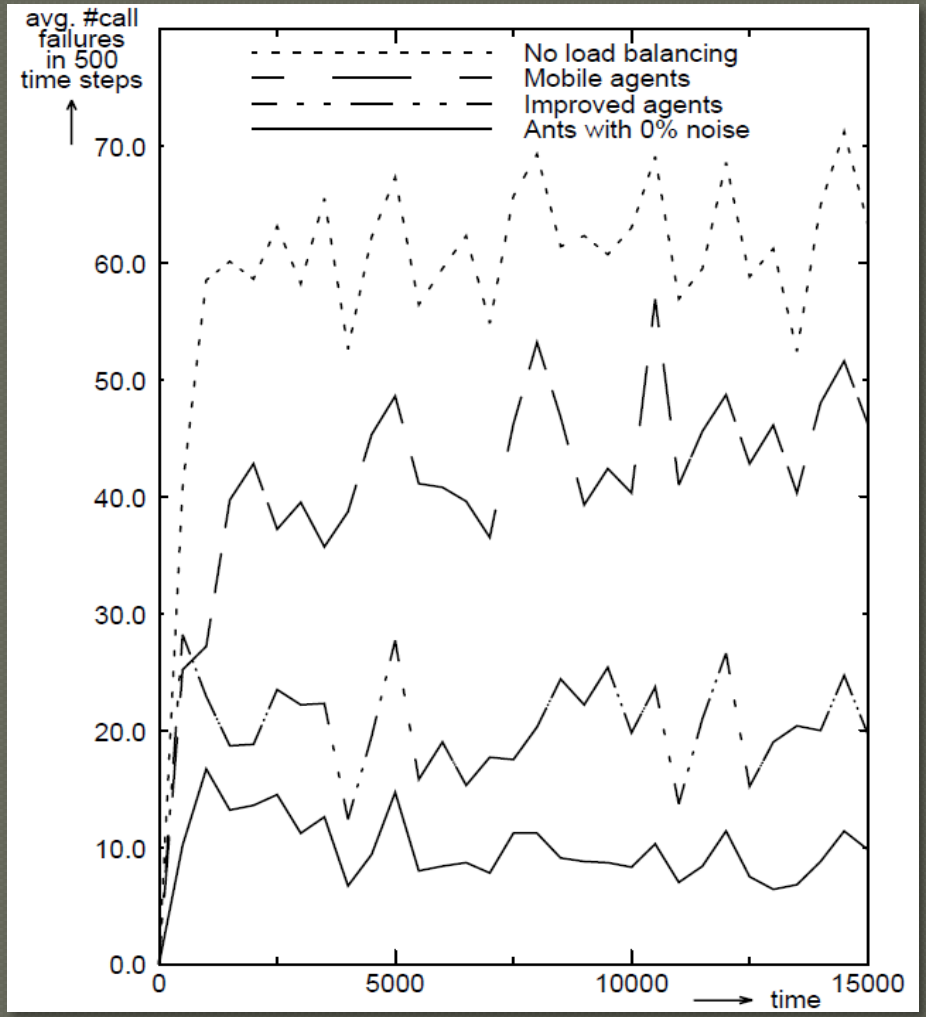
- At each time step an ant was released from each node with a random destination
- All pheromone tables were initialized with equal probabilities
- Two different trials were executed, one with no *noise* and one with 5% noise
- 10 different call-distributions were randomly generated to simulate congestion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

Results

- 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

Results woo

- 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