Imperial College London

Intelligent Systems & Networks

AD HOC COGNITIVE PACKET NETWORKS AND NETWORK TESTBED

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INTRODUCTION

Ad Hoc Cognitive Packet Networks (AHCPN) are self-organizing networks of mobile and wireless nodes that utilize smart packets to dynamically create and maintain quality-of-service (QoS) routes. AHCPN extends CPN by effectively combining broadcast and unicast transmissions to deal with changes in topology, for example, those resulting from node movement. As with CPN, unicast routing decisions are made with the help of random neural networks, whose stored weights attempt to follow the current status of the network. For this, packets collect relevant network information as they move, which is disseminated to the nodes in the path in acknowledgement packets. The information is then used to train the random neural networks via reinforcement learning and according to a pre-selected reward function. The QoS seek by the user is reflected in the selection of a goal function (inversely proportional to the reward).

ROUTING GOALS

Given a packet moving along path $P = (1, 2, \ldots, i, \ldots, n)$

The following are examples of goals that may be formulated at node i in reference to destination d:

Latency-based goal

where

$$G^d_{i,n} = \eta_d \sum_{j=i}^{n-1} D_{j,j+1}$$

η_d : scaling factor

$D_{j,j+1}$: round-trip delay between nodes j and j+1

Load balancing goal

where

$$G^b_{i,n} = \sum_{j=i+1}^{n-1} (\eta_1 + \eta_2 \, Q_j)$$

: scaling factor (create shortest paths in balanced networks)

η_1 : scaling factor

η_2 : buffer occupancy at j

Q_j

Energy-aware goal

where

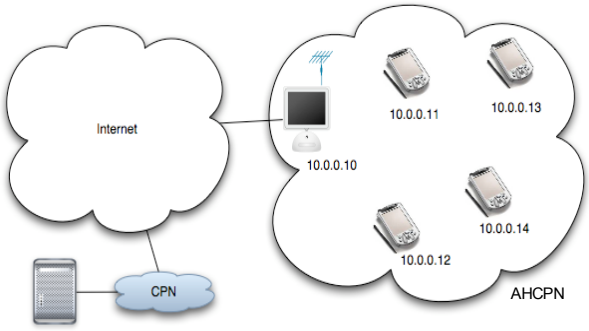
$$G^e_{i,n} = \sum_{j=i+1}^{n-1} \left[\eta_3 + \eta_4 \left(1 - \frac{b_j}{B} \right) \right]$$

: scaling factor (create shortest paths in balanced networks)

η_3, η_4 : remaining battery at node i

b_i : network-wide reference of full-charged battery

B



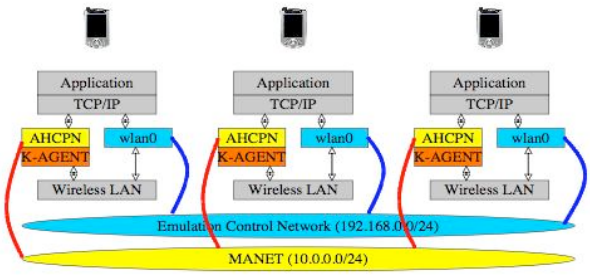
TESTBED

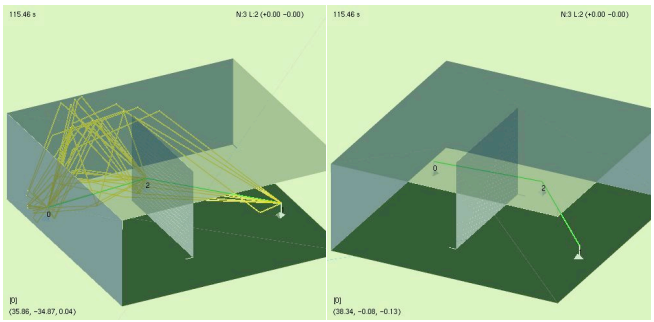
The implementation approach was to create a virtual interface containing all AHCPN functionality for a Linux kernel, wrapping one or more physical interfaces (e.g. IEEE 802.11) to allow the encapsulation of any layer-3 protocol (such as IP). The testbed consists of mobile nodes (H5500) and stationary computers.

EMULATION

Testing is often hybrid, combining real systems and simulation of certain parameters difficult to control and reproduce in a testbed (e.g. mobility patterns, energy level of nodes, etc.) offering the added advantage of allowing the use of stationary computers in place of mobile nodes.

The emulation is created by a central node (manager), which recreates the world where the experiment is conducted. The manager simulates the position and other parameters of interest (e.g. remaining energy) of nodes in a scenario that may contain obstacles. Radio propagation calculations are done via ray tracing to determine the resulting topology, which is informed to nodes and enforced with packet filtering by a kernel agent deployed before the AHCPN module in the nodes.





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