Topology Aware Component Based Models for Performance Evaluation of Ad-Hoc Routing Protocols

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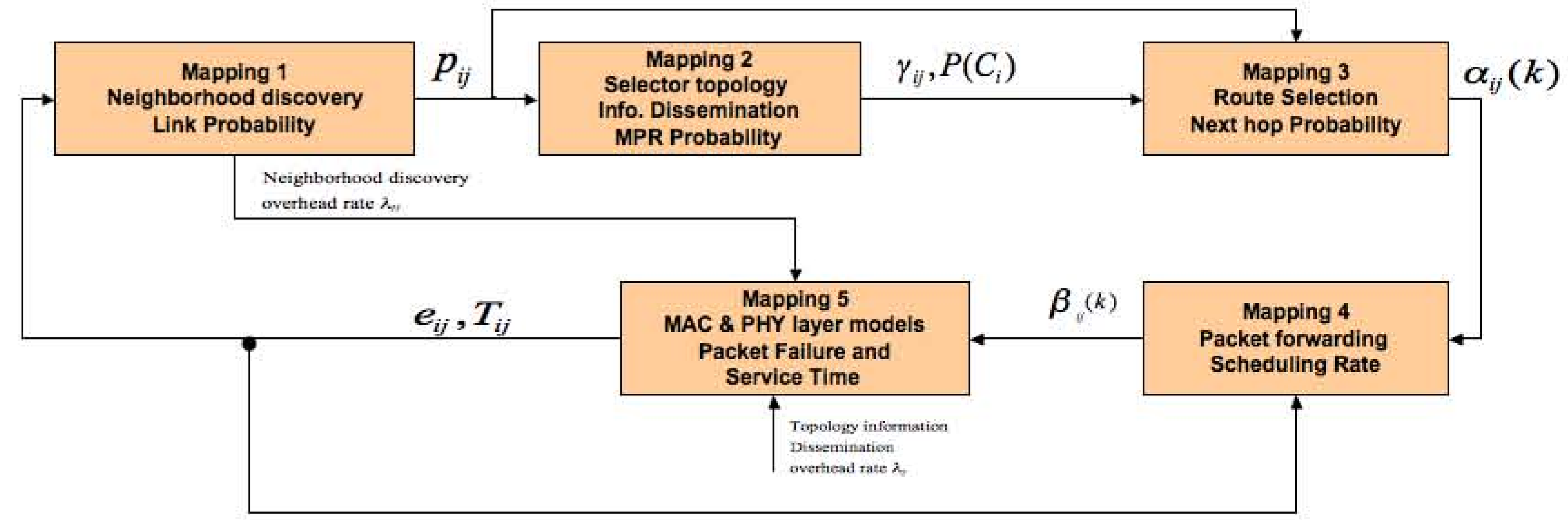
HyNet

Objective and Approach:

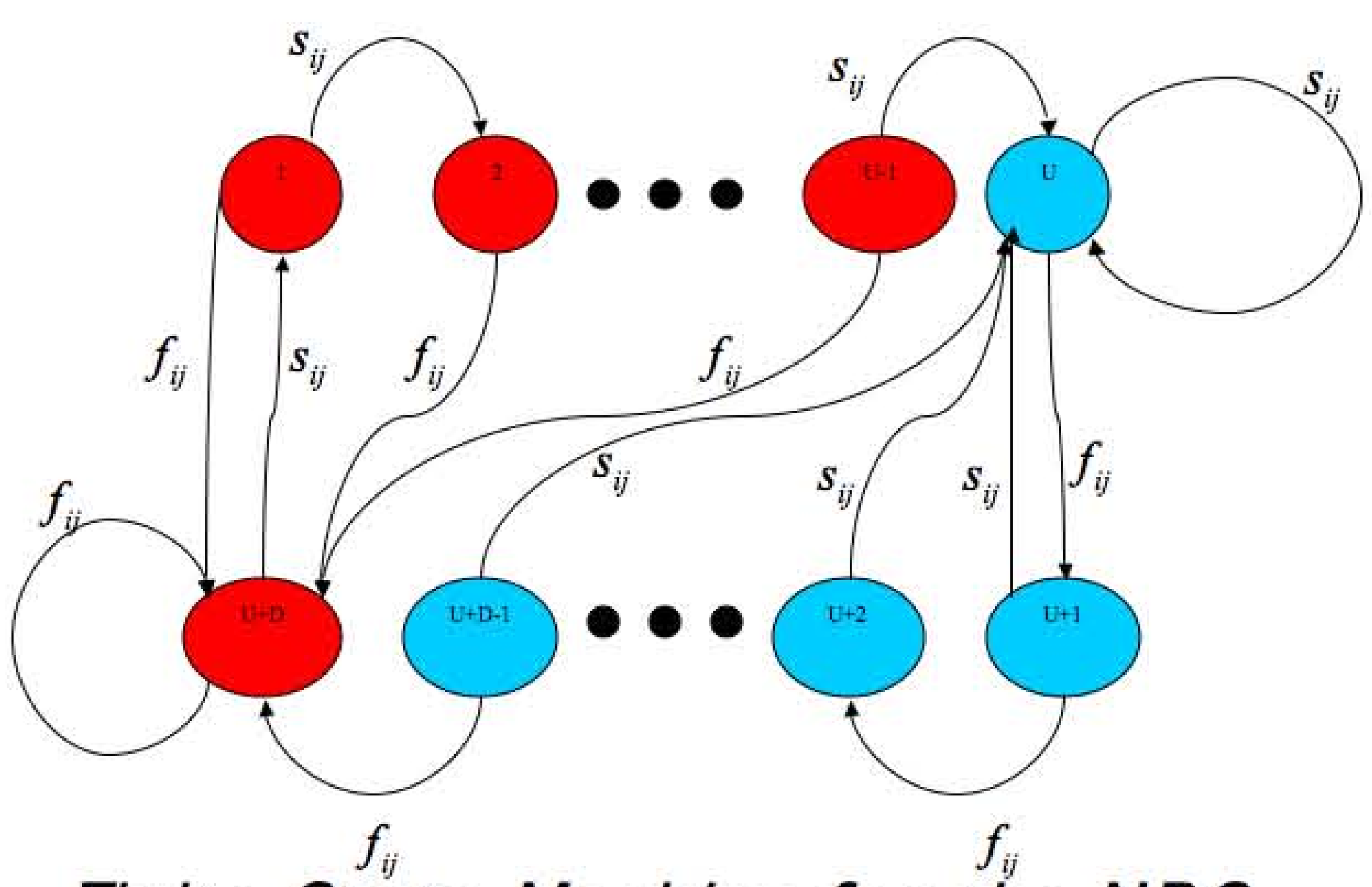
- A modular and structural method for design and analysis of ad-hoc routing protocols.
- Specification of the main components of a routing protocol
- Specification of the inputs and outputs of each component
- Specification of the performance metrics and bounds for each component.
- The main components are:
  - Neighborhood Discovery Component (NDC)
  - Selector of Topology Information to Disseminate
  - Route Selection
- We have implemented these models for OLSR routing algorithm

Fixed Point Iteration



Neighborhood Discovery:

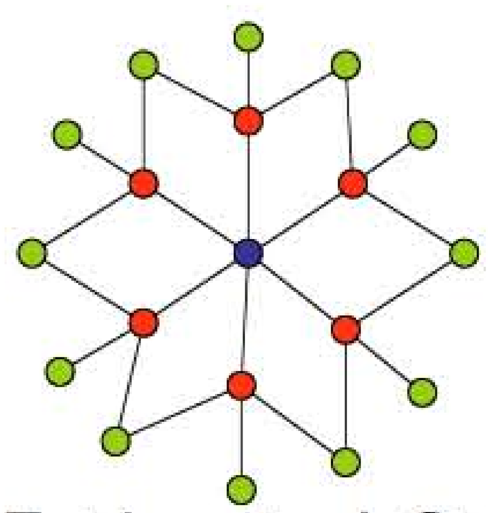
- Periodic transmission of HELLO messages to detect bidirectional links and identify second order neighbors.
- We model this block as a finite state Markov Chain.
- The control parameters are U and D.
- The input is transmission success probability
- The output is probability of link detection, which can be computed from probability of being in the blue states.
- Average delay in detection of an operational link and a broken link can also be computed.



Finite State Machine for the NDC

Selector of Topology Information to Disseminate (MPR selection):

- Every node selects a subset of its neighbors as its MPR nodes.
- Only links from selected MPR to the MPR seector are advertised.
- MPR nodes are selected to cover all second order neighbors of a node.
- State of a node represents its selected MPRs, which is a random process.
- We use Monte Carlo simulation to estimate the state probabilities for each node.
- For the state probability computation, we have to consider links of a node and its neighbors in the sumlation.
- Hence, the simulation time for each node is scalable and is not affected by the network size.



Estimated State Probability for the Center Node by Monte-Carlo Simulation and Exhaustive Search

Path Selection:

- Input is the link detection and state probabilities.
- Output is next-hop probabilities.
- In the reverse network links are from nodes to their MPRs
- We compute the average hop count using a probabilistic set of Bellman-Ford (DP) equations on the reverse network:

$$h(i, C_i, k) = 1 + \min_{j \in MPR(C_i)} (h(j,k), h(i,k)),$$

$$h(i,k) = \sum_{C_i} P(C_i) h(i, C_i, k).$$

- We also take into account that for the last hop, nodes do not need to use their MPR.
- We use the average hop count on the reverse network to compute the average hop count on the forward network.
- After computing the average distance, we estimated the hop distance using Maximum Entropy Estimator.
- For each node i at state Ci, probability of selecting an MPR j as the next hop is probability of j having minimum distance among neighbors.
- We use this principle together with the estimated distance distributions to estimate the next hop probabilities on the forward network.