Competition and cooperation: Topology formation

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Competition and cooperation

- Fundamental question:
  When can local competition yield global cooperation?
- Distributed coordination:
  Design the system so individually “selfish” behavior leads to a collectively “good” outcome.

Topology formation

If MANETs try to build a network topology (for routing, distributed computation or control, etc.), they suffer from a *lack of global information.*

What local link formation dynamic leads to a good global topology?

Topology formation

- Most game theoretic models applied to engineering use *static analysis,* as many dynamic models are often intractable.
- But *dynamics of decision making* are critical in MANETs!
- Reasonable analytical approach:

  Myopic best response dynamics

  Each node chooses its best course of action,
  but only in the current stage (i.e., ignoring past history or predicted future evolution)

The model

- N nodes
- Traffic matrix: uniform all-to-all
- Cost of link maintenance:
  M for each endpoint
- Traffic transit/termination cost:
  c_i per unit through node i
- Cost per unreachable destination:
  λ (assumed large)

Node payoff

- Given a graph G = (V, E), let P (i, j; G) denote contracted payment *from* i *to* j
- Traffic routed along shortest paths
- *Payoff to node* i =
  payments received – payments made
  - M £ adjacent links
  - λ £ unreachable nodes
  - c_i £ traffic through i

Contracting function

- P is called the *contracting function*
- It is a *design variable*

Our design choice:

Assume P (i, j ; G) is antisymmetric, and “monotone” in routing cost of j

Example:

Local cost sharing
(incremental cost of a link is shared by endpoints)

Myopic best response dynamics

- Suppose at each step, nodes can choose to break one link, and/or form another
  (Payments on all other links remain the same before and after)
- Nodes act to maximize *single stage payoff*

Theorem: Dynamics converge to a "pairwise stable" tree with minimum routing cost nodes in interior

Moral: Antisymmetry and monotonicity guide dynamics to a *good equilibrium*

Roadmap

1. Study local information exchange needed to converge to good global topology (*current)*
2. Simulate performance under non-homogeneous assumptions
3. Add robustness (i.e., redundancy) to payoff model
4. Study tradeoff between *complexity* of local exchange and *robustness* of global dynamics