**Motivation**

- Communication networks have been involved to be so complex that people, who created them, cannot control them.
- **Future vision:** to understand and control such complexity.
- **Network science**
  - The Internet and other communication networks
  - Social networks
  - Biological networks

They are autonomic.

**Trust in Communication Networks**

<table>
<thead>
<tr>
<th>Traditional networks</th>
<th>Autonomic networks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internet, cellular networks</td>
<td>MANETs, P2P</td>
</tr>
<tr>
<td>Centralized trusted authority</td>
<td>No trusted centralized authority</td>
</tr>
</tbody>
</table>

- **Objective:** use **mathematical analysis** to understand and predict the **emergent behaviors** of trust management systems in autonomic networks.
- **Trust Management System in Autonomic Networks:**
  - Prior trust relations
  - Local observations
  - Local key exchanges

**Trust and Cooperation**

- The evaluation rule can be interpreted as **dynamic (repeated) games**:
  - $d_i$ can be interpreted as the worth of player $j$ to player $i$.
  - The game is interpreted as a **cooperative game**, where nodes who collaborate with neighbors form a coalition.
  - The characteristic function of a coalition $S$ is defined as $v(S) = \sum_{i \in S} d_i - \sum_{i \notin S} d_i$.

**Trust Credential Distribution**

- **No centralized trusted party:** trust credentials are scattered in the network.
- **Problems:**
  - Where and how to find all needed credentials?
  - Where and how to store credentials such that searching is efficient?
- **P2P file sharing:**
  - The problem of trust credential distribution shares many characteristics of P2P file sharing systems (Freenet).
  - Network coding based file sharing has been shown to be efficient and based on local information only.
- **Network Coding Based Scheme**
  - Extremely simple to implement
  - Only local information exchange
  - Easy for discovering new credentials
  - Small storage requirement
  - Efficient distribution

**Trust Evaluation Policy**

- The trustworthiness of an agent is based on other peers' opinion
- **Voters:** neighbors with positive trust value are qualified as legitimate voters.
- General voting rule: $s_i = f(d_j, s_j, \forall j \in N_i, s_j > 0)$.
- **Stochastic voting:**
  $$\Pr(s_{i}(k + 1)|s_{i}(k)) = \frac{\prod_{j \in N_{i}} \Pr[d_j | s_{i}(k + 1), s_{i}(k)] \Pr[s_{i}(k + 1)]}{Z(k)}$$

- **Convergence:**
  - The update rule iterates over time. We are interested in the steady state.
  - The stochastic voting can be interpreted as a Markov chain. Under trivial conditions, it can be shown that the update rule converges to a unique stationary distribution.
- **Criterion:** probability of correct estimation.

**Phase transitions in two parameters:**
- Degree of certainty $b$
- Probability of error $p_g$

**Theoretical analysis:** results in the Ising model and the spin glass model, where $d_j = J_{ji}$, replica method.

**Applications**

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**Subset $S$**:

$$v(S) = d_{i1} + d_{i2} + d_{i3} + d_{i4} + d_{i5} + d_{i6}$$

Objective:

- to find what form or policy $d_i$ can induce all (or most) nodes to cooperate: **maximize** the coalition.

**Negotiation:** Players with positive gain can negotiate with their neighbors by sacrificing certain gain.

**Trust:** By introducing a trust mechanism, all nodes are induced to collaborate without any negotiation.