**DEGAS (Distributed Energy conscious Ad hoc and Space networking) Group**

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**Current Research Projects**

- **NSF: Ad hoc Networking with Swarm Intelligence**
  - Unicast and multicast routing
  - Topology control
  - Energy conservation
  - Cross-feature and cross-layer issues
- **NSF: Scalable Wireless Testbed (joint with UCLA, UCSD, UCSB, UCD, UCR, USC)**
  - Transport layer issues - Cellular SCTP and Ad hoc SCTP
- **NSF: CAREER-Survivable Hybrid Networks**
  - Hybrid routing and transport protocols
  - Trajectory control
  - Utility maximization of TCP over wireless links
- **ARL: Ad hoc Networking with Power and Directionality Control**
  - Topology control with directional antenna
  - Broadcast and multicast with directional antenna
Ants likely choose paths with higher pheromone intensity.

Trail gets reinforced (positive feedback).

Without reinforcement, pheromone evaporates (negative feedback).

Ants lay pheromone.

Most ants follow trail with highest intensity.

But some may choose alternate paths with small probability (amplification of fluctuation).
**Essence of Swarm Intelligence**

- Positive and negative feedback
  - search good solutions and stabilize the results
- Amplification of fluctuation
  - discover new solutions and adapt to changing environment
- Multiple interactions
  - Allows collaborations among distributed entities to coordinate and self-organize

**A distributed adaptive control system**

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**Ad hoc Networking with SI (ANSI)**

- Unicast routing (ANSI)
- Multicast routing (MANSI)
- Topology control (ABTC)
- Energy conservation (ABEC)
- Feature interactions - cross-layer and cross-feature
MANSI

- Multicast for Ad hoc Networks with Swarm Intelligence

- MANSI extracts a subset of nodes, called a **forwarding set**, for rebroadcasting data packets
  - Mesh-based, reactive protocol
- **Issue:** A minimum forwarding set is hard to compute
- **Approach:** Use SI-based technique as a heuristic to opportunistically explore and learn new paths that lead to forwarding set of lower cost
- In high mobility areas, more nodes are requested to form a forwarding set to increase reliability

ABTC: Ant-Based Topology Control

- Ants opportunistically discover other paths
Trajectory Control for MAPs in MANET

- Rugged terrains or specific mission requirements can cause a network to be partitioned into isolated islands of nodes
  - Nodes in different partitions still need to communicate

Network Model

- **Mobile Access Points (MAP)** resides in each partition
- MAPs are highly capable nodes and always connected via airborne unit(s) in order to bridge partitions together
- MAPs’ movement can be controlled by a trajectory control algorithm

Trajectory Control Algorithms

- **Location-based (LTC)**
  - GPS is required at regular nodes and MAP
  - Each node maintains a list of its downstream nodes with respect to the tree generated by MAP announcement
  - Weighted geometric centroid of each subtree is computed recursively and combined all the way to MAP
  - MAP navigates to the weighted centroid of the entire partition
Future Research

- **Salutogenic approach to robust P2P systems over mobile ad hoc and wireless sensor networks**
  - Apply biological metaphors to design functional primitives that can be composed to build robust P2P systems over MANET and SN

- **Toward virtual and open spectrum**
  - Dynamic spectrum management architecture and protocols
  - Software-defined radio