Research Objective

- Theory, practical algorithms and techniques to manipulate functionality, and predict behavior and evolution in heterogeneous networks, both friendly and adversarial
  - Data-driven analysis of (primarily social-cognitive) network datasets to discover structural characteristics
  - Use simplicial complexes instead of graphs to better capture group interactions and relationships

Challenges

- Research in social-cognitive networks using simplicial complexes is not well-developed
- High complexity is inherent in simplicial complexes due to its combinatoric nature

ARL Facilities and Capabilities Available to Support Collaborative Research

- Network Science Research Laboratory
  - Integrated framework for experimentation on networks
- MATLAB code for visualization and homology computation
- Results:
  - Power law distribution in the number of vertices with facet degree $k$
  - Near linear growth relation between 2D holes and minimal-non faces
  - Strong collapsing techniques enable efficient homology computations without HPC and reduce complexity by roughly an order of magnitude

Generative model of large collaboration network (DBLP) with accompanying facet (group) degree distribution

Complementary Expertise/ Facilities/ Capabilities Sought in Collaboration

- Desire expertise in advanced topology and combinatorics theory and applications
- Exploring potential extension of persistent homology approaches in social network dynamics
- Currently adapting approaches for applications in communications sensor networks

<table>
<thead>
<tr>
<th>Dataset</th>
<th>Betti seq.</th>
<th>Elementary</th>
<th>Strong+Elementary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Singapore chat/email</td>
<td>1, 3, 6, 9, ..., 12</td>
<td>*</td>
<td>44s</td>
</tr>
<tr>
<td>Enron email</td>
<td>3, 9, 10, 20, ..., 50</td>
<td>13.3s</td>
<td>1.2s</td>
</tr>
</tbody>
</table>

Time complexity for computing Betti sequence

Reduction of computational complexity to due to collapsing in random network and small chat/email datasets