The Open Source Software Community Structure

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COMMUNITY STRUCTURE

- In most networks, some nodes are grouped together by a high density of edges, while there are few edges between those groups.
- Communities: tightly-connected groups (Newman & Girvan 2004)
- Applications:
  - Scientists grouped together by similar research topics or methodology (Givan & Newman 2002)
  - Functionally related genes in gene networks (Wilkinson & Huberman 2004)
  - Actual social relationships in email networks (Tyler 2003)
INFLUENCE IN OSS NETWORK

- Identify projects which might have related subjects, similar programming environment, or common developers.
- Study projects interaction during their growth.
- Get information about the communication path and knowledge flow within or between communities. Such information can help us adjust and improve the robustness of communications in OSS.

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PREVIOUS RESEARCH

- **Edge betweenness (Girvan & Newman 2002)**
  - Top-down, remove edges with the highest betweenness
  - $O(m^2n)$ time on a network with $m$ edges and $n$ vertices
  - $O(n^3)$ on a sparse graph

- **Greedy Algorithm (Newman 2004)**
  - Bottom-up, two communities are picked to join
  - $O((m+n)n)$ time on a random network
  - $O(n^2)$ on a sparse graph

- **Implementation of more sophisticated data structure (Clauset & Newman 2004)**
  - $O(n\log(n^2))$
Modularity $Q$: the fraction of edges within communities subtracts the expected value of the same quantity if edges fall in a random network.

The best community structure is where $Q$ is the largest.

$$Q = \sum (e_{ii} - a_i^2)$$

$$a_i = \frac{k_i}{\sum e_{ij}}$$

$e_{ij}$ is the fraction of edges that connect nodes $i$ and $j$.

$a_i$ is the fraction of edges that connect to node $i$.

The total edges in the network.

$k_i$ is the number of edges connecting to group $i$. 

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RESULTS

- Project network: 2 projects are connected if they have 1 or more common developers
- The largest component of the project network in Jan. 2003.
- Exclude project 1 which is the Sourceforge because it links to 10,000 projects
- The project network consists of 27,834 nodes and 173,644 edges
THE VALUE OF Q

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ANALYSIS

- Max Q = 0.2227
- 611 groups
- The largest group consists of 3467 projects
- Many small communities with size less than 10
- The 10 largest groups include 64.8% of the whole projects
- The important communication paths are those connections between communities
- Common developers are keys to transfer information between two project groups

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Several explanations exist for the community structure:

- Mutual acquaintance: two nodes with a common neighbor are more likely to link to each other.
- Homophily: two nodes with the same attributes are more likely to link to each other.
  - Measure: assortative mixing.
ASSORTATIVE MIXING

- Assortative coefficient

\[ r = \frac{\sum_i e_{ii} - \sum_i a_i b_i}{1 - \sum_i a_i b_i} \]

- \( e_{ij} \) is the fraction of edges in a network with type \( i \) to nodes of type \( j \)
- \( b_j \) is the fraction of edges of each type with nodes of type \( i \)
ASSORTATIVE MIXING FOR OSS

- Topic – 0.1009
- Operating System – 0.1078
- User interface – 0.0893
- Development status – 0.0553
- Intended audience – 0.0449
- Programming language – 0.1541
CONCLUSION

- Community structure exists among Sourceforge project network
- Key communication paths are identified among groups
- Projects with the same programming languages, operating systems and topics are more likely to group together.