Random Graphs - 2

Lecture 12

CSCI 4974/6971

13 Oct 2016

Today's Biz

1. **Reminders**
2. Review
3. Random network generation and comparisons

Reminders

- Assignment 3: **Monday 17 Oct 16:00**
- Assignment 4: out soon - due Thursday 27 Oct 16:00
  - Setting up and running on CCI clusters
- Office hours: Tuesday & Wednesday 14:00-16:00 Lally 317
  - Or email me for other availability
- Tentative class schedule:
  - Next Monday: Go over assignment 3 - distributed graph representation
  - Next Thursday: Fully distributed graph processing

Today's Biz

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2. **Review**
3. Random network generation and comparisons

Quick Review

Random graphs

- Several models - uniformly random, small world, scale free, recursive, many more
- Usage:
  - Comparison to real networks to explain observed phenomena (e.g. Barabasi-Albert preferential attachment model to explain the structure of the Internet)
  - Testing computational graph analytic code (e.g. how will my algorithm scale on a skewed skewed graph? - use R-MAT with high A probability)
  - Testing analytics hypothesis (e.g. I observe some re-occurring structure on this network, how more often does it appear relative to a random graph?)
- Generation
  - Ideally want $O(m)$, but $O(m) \log n$ would suffice
  - Generate edges independently - i.e. fully parallelizable

Quick Review

Erdos-Renyi graphs

- "Uniformly Random" network
- Probability p any two $v, u \in V$ are connected
  - As $p \rightarrow 1.0$, G becomes fully connected
  - Conversely - m edges connecting two random v, u - $p = \frac{m}{v(v-1)}$
- Clustering: very low
- Diameter: low
- Degree distribution: binomial around k

Quick Review

Watts-Strogatz

- "Small-world" network
- v connected to immediate k neighbors, probability β any connection gets rewired
- Clustering:
  - As $\beta \to 0.0$, high clustering
  - As $\beta \to 1.0$, approaches Erdos-Renyi
- Diameter:
  - As $\beta \to 0.0$, high diameter, $O(n)$
  - As $\beta \to 1.0$, approaches Erdos-Renyi
- Degree distribution:
  - As $\beta \to 0.0$, Dirac delta on k
  - As $\beta \to 1.0$, binomial on k

Quick Review

Barabasi-Albert

- "Scale-free" network
- Preferential attachment - add new v to network with m_0 new edges, probability of edge creation to all existing u is proportional to degrees of u
- Clustering - moderate
- Diameter - low
- Degree distribution: power law, $P(k) = k^{-\alpha}$ where $\alpha = 3$

Quick Review

Other Random Networks

- R-MAT and Kronecker - Place edge by recursively subdividing adjacency matrix A in four submatrices using probabilities a, b, c, d
- Chung-Lu - generate power law graphs using an expected degree distribution
- BTER - Block Two-Level E-R Graphs - Generate graphs using an expected degree distribution *and* clustering coefficient

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Random Networks
Blank code and data available on website
(Lecture 12)

www.cs.rpi.edu/~slotag/classes/FA16/index.html