Distributed Systems

Coloring and MIS

Rik Sarkar

University of Edinburgh
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Coloring a graph

- Assign a color to each vertex such that
  - Neighboring vertices always have different colors

- Easy with n colors
- Problem is harder with fewer colors

Application of coloring

- Suppose there are restrictions such that certain pairs of nodes must not operate (or access a resource) at the same time
- A coloring gives us sets of nodes that *can* operate at the same time

Example

- Suppose we have a wireless network
- Nearby nodes should not transmit at the same frequency (channel) at the same time
- We can construct a graph where nodes within range of each-other are connected by an edge
- A coloring of this graph is an assignment of communication channels to nodes
  - Such that they will not interfere

Example

- Suppose we have a wireless network
- Nearby nodes should not transmit at the same frequency (channel) at the same time
- We can construct a graph where nodes within range of each-other are connected by an edge
- A coloring of this graph is an assignment of communication channels to nodes
  - Such that they will not interfere
- Alternatively, using time division access
  - A coloring is assignment of time slots

Independent set (IS)

- A subset of vertices that can have the same color
  - No two vertices are adjacent
  - In a coloring, vertices of each color form an IS

Maximum independent set (maxIS)

- Independent set of largest possible size
- NP-hard: polynomial time algorithm unlikely

Maximal IS (MIS)

- Independent set such that
  - No other vertex can be added to the set

- MIS can have very few vertices compared to MaxIS

MIS algorithm (synchronous)

- Each vertex has states
  - Undecided (initial)
  - Decided to enter MIS
  - Decided not to enter MIS
- Algorithm (repeated at each node until a decision (enter or not enter)):
  - If a neighbor has decided to enter MIS
    - Decide not to enter
  - If some neighbors are undecided and one or more undecided neighbor has higher id
    - Stay undecided
  - If some neighbors are undecided and none has higher id
    - Decide to enter MIS

MIS algorithm

- Time complexity: O(n)

- When nodes are in a chain, sorted by id

MIS

- We want something faster that O(n)

Fast-MIS (randomized)

- d(v) is degree of v
- Each v marks itself with probability 1/2d(v)
- If no higher degree neighbor is marked
  - v joins MIS
  - Else v un-marks itself
- Remove all nodes that joined MIS and their neighbors

Fast-MIS

- Run time: O(log n)
- Proof : somewhat long.
- If you want to learn more, see:
  - Alon et al. 1986 : A fast and simple randomized parallel algorithm for the maximal independent set problem
  - Slides: http://www.net.t-labs.tu-berlin.de/~stefan/netalg13-6-MIS.pdf