Introduction to Graphs and Their Relation to Power Sensitive Routing Techniques

By:
Dave Burlone &
Sneha Sharma

Overview of Presentation

- Basic Properties of a Graph
  - Undirected Graph
  - Directed Graph
  - Other Types of Graphs
- Graphs and Routing in Sensor Networks

Basic Properties of a Graph

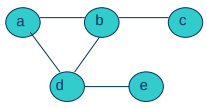
- Definition – A set of vertices connected by a set of edges
- The vertices are the nodes (dots)
- The edges are the lines

Basic Properties of a Graph – Undirected Graphs

- Names: Undirected Graph, Graph
- Definition: An ordered pair G:=(V, E)
  - V is a set of vertices (nodes)
  - E is a set of unordered pair of distinct edges
  - Degree or Valency – The number of edges incident to the vertex, with loops counted twice

Basic Properties of a Graph – Undirected Graphs

- An Undirected graph
  - V = {a, b, c, d, e}
  - E = {(a, b), (a, d), (b, d), (b, c), (d, e)

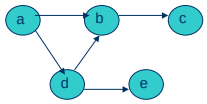


Basic Properties of a Graph – Directed Graphs

- Names: Directed Graphs, Digraphs, Quivers
- Definition: An ordered pair G:=(V, A)
  - V is a set of vertices (nodes)
  - A is a set of ordered pairs called directed edges, arrows arcs
- Definitions:
  - Indegree: The *in-degree* of a vertex *u* is the number of edges *(v, u)* for all *v* E*V(G)*
  - Outdegree: The *in-degree* of a vertex *u* is the number of edges *(u, v)* for all *v* E*V(G)*

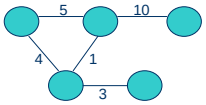
Basic Properties of a Graph – Directed Graphs

- A Directed Graph
  - V = {a, b, c, d, e}
  - E = {(a, b), (a, d), (b, c), (d, b), (d, e)}



Other Types of Graphs – Weighted

- Can be directed of undirected
- Follows same definitions of weighted or unweighted
- Has additional characteristic of weight/cost to traverse to neighboring vertices



Other Types of Graphs – Trees

- Graph where any two vertices are connected by **exactly** one path
- Can be weighted or unweighted
- Can be directed or undirected

Other Types of Graphs – Complete Graphs

- Can be weighted or unweighted
- Can be directed or undirected
- Follows same rules as either type.
- A graph where an edge connects every pair of vertices

Graphs and Associated Algorithms

- Shortest Paths
  - *Dijkstra's Algorithm* – solves the single –source shortest-path problem on a weighted graph, provided all edge-weights are nonnegative.
  - *Bellman-Ford Algorithm* - solves the single-source shortest-path problem. It allows negative edge weights, but does not allow a directed cycle of negative weight.

ROUTING

- Act of moving information across an internetwork from source to destination
- Core concept of internet and many other networks
- Occurs at layer 3 i.e. the Network layer of the OSI-seven layer model
- Two basic activities involved:
  - Determining optimal routing paths and
  - Transporting information groups (typically packets) through an internetwork

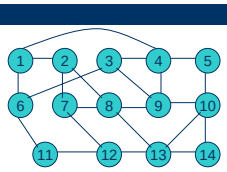
Routing in Normal Networks

- The source and destination are always known
- Data packets are transmitted from one source to specified destination and not necessarily to all nodes in the network.

Routing Table

- Routers (devices in a network that handle message transfer between computers) can only recalculate the best routes very slowly relative to the rate of arrival of packets
- Routers keep a **routing table** that maintains a record of only the best possible routes to certain network destinations and the routing metrics associated with those routes.
- A Routing Table has two fields:
  - Address of a destination
  - Address of the destination of the next hop

Routing Table example



Destination	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Next Hop	*	2	6	4	4	6	2	2	4	4	6	2	2	4

Routing in Ad hoc Networks

- Ad hoc network

  A collection of mobile hosts with wireless network interfaces forming a temporary network without the aid of any established infrastructure or centralized administration.

Routing in Ad hoc Networks

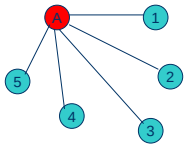
- In case of ad hoc networks, source and destination need not be fixed.
- At any point of time nodes come in and go out from the network.
- Each node shouts out its messages to all other nodes : Broadcasting

Comparison: Conventional and Ad hoc networks

- Routing protocols in conventional wired networks use *Distance vector* or *Link State* routing algorithms.
- Wired networks are usually explicitly configured to have only one or small number of routers connecting any two networks.
- No such explicit links in ad hoc network, all communication by broadcast transmissions
- In conventional routing, routers do not move around dynamically (they are static) unlike in ad hoc networks.

Sensor Networks

- Routing in Sensor networks closely resembles to routing in ad hoc networks.
- Typical sensor network has a Base station and many nodes(sensors) connected to the base



Sensor Networks

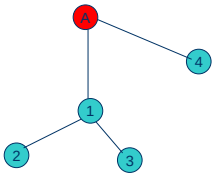
- Nodes are sensors
- Sensors work on battery power and can thus fail whenever the power is lost…
- They keep going in and out from the network

Routing In Sensor Networks – The Goal

- Low Power Consumption
- Sensor networks – longer life span
- Good Algorithm For Restructuring

Sensor Networks

- Minimum number of hops



Use of Graphs

- Picture each sensor as a vertex in some graph
- The edges are constructed based some graph algorithm
  - Shortest Distance
  - Maximum Flow (Bandwidth)
  - Minimum Number Hops

Conclusion

- Wireless sensor networks closely resemble ad hoc networks
- To optimize power consumption reducing the number of hops can be achieved by using various distance algorithms in Graph Theory

References

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Questions ??