Frugal: Building Degree-constrained Overlay Topology from Social Graphs

Saumitra Aditya, Renato J Figueiredo – University of Florida

Motivation

How to manage and co-ordinate secure connectivity among increasing number of user-facing network enabled devices?

Providing end to end, private connectivity to mobile, distributed devices is a challenge.

Online Social Networks (OSN's), widely accepted, intuitive to use global network with embedded relationships.

Leverage Online Social Networks for peer discovery and bootstrapping but support p2p communication via overlays.

Challenge: Mapping social links in OSN's social graph to overlay links in P2P networks accommodating high social degree nodes, with the objective of limiting overlay link degree.

Why care ? More overlay links leads to higher consumption of network bandwidth, memory, computation and energy – Important for power constrained devices.

Social Network structural properties

Orkut's dataset: 3 million vertices, 220 million edges, median degree 45; 10% nodes have excess of 158 friends and 1% over 524.

Facebook dataset: 721 million users, median degree 99; 1 in every 1000 user with a degree of 500 or more.

High social degree nodes ("hubs"), play pivotal role in ensuring connectivity of the graphs

Small world property: Any two nodes in a social graph have a average hop separation between 4.3-4.7.

High clustering coefficient: If there exists a social link between Carol and Bob, Alice and Carol, there is a high probability of a social link existing between Alice and Bob.

Takeaway:

High social degree nodes "hubs" are inevitable in a social graph, overlay network must accommodate them.

The structural property of high clustering coefficient in OSN's can be leveraged to reduce the number of overlay links needed without sacrificing connectivity.
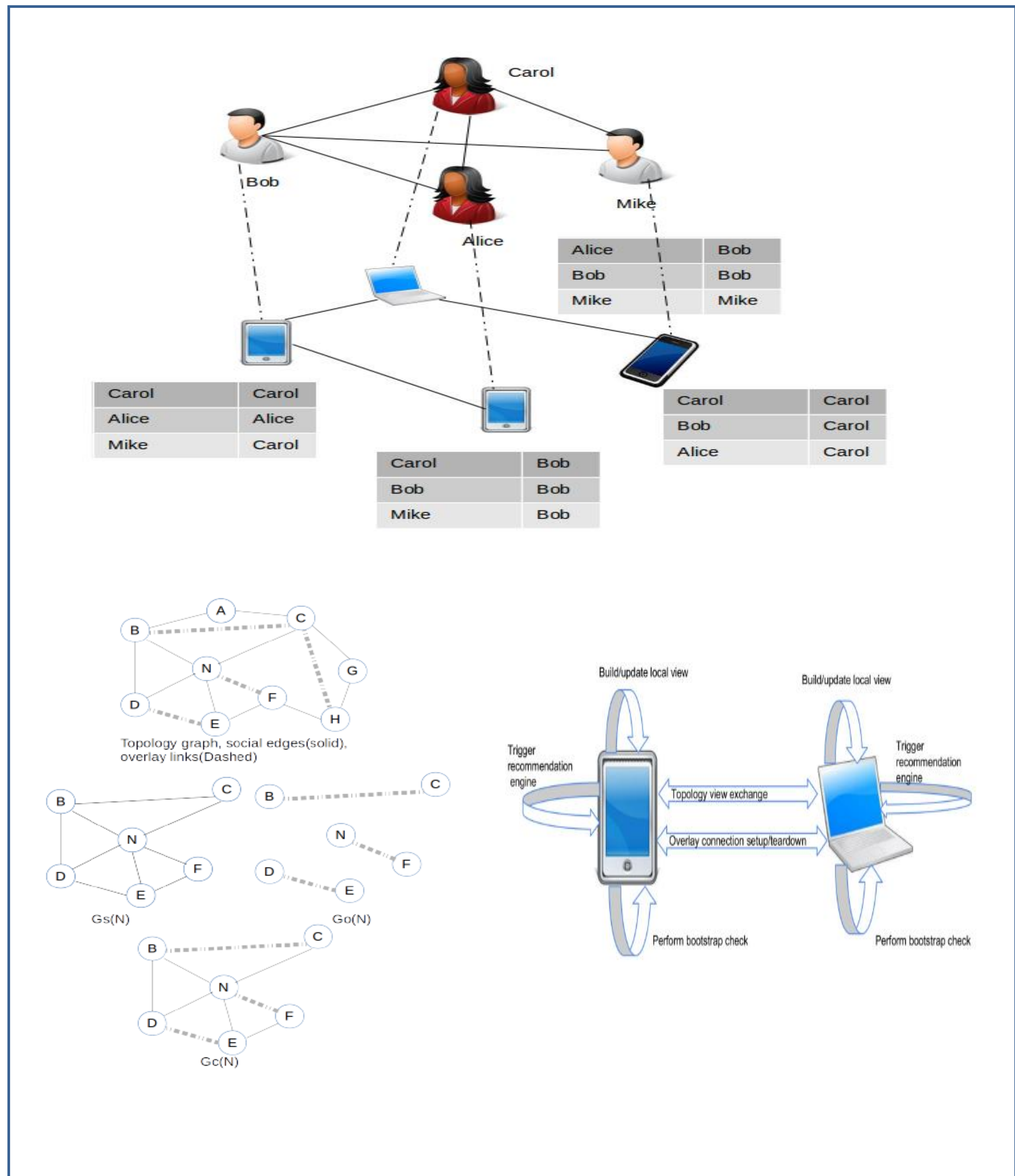
Frugal- Heuristic

Frugal follows a decentralized, event driven architecture; it runs on every participating device.

Connectivity information exchange
Each node exchanges information about its social and overlay links with its social neighbors.

Build local topology view
Fuse social and overlay graphs received from neighbors to create a 2-hop
local topology view centered at the node, this reveals mutually connected
Neighbors.

Generate overlay link recommendations

Create a undirected weighted graph local topology view with costs of edges scaled to prioritize existing overlay links and social links with frequent communication and discourage links between heavily loaded nodes. Construct a Degree Constrained Minimum Spanning tree of this Graph and send connection requests to nodes with whom an edge exists in the computed recommendation set.

Bootstrap phase

Accommodate nodes which failed to connect to the network owing to exhaustion of peer's connectivity constraint.

Greedy phase

Often number of recommended edges less is smaller than the link constraint. This phase bridges the gap by greedily selecting unmapped high priority social edges and maps them to overlay links.

Simulation and Evaluation

Dataset:

Facebook Konect, 63,731 users, 817,035 edges and median degree 10. Overlay degree constraint capped at 20.

Metrics:

Total overlay edges, partitions, Traffic hop distribution , Social Hop distribution.

scheme	edges	partitions
Frugal	333665	201
Greedy	323790	1536
Random	329928	1959
Greedy Bootstrap	333483	300
Random Bootstrap	343253	323
Frugal w/o greedy	181151	212

a. Network-wide traffic-hop distribution

b. Social-hop distribution of nodes

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