Bridgeness: a novel centrality measure to detect global bridges

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BRIDGENESS

A NOVEL CENTRALITY MEASURE TO DETECT GLOBAL BRIDGES

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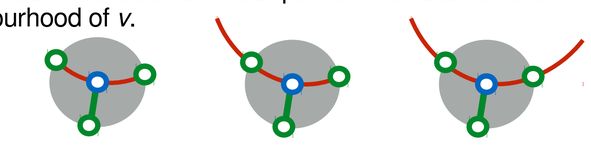
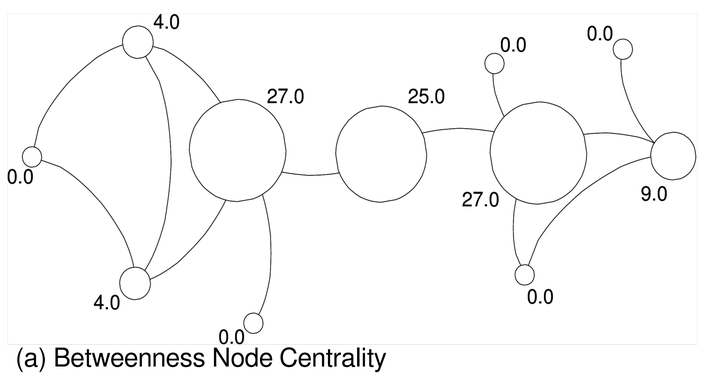
Finding nodes occupying interesting positions in a graph is useful to extract meaningful information from large datasets. While numerous measures have been proposed to evaluate the centrality of nodes, few indicators quantify the capacity of nodes to connect different regions of the graph. Usually, betweenness centrality is used for this purpose, but we show here that it gives equal scores to “local” centers (i.e. nodes of high degree central to a single region) and to “global” bridges, which connect different regions. This distinction is important because the roles of these nodes are quite diverse. For example, in networks of scientific collaborations, local centers correspond to nodes which are important for a single sub-discipline, while bridges correspond to nodes which connect different sub-disciplines, leading to interdisciplinary collaborations. We show that a new measure of network topology, the bridgeness, is able to discriminate between local centers and global bridges, in synthetic and real networks.

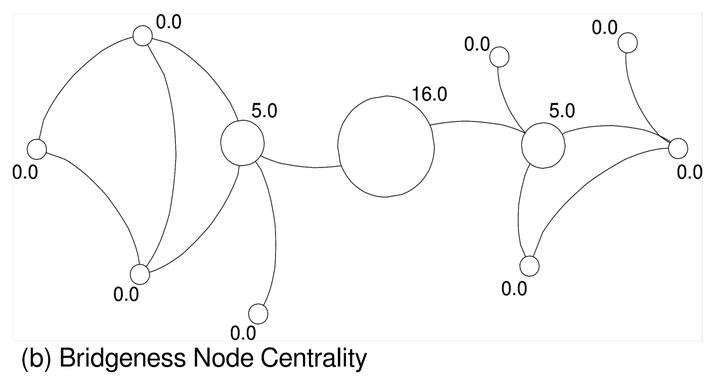
The figures show the betweenness (a) and bridgeness (b) scores for a simple graph. Betweenness does not distinguish centers from bridges, as it attributes a slightly higher score (Figure a, scores = 27) to high-degree nodes which are local centers, than to the global bridge (Figure a, score = 25). In contrast, bridgeness rightly spots out the node (Figure b, score = 16) that plays the role of a global bridge.

Bridgeness removes all shortest-paths which start or end in the neighbourhood of *v*.





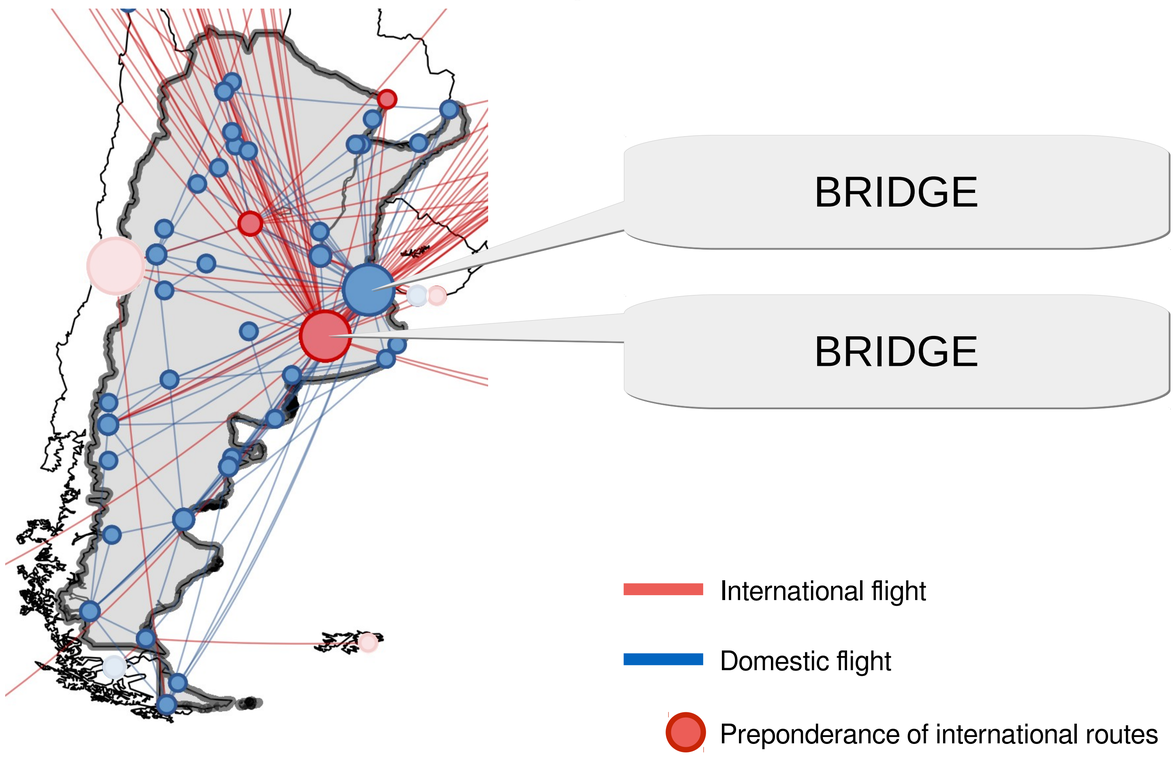
(a) Betweenness Node Centrality



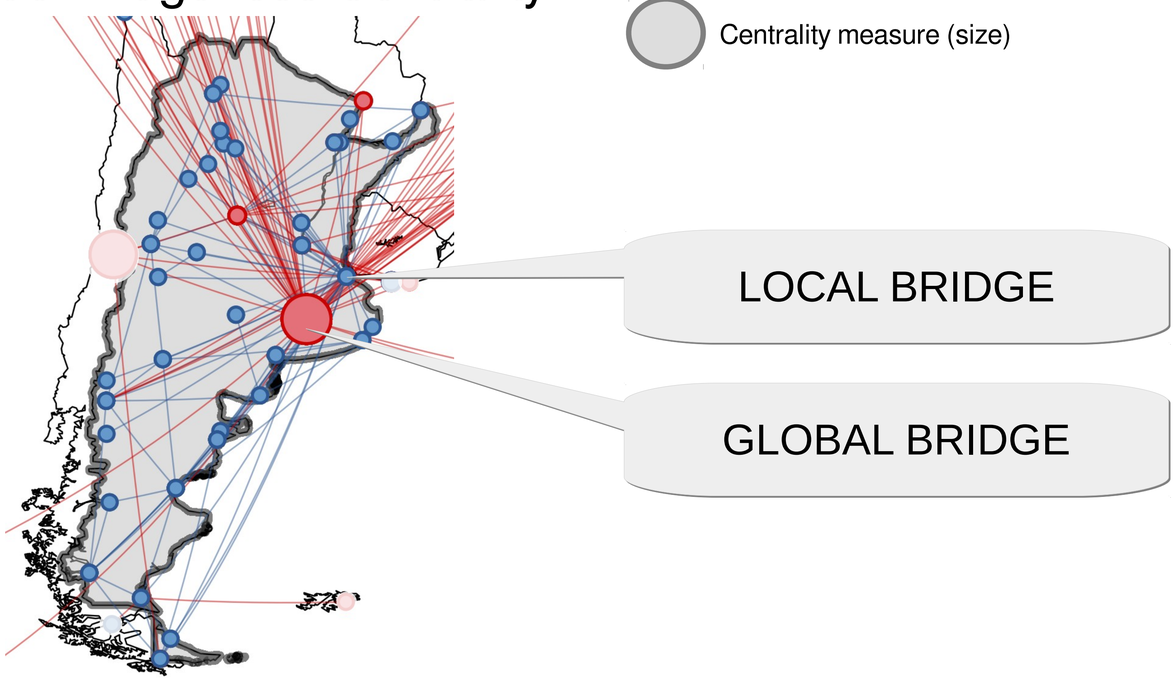
(b) Bridgeness Node Centrality

Example of the two largest Argentinean airports, Ezeiza (EZE) and Aeroparque (AEP). Both have a similar degree (54 and 45 respectively), but while the first connects Argentina to the rest of the world (85% of international connections, average distance 2.848 miles), Aeroparque is only a local center (18% of international connections, average distance 570 miles). However, as in the simple graph (Figure 1), BC gives the same score to both (BC_EZE =79 000 and BC_AEP = 82,000), while bridgeness clearly distinguishes the local center and the bridge to the rest of the world, by attributing to the global bridge a score 250 times higher (Bri_EZE =46,000 and Bri_AEP = 174).

Node Betweenness Centrality



Node Bridgeness Centrality

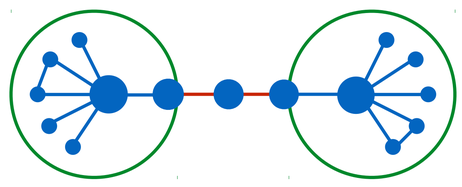


The problem with betweenness centrality

$$G = (V, E) \qquad g(v) = \sum_{s \neq v \neq t} \frac{\sigma_{st}(v)}{\sigma_{st}} \qquad s, v, t \in V$$

σ_{st} - Shortest-path between s and t

- Somewhat captures the centrality of nodes
- Assigns high centrality values for high degree nodes by default
- This definition mixes the global and local bridges

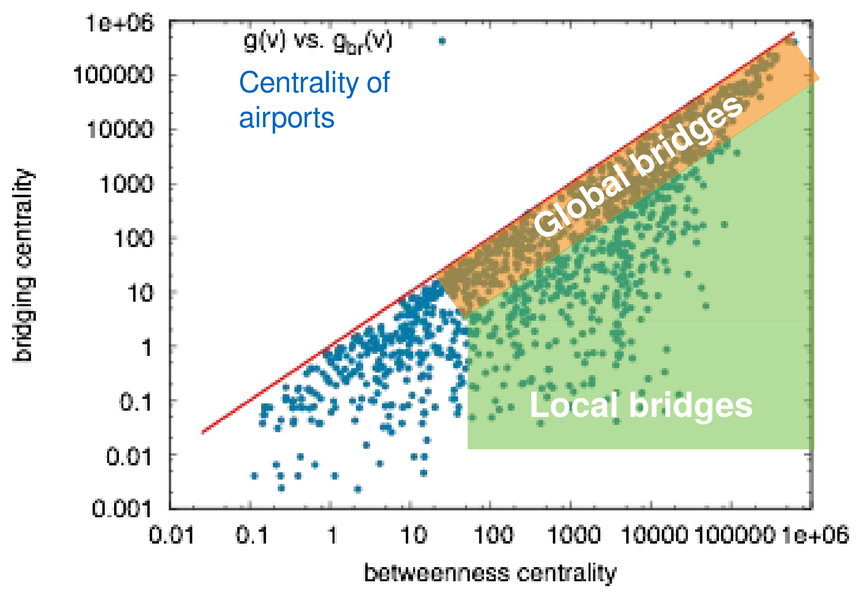


Local bridges:
- *placed in communities*
- *connects similar nodes*

Global bridges:
- *placed between communities*
- *connects dissimilar nodes*

Bridging node centrality - properties

$$g(v) = g_{br}(v) + g'(v) \qquad g_{br}(v) \leq g(v)$$



INVENTEURS DU MONDE NUMÉRIQUE

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