
**Unnormalized and normalized forms of gefura measures in directed and undirected networks**

**Key words:** Networks subdivided in groups, Partitions, Gefura measures, Q-measures, Brokerage role, Directed and undirected networks, Brandes’ algorithm

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Overview

• Gefura measures $\Gamma$ – previously known as Q-measures – are indicators of a node’s brokerage role between groups in a network
  – They measure to what extent an article (node) play a bridging role between journals (groups) in a citation network?
  – They are analogous to betweenness centrality

• Main contributions of this article:
  – Gefura measures in directed networks
  – Two types of normalization
  – Efficient algorithm to calculate gefura measures
Unnormalized gefura

\[ \Gamma_G(a) = \sum_{g, h \in V \atop \text{group}(g) \neq \text{group}(h)} \frac{p_{g, h}(a)}{p_{g, h}} \]

where:

- \( p_{g, h} \): number of shortest paths from \( g \) to \( h \)
- \( p_{g, h}(a) \): number of shortest paths from \( g \) to \( h \) through \( a \)
Two normalizations

**Structural** normalization: $\Gamma(a_1) = \Gamma(b_1) = \Gamma(c_1) \rightarrow$ group level

**Basic** normalization: $\Gamma(a_1) < \Gamma(b_1) < \Gamma(c_1) \rightarrow$ node level
Algorithm

• Adaptation of Brandes’ (2001) algorithm for betweenness centrality
• Time complexity: $O(nm)$
• Implementation available