Basic notions on Social Network Analysis - Dealing with 2-mode networks

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In the 'Flows and Network' package, we focus on different types of relations between countries on a world scale (economic, political, financial, and diplomatic). Therefore, working with tools from 'Social Network Analysis' (SNA) seemed quite obvious. The aim of these methodological papers is to explain, as simply as possible, what is the principle, the vocabulary and the methods employed. Each paper will provide example taken from the EuroBroadMap project.

From one-mode to two-mode networks

Let's start with mathematics. A *bipartite graph G* is made of three elements: a set of actors {*A*}, a second set of actors {*B*}, and a set of relations {*R*}. Each relation in {*R*} gets an extremity in {*A*} and the other one in {*B*}. A *two-mode network* really looks like a bipartite graph; it represents relations between two different sets of actors (teachers and students, businessmen and companies and so on). It looks like but it's not exactly the same as you could perfectly imagine a two-mode network symbolizing three kinds of relations: relations inside the two sets of actors and relations between these two sets... For methodological reasons, it's barely done and almost every two-mode networks can be considered as bipartite graph. It could of course be possible to imagine three-mode networks (or more) but very few methodological tools could be used for them.

Measures of two-mode networks

As you can't get relation inside a set of actors, measures on two-mode networks are different from usual, and some specific measures also exist.

Density remains the same in a two-mode network (number of actual links divided by number of possible links) but, as links inside a set of actors are not allowed, its formula is different. If you get a set {*A*} with *x* actors and a set {*B*} with *y* nodes, then the density is equal to the number of present nodes divided by *x.y*. The figure 1 illustrates this logical calculation.

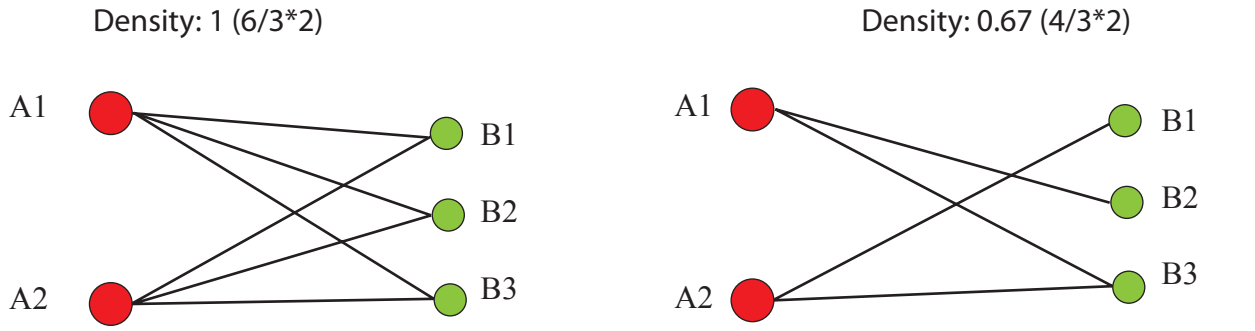


Figure 1: A complete two-mode network (left), same sets but a lower density (right)

Pajek

To get normalized degree, the unit of reference for actors in a set are... the number of actors in the other set. In a one-mode network, the normalized degree of a node is equal to its degree divided by the maximum possible degree (number of nodes minus 1 as loops – tie from a node to itself – are generally forbidden). On a two-mode network, the logic is different. If you consider the node A1 on figure 1, it can get maximum 3 links. If it gets one, its degree is 0.33 (1/3), if it gets two links, its degree is 0.67 (2/3) etc.

Adaptations regarding calculations of closeness, betweenness, and centralization can be found in Borgatti and Everett, 1997.

Regarding subgroups, the situation becomes more complex. As you can't have a link inside a set of actors, you can neither have any clique. The two authors just mentioned proposed the search of *biclique*. It designs a maximal complete bipartite subgraph of a given bipartite graph. If you consider the graph on the right side of figure 1, not any biclique exists. But, if a link is added from A2 to B2, you obtain a biclique {A1–A2}{B2-B3} because all possible links between these two subsets would be present, and you could not add any node without losing this property.

One of the most convenient ways to analyze a two-mode network is to transform it in two complementary one-mode network, and then to use the usual tools from Social Network Analysis presented in the last methodological papers. The two-mode network on the right of figure 1 can be transformed in the two following matrices (see figure 2). In each case of the matrix, you have the number of shared links with the other nodes inside the set considered. Diagonals are in grey as considering them would be irrelevant.

	B1	B2	B3
A1	0	1	1
A2	1	0	1

	A1	A2
A1	3	1
A2	1	3

	B1	B2	B3
B1	2	0	1
B2	0	2	1
B3	1	1	2

Figure 2: from one two-mode network to two one-mode networks

Once diagonals are deleted, these matrices can be treated with all classical tools from Social Network Analysis. One precaution must be reminded: the derivate matrices don't represent a direct relation between actors, so comments on empirical data must stay cautious regarding the interpretation of results obtained.

Political links at the United Nations General Assembly (UNGA)

Only States can be member of the UNGA, but groups of States can pronounce speeches, propose resolutions - and they have been more and more present for the last decade. A way to map the influence of a group is to count how many States declare they support a group declaration.

To get a more readable figure, only States with degree equal or greater than 2 are represented here. In other words, each country speaker of these States, during the 51th session of the UNGA (1996-1997), declared at least twice he supported a declaration previously made by a group.

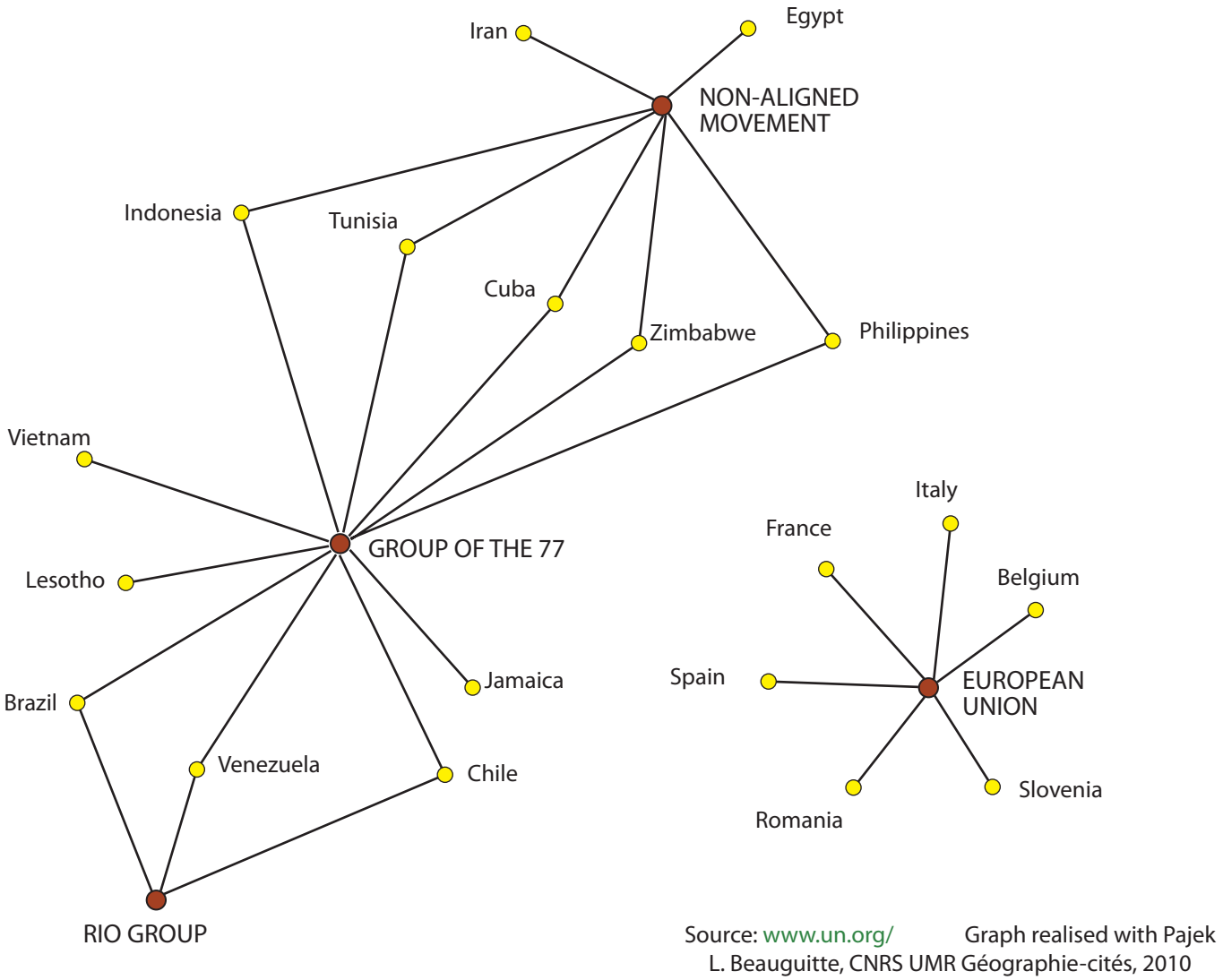


Figure 3: Groups-States speaking relations at the UNGA (1996-1997)

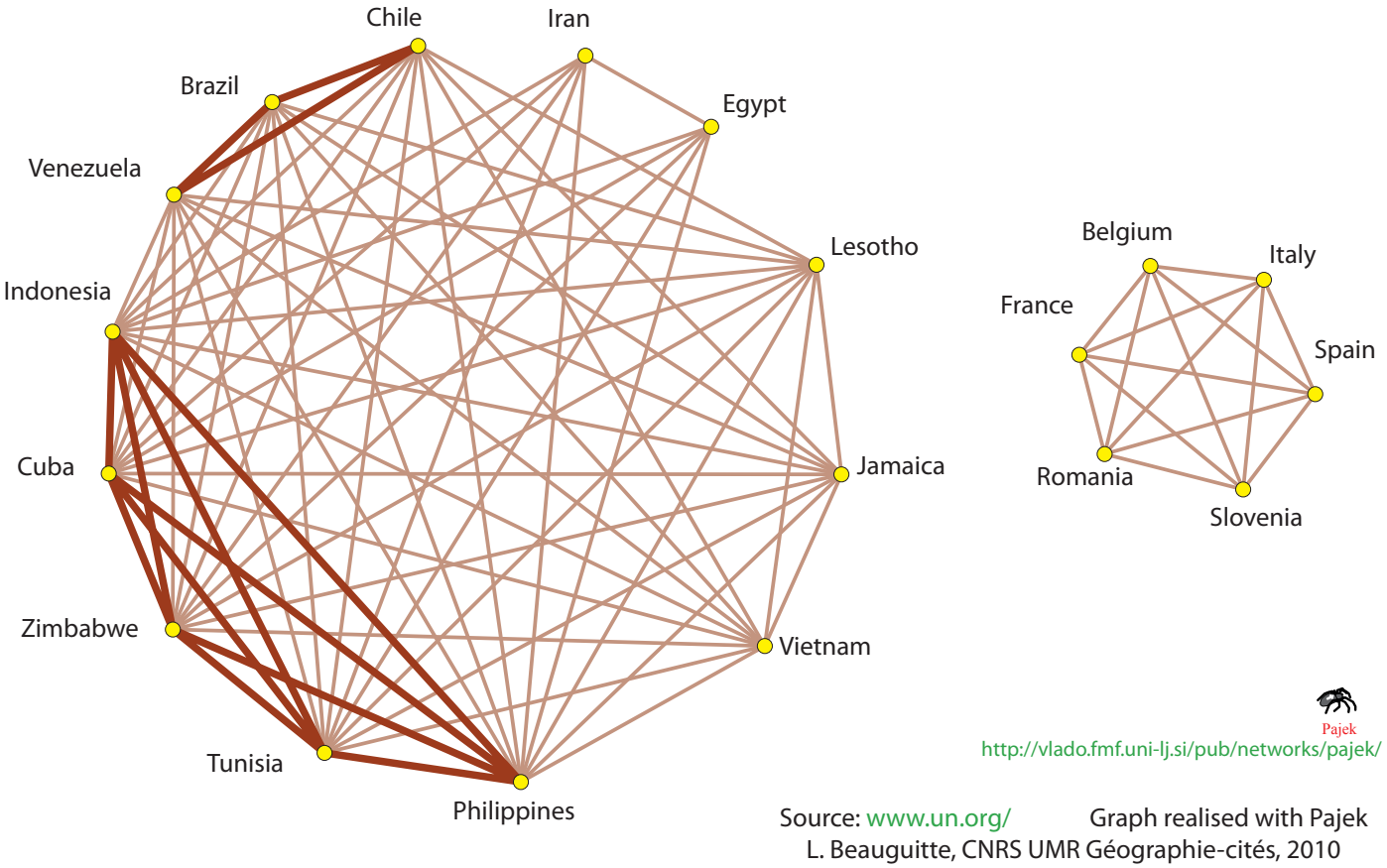
The density of this graph is 0.35 (2 sets of respectively 19 and 4 actors, and 27 links). Two bicliques / set of countries are presents:

- Brazil, Chile, Venezuela associated with the Group of the 77 and the Rio Group,
- Cuba, Indonesia, Philippines, Tunisia, Zimbabwe associated with the Group of the 77 and the Non-Aligned Movement.

The transformation in two one-mode networks can be useful in order to study relations within countries or between groups at the UNGA.

Common group affiliation at the UNGA in 1996-1997

Width of links is related to the number of common supports to groups speeches.



Source: www.un.org/ Graph realised with Pajek
L. Beauguitte, CNRS UMR Géographie-cités, 2010

Figure 4: A one-mode network issued from one two-mode.

To go further

A very clear presentation from S. Borgatti is also available on line (http://www.steveborgatti.com/presentations/AffiliationsKeynote.pdf)

Two classical articles are:
S.P. Borgatti and M.G. Everett, 1997, "Network analysis of 2-mode data", *Social Networks*, 19, p.243-269
K. Faust, 1997, "Centrality in affiliation networks", *Social Networks*, 19, p.157-191.

A more technical paper is from M. Latapy, C. Magnien and N. Del Vecchio, 2008, "Basic Notions for the Analysis of Large Two-mode Networks", *Social Networks*, 30, p. 31-48 (available at http://www-rp.lip6.fr/~latapy/Publis/socnet07.pdf)

Coming next

Methodological paper n°5: Visualising networks (Nov. 2010)
Methodological paper n°6: World-Trade and Social Network Analysis (Feb. 2011)