community structure

introduction to *network science in Python* (*NetPy*)

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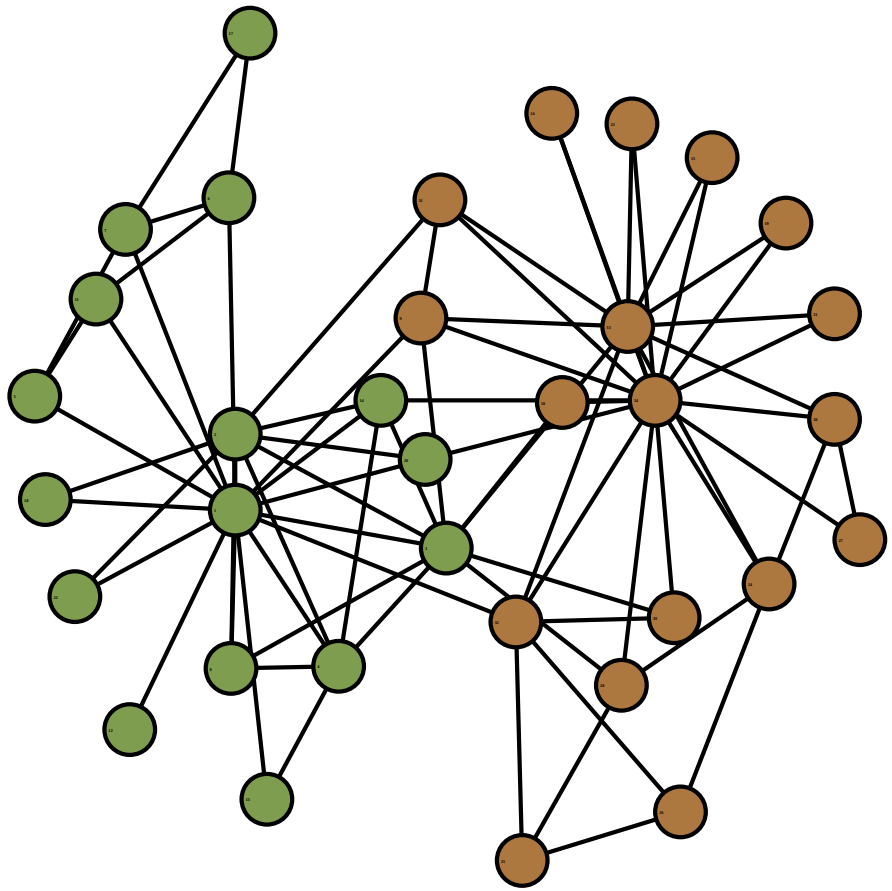
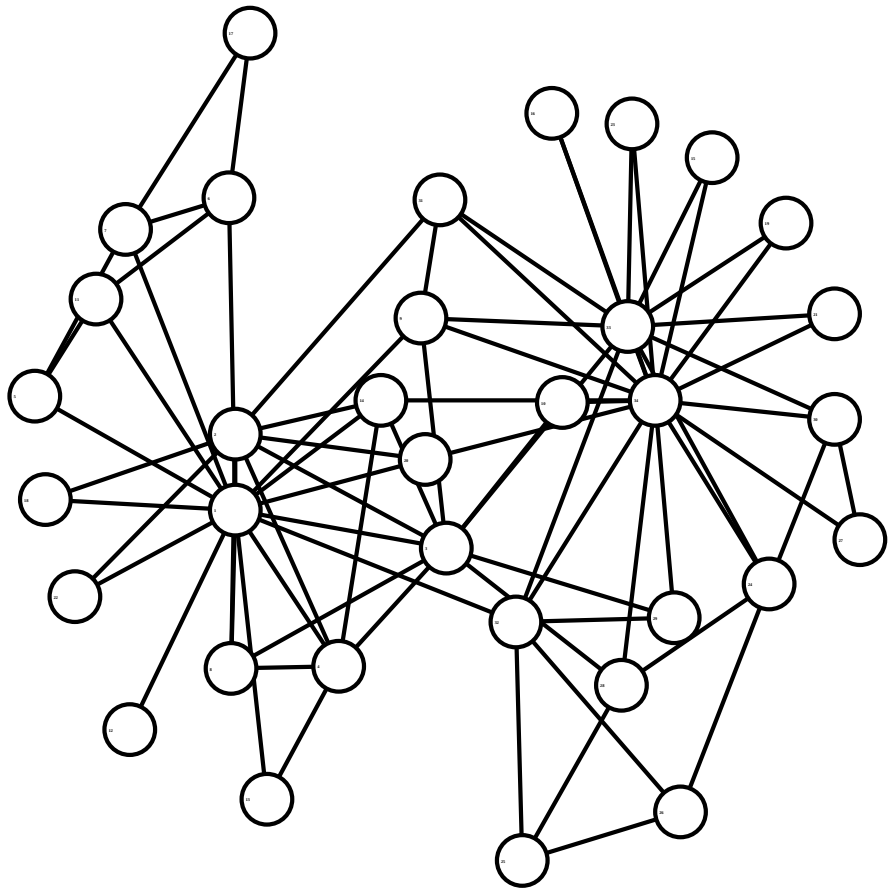
community *structure*

karate club *network split* [Zac77]



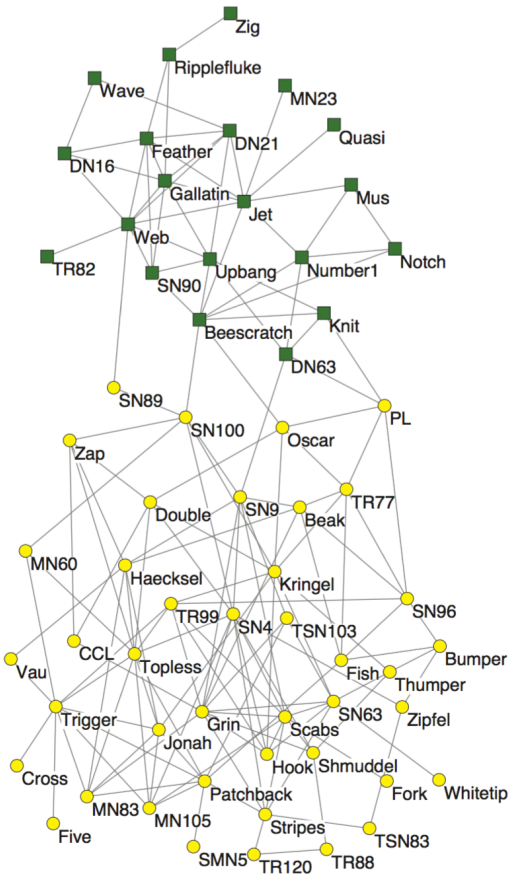
community *detection*

karate club *split detection* [RAK07]

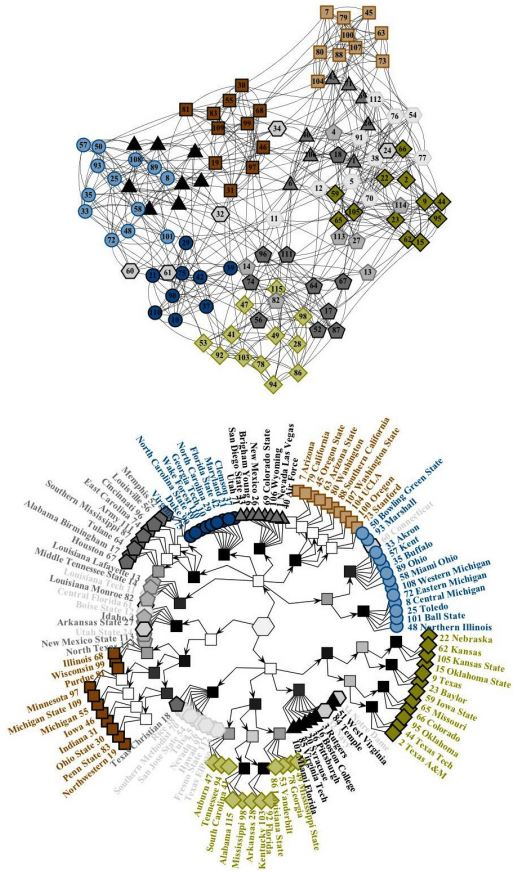


community *examples*

most social networks contain *communities* [GN02]



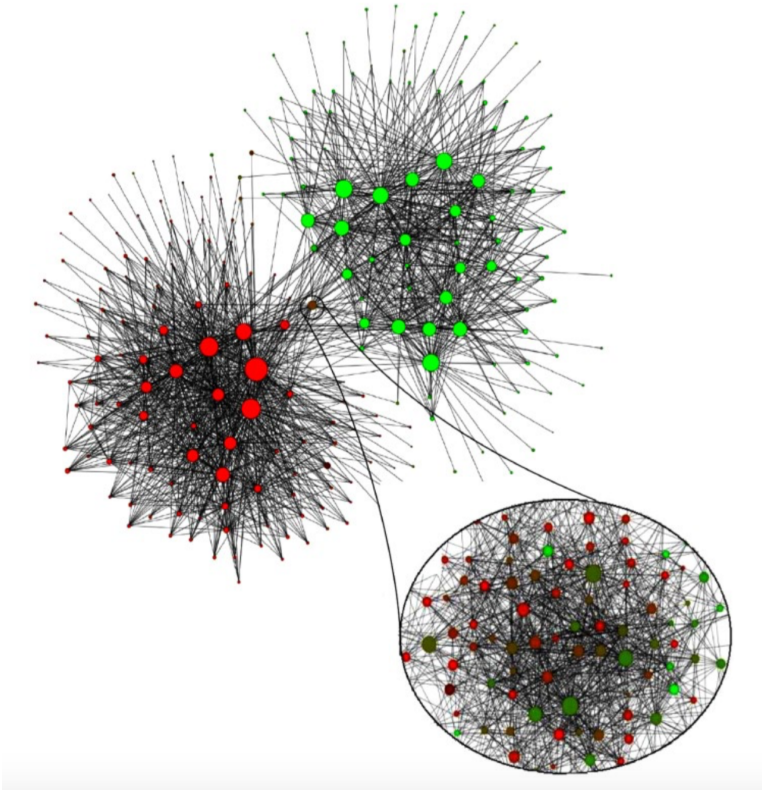
bottlenose dolphins [LSB+03]



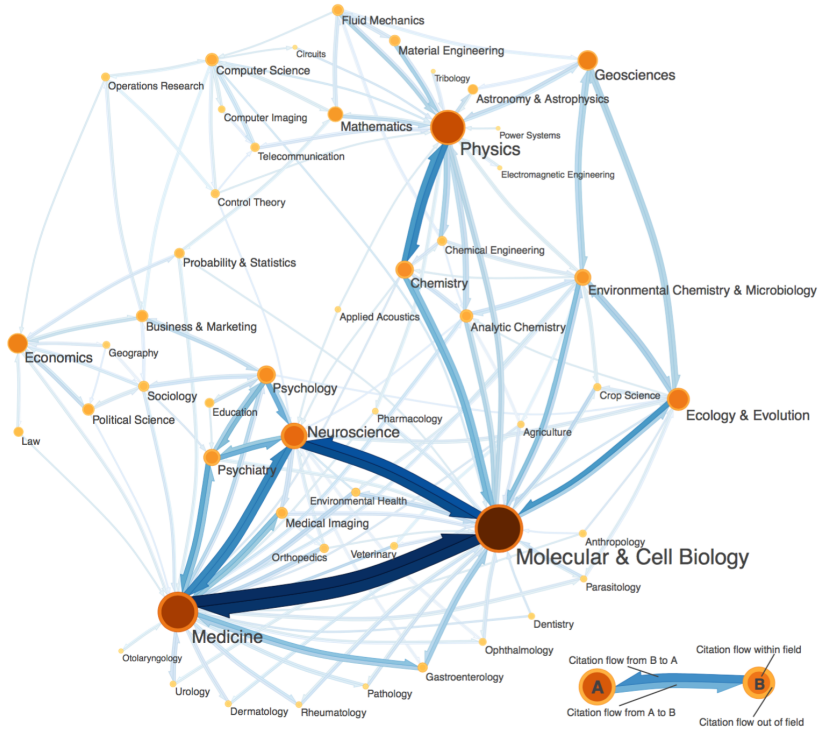
college football [GN02]

community *examples*

many information networks contain *communities* [FLG00]



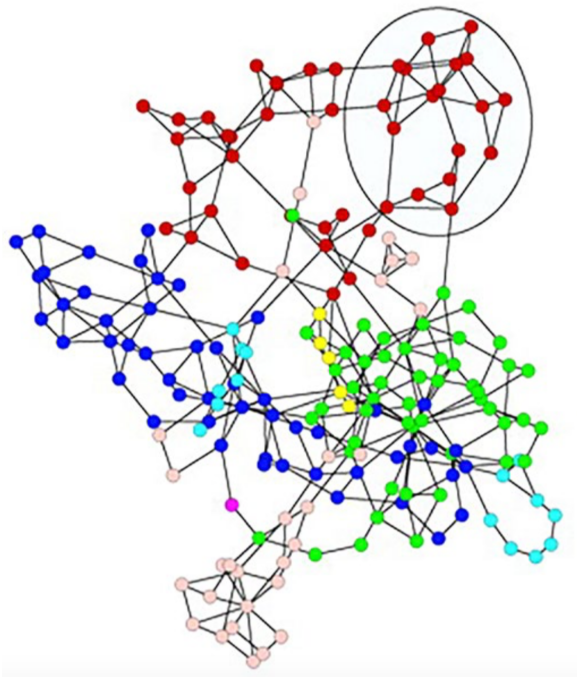
mobile communications [BGLL08]



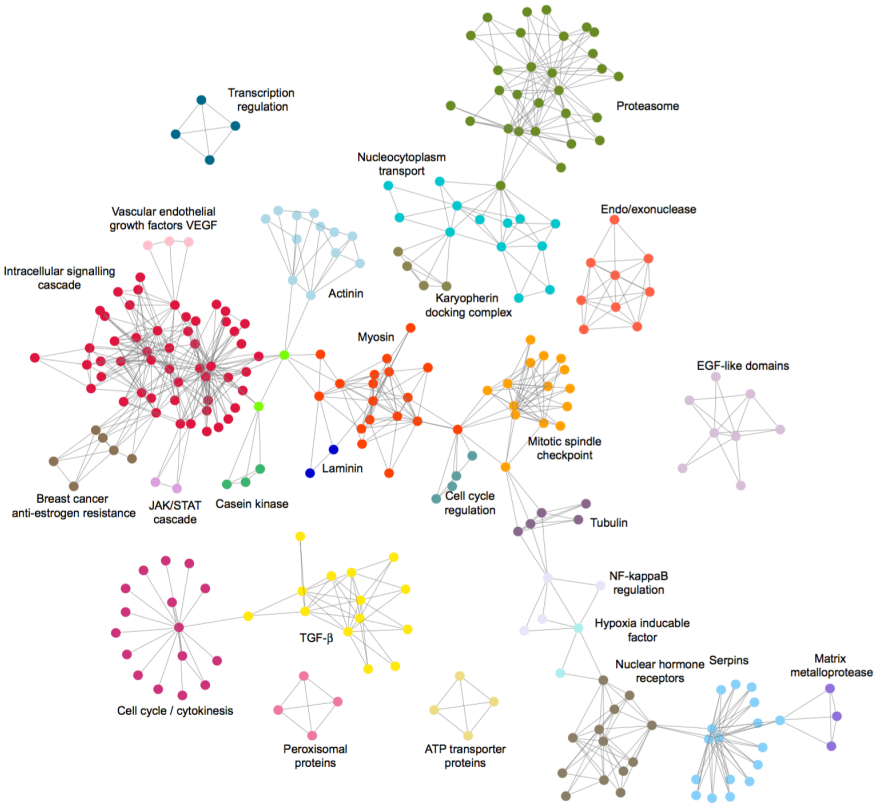
journal citations [RB08]

community *examples*

many biological networks contain *communities* [RSM+02]



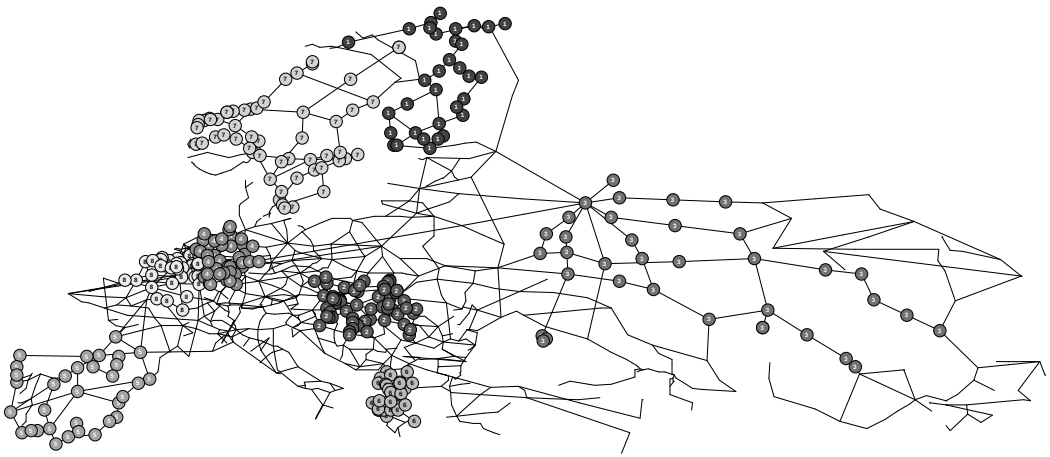
E. coli metabolism [RSM+02]



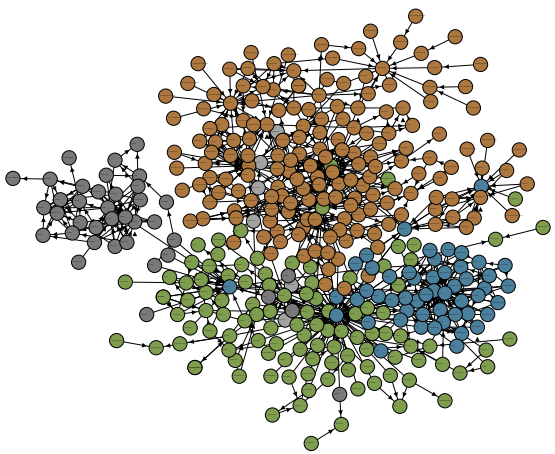
protein interactions [JCZB06]

community *examples*

technological networks *rarely* contain *communities* [ŠB11a]



European highways [ŠB11b]



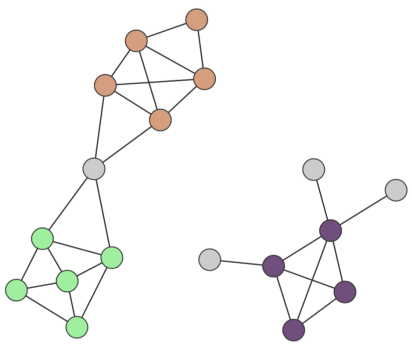
JUNG dependencies [ŠB11a]

community *definition*

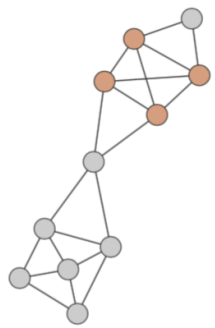
- *clique* is *complete subgraph of* some *graph*
- *community* is *dense subgraph of sparse network* [GN02]
- *strong* and *weak community* C [FLG00, RCC+04] defined as
  - k_i^{int} and k_i^{ext} are *internal* and *external degree* of i

$$\forall i \in C : k_i^{int} > k_i^{ext} \qquad \sum_{i \in C} k_i^{int} > \sum_{i \in C} k_i^{ext}$$

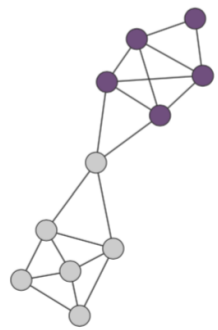
- *community detection* is $\gg$ *graph partitioning* [For10]



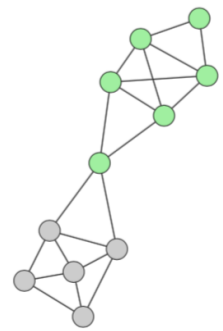
connected communities



maximum clique



strong community



weak community

community *modularity*

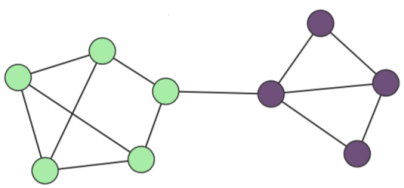
— *random graphs* should *lack community structure*

— *modularity* Q [GN02] of *communities* $\{C\}$ defined as

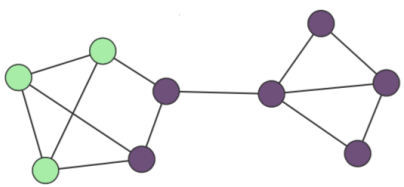
$$Q = \frac{1}{2m} \sum_{ij} \left(A_{ij} - p_{ij} \right) \delta_{c_i c_j} = \frac{1}{2m} \sum_{ij} \left(A_{ij} - \frac{k_i k_j}{2m} \right) \delta_{c_i c_j}$$

— $p_{ij} = \frac{k_i k_j}{2m}$ is link probability in *configuration model* [NSW01]

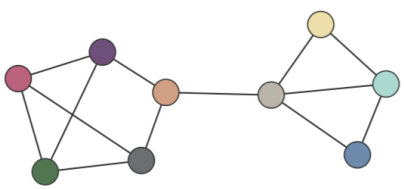
— *modularity* Q popular *quality*/*optimization function* [For10]



optimal $Q = 0.41$



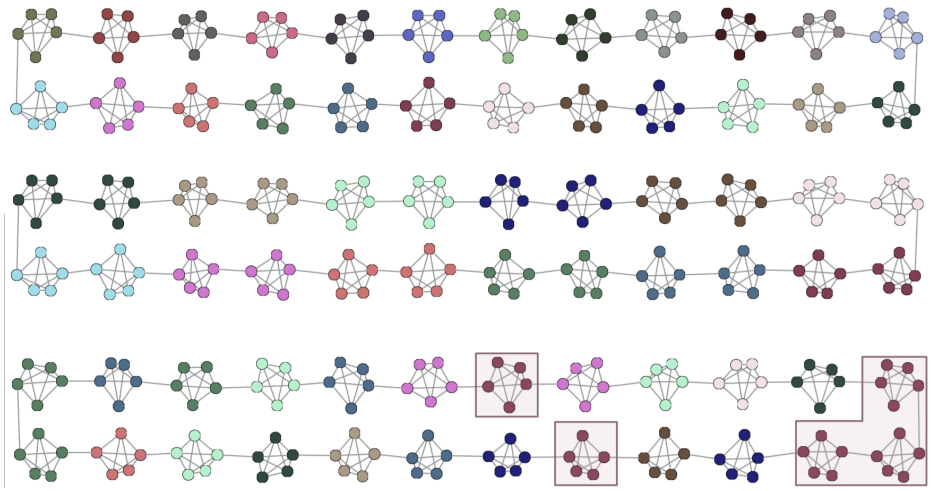
suboptimal $Q = 0.22$



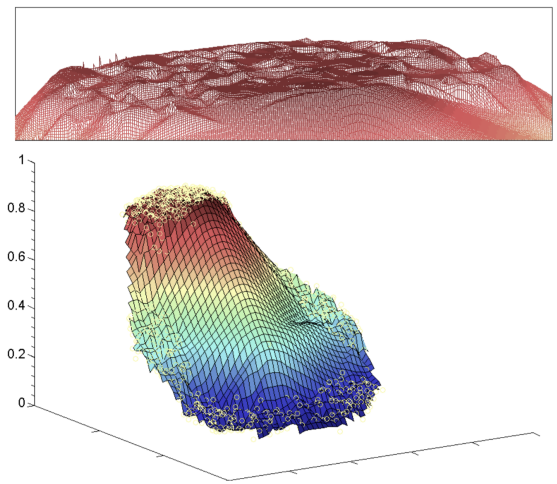
isolates $Q = -0.12$

community ¬*modularity*

- *modularity* $Q \gg 0$ also in *random graphs* [GSPA04]
- *modularity* Q has *resolution limit* at $k_c \leq \sqrt{2m}$ [FB07]
- *modularity* Q *lacks clear optimum* in real networks [GdMC10]

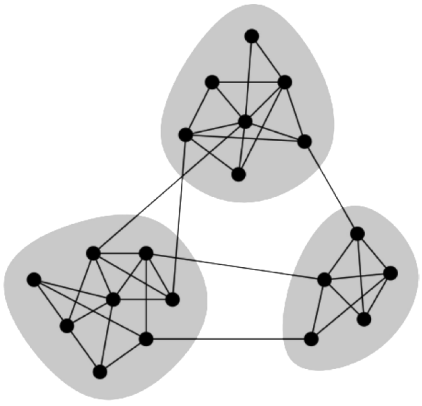


intuitive $Q = 0.867$, *optimal* $Q = 0.871$ and random $Q = 0.8$

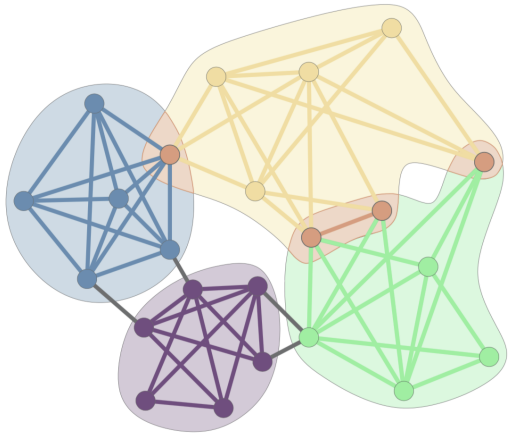


Q *plateau* and maxima

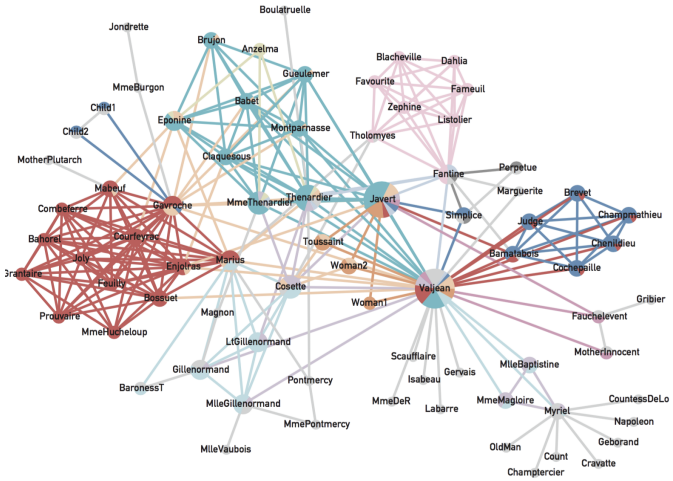
community *overview*



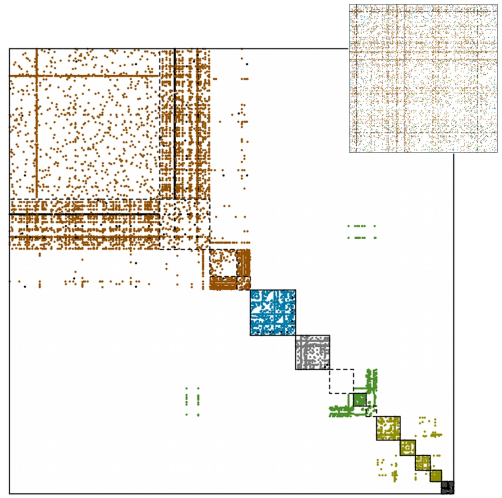
communities [GN02]



overlapping communities [PDFV05]



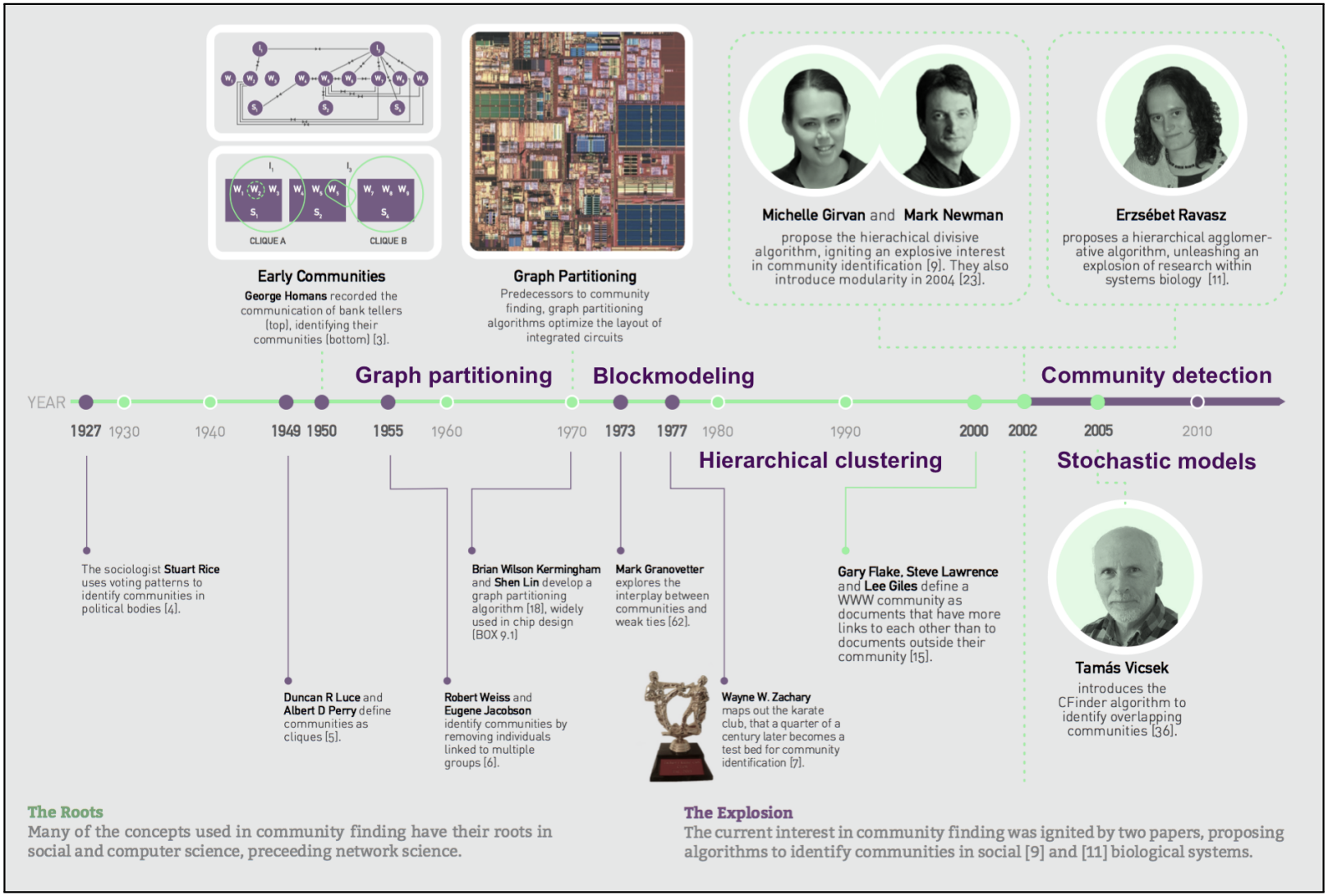
link communities [EL09, ABL10]



block models, *blockmodeling* etc.

`javax.swing`, `javax.management`, `javax.xml`, `javax.print`, `javax.naming`, `javax.lang`

community *history*



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