

# Multi-Scale Structure Learning

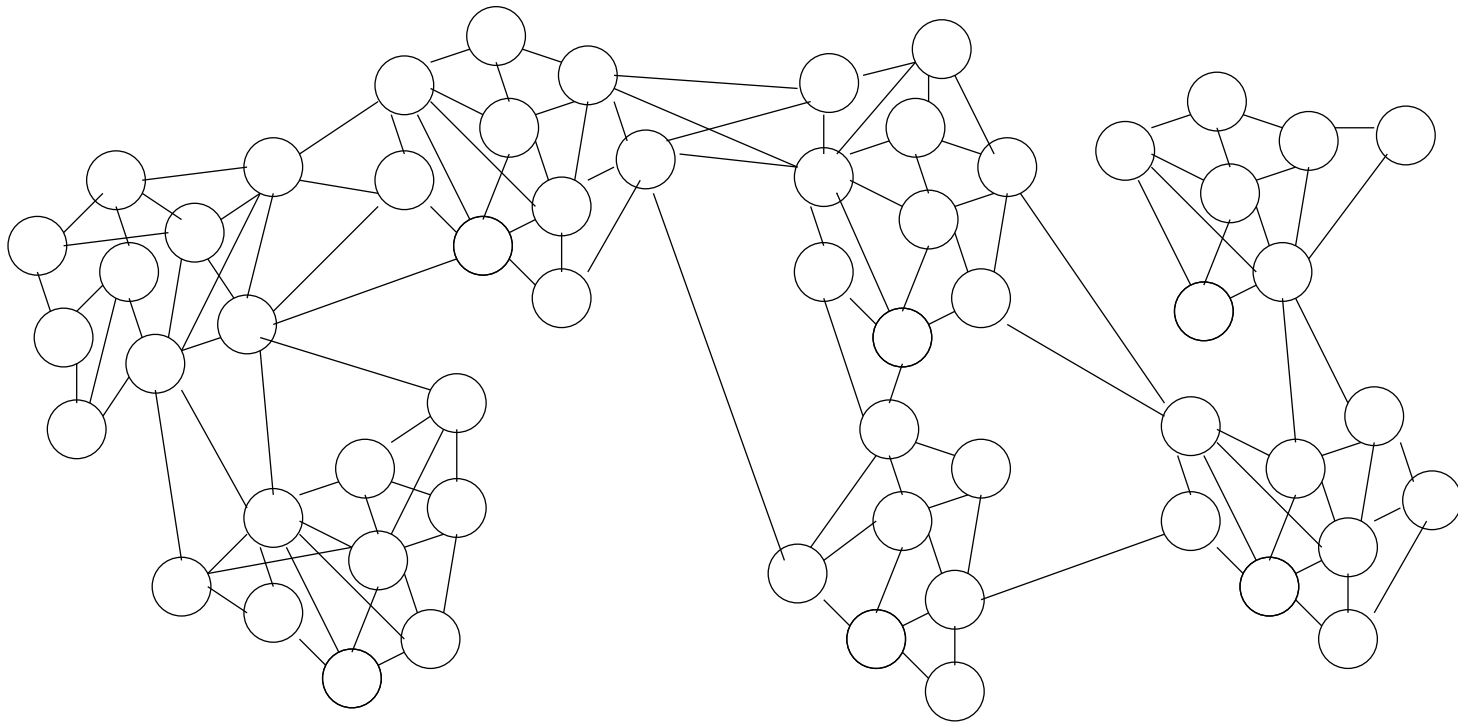
Mohammad Emtiyaz Khan and Kevin Murphy

Department of Computer Science

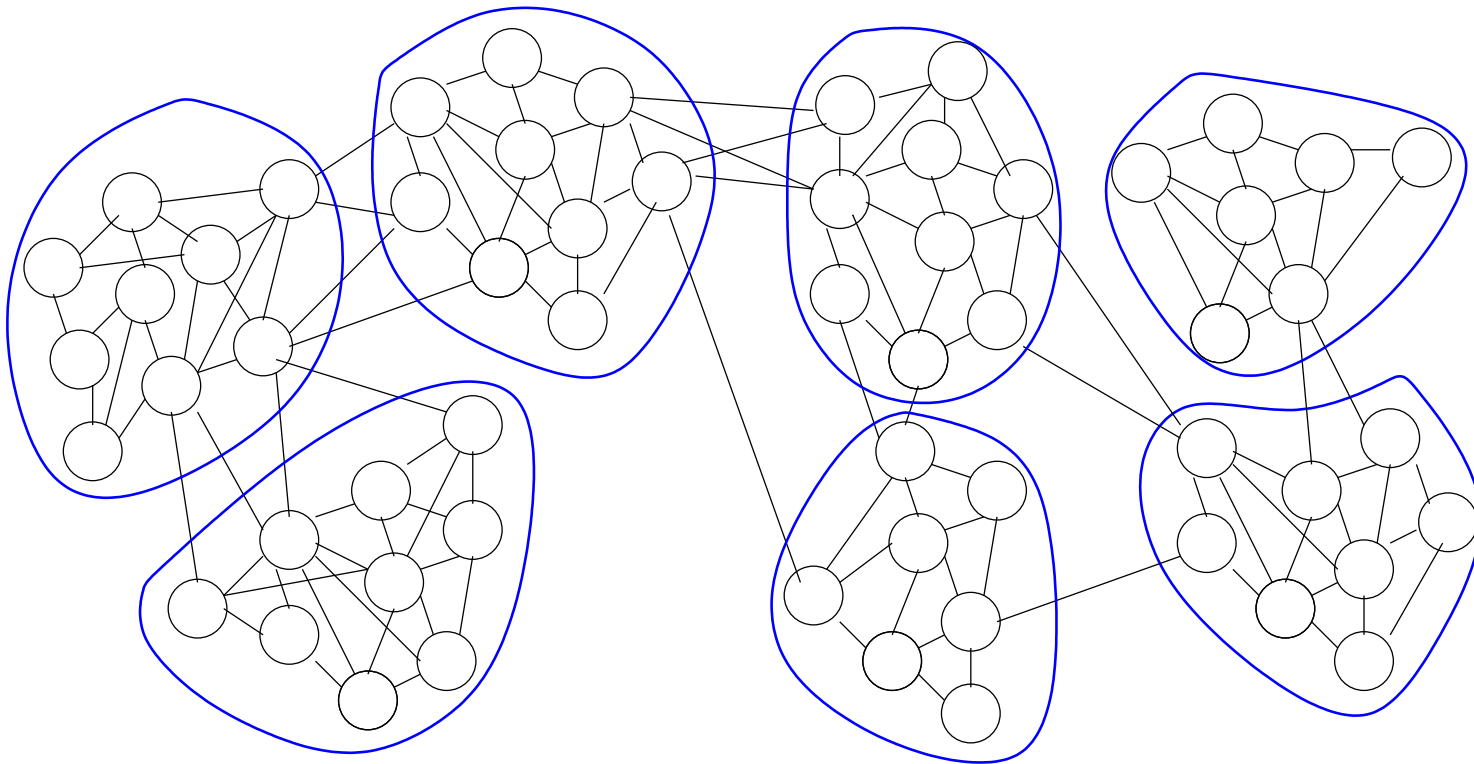
University of British Columbia

Vancouver, Canada

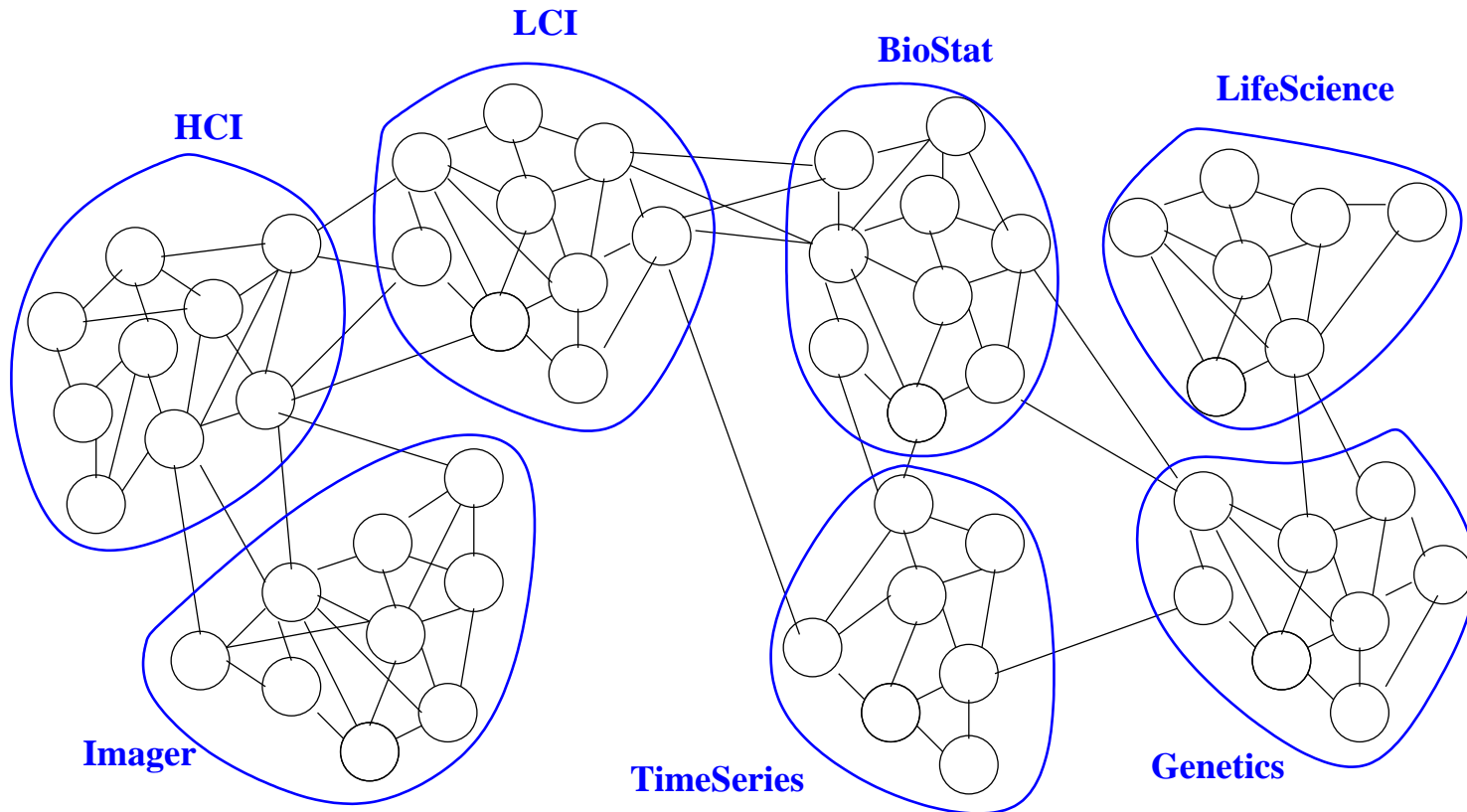
# An Intuitive Example



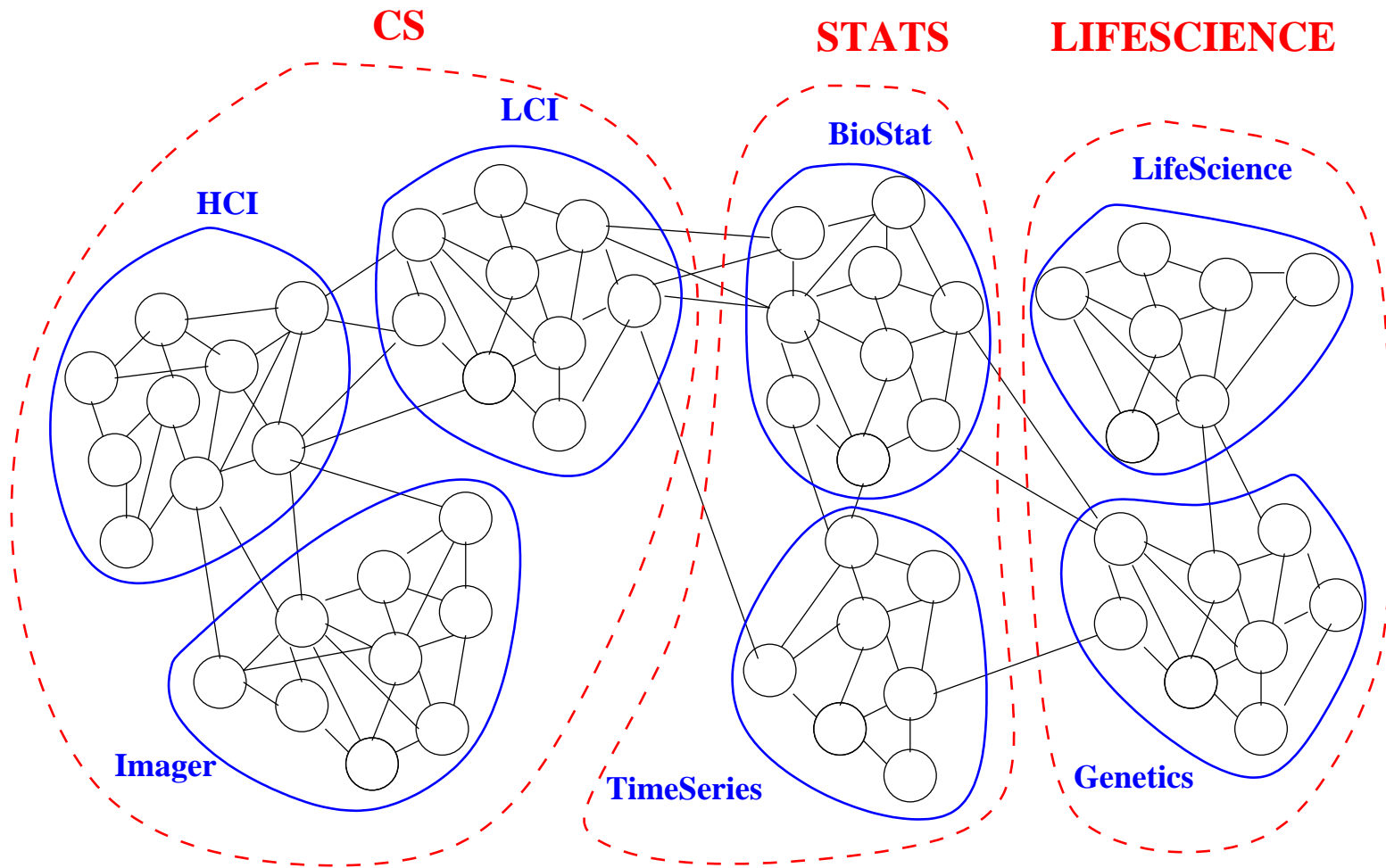
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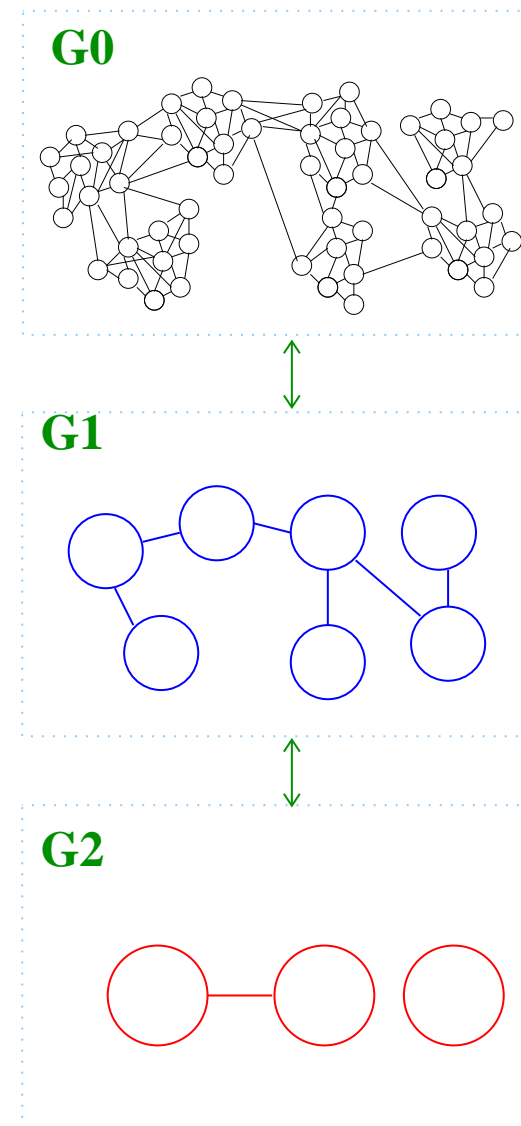
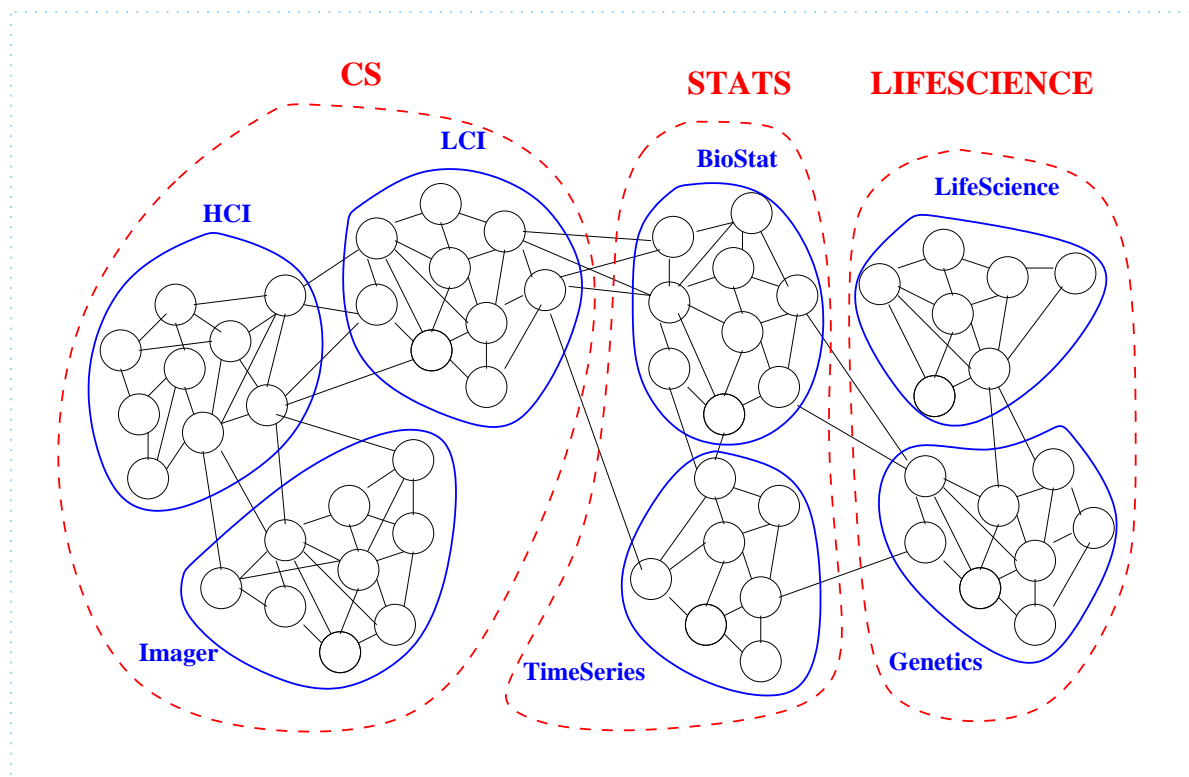
# An Intuitive Example



# An Intuitive Example



# Multiscale Representation of Graphs

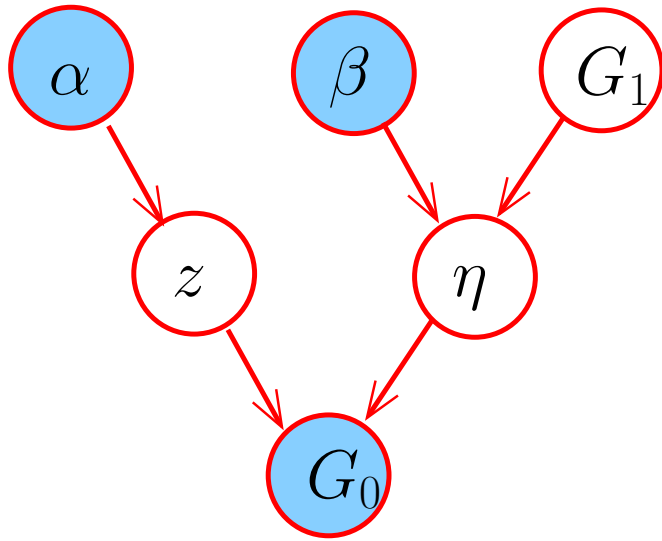


Learn at different scales and exchange information between scales for better learning

# Related Work

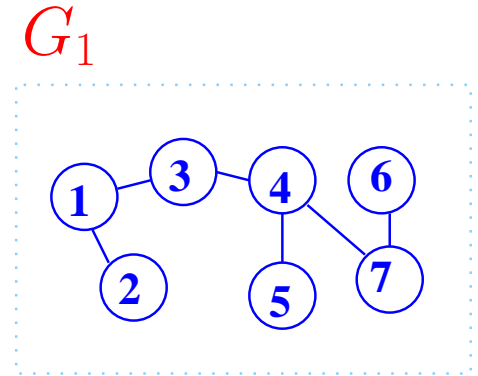
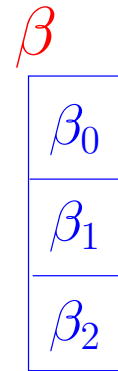
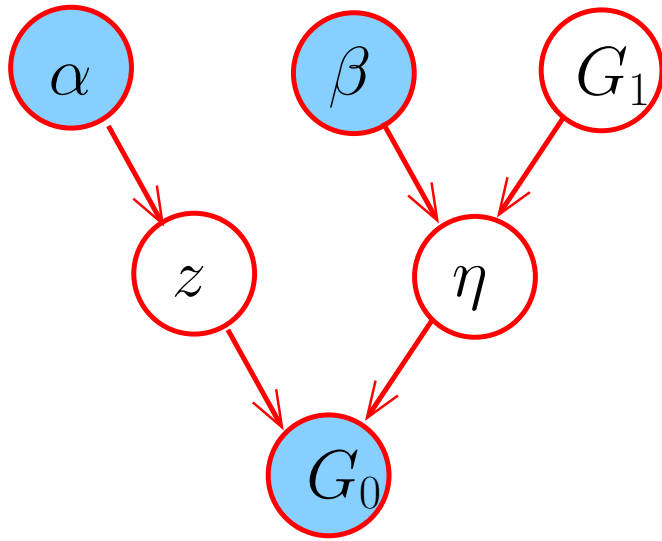
- Heirarchical Bayesian Models
- Structured priors for structure learning (2006, Josh Tannenbaum et.al.)
- Stochastic Blockmodeling
- Entity Resolution, Spectral Clustering, Modular Networks...
- Probably Many more...

# A Generative Model

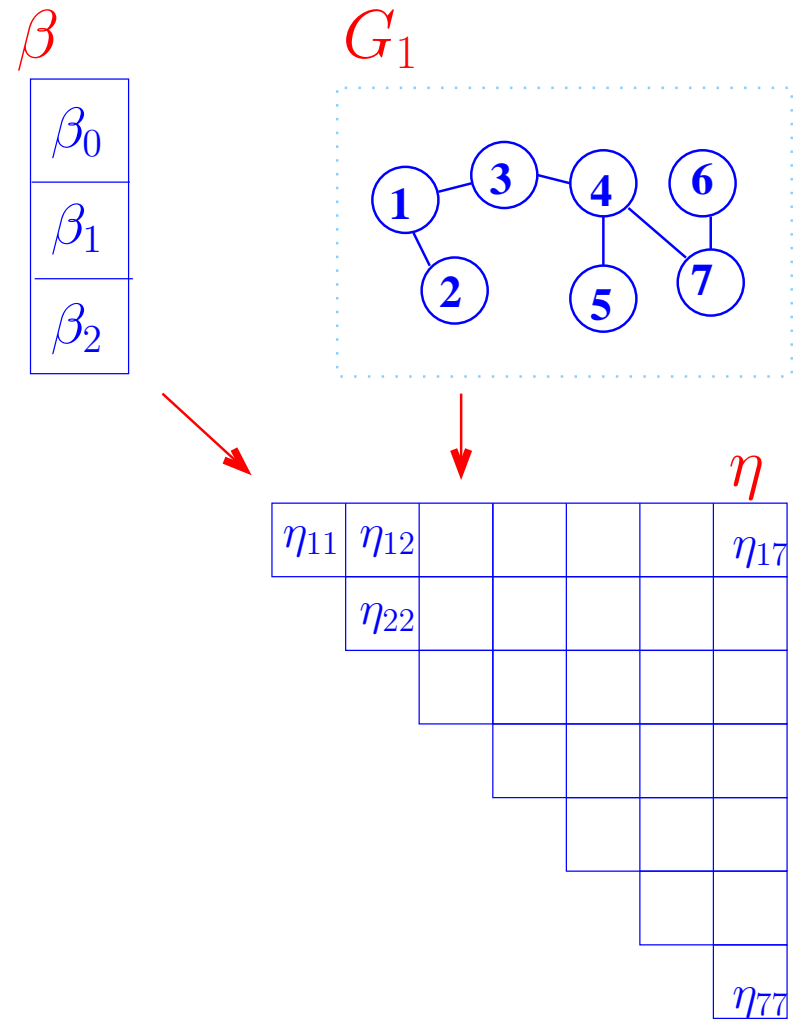
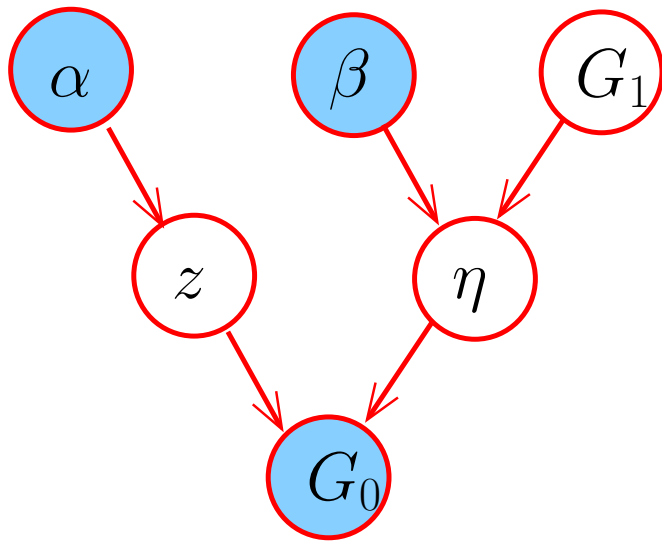




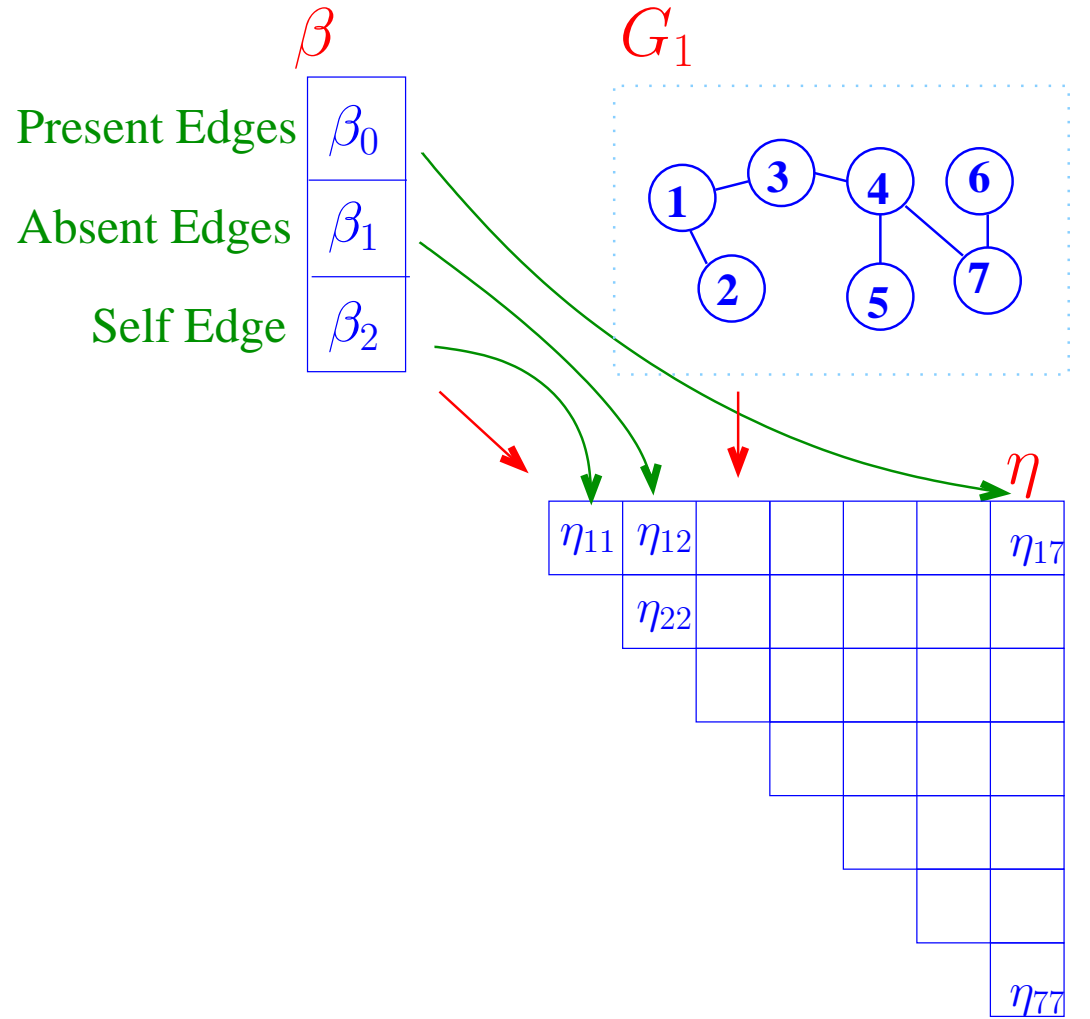
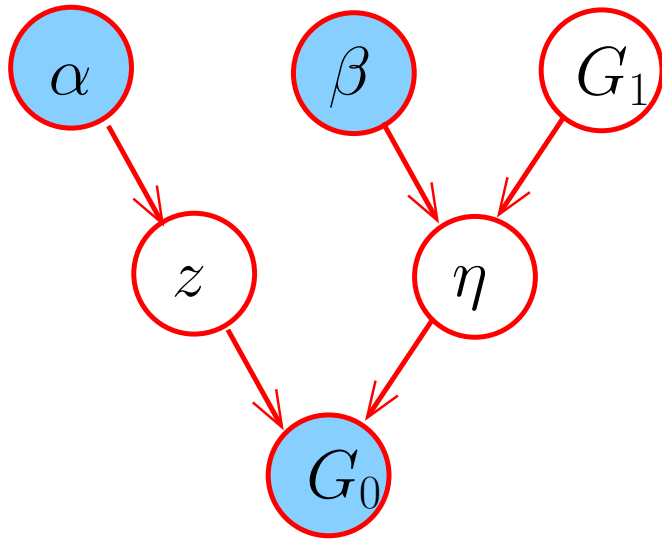
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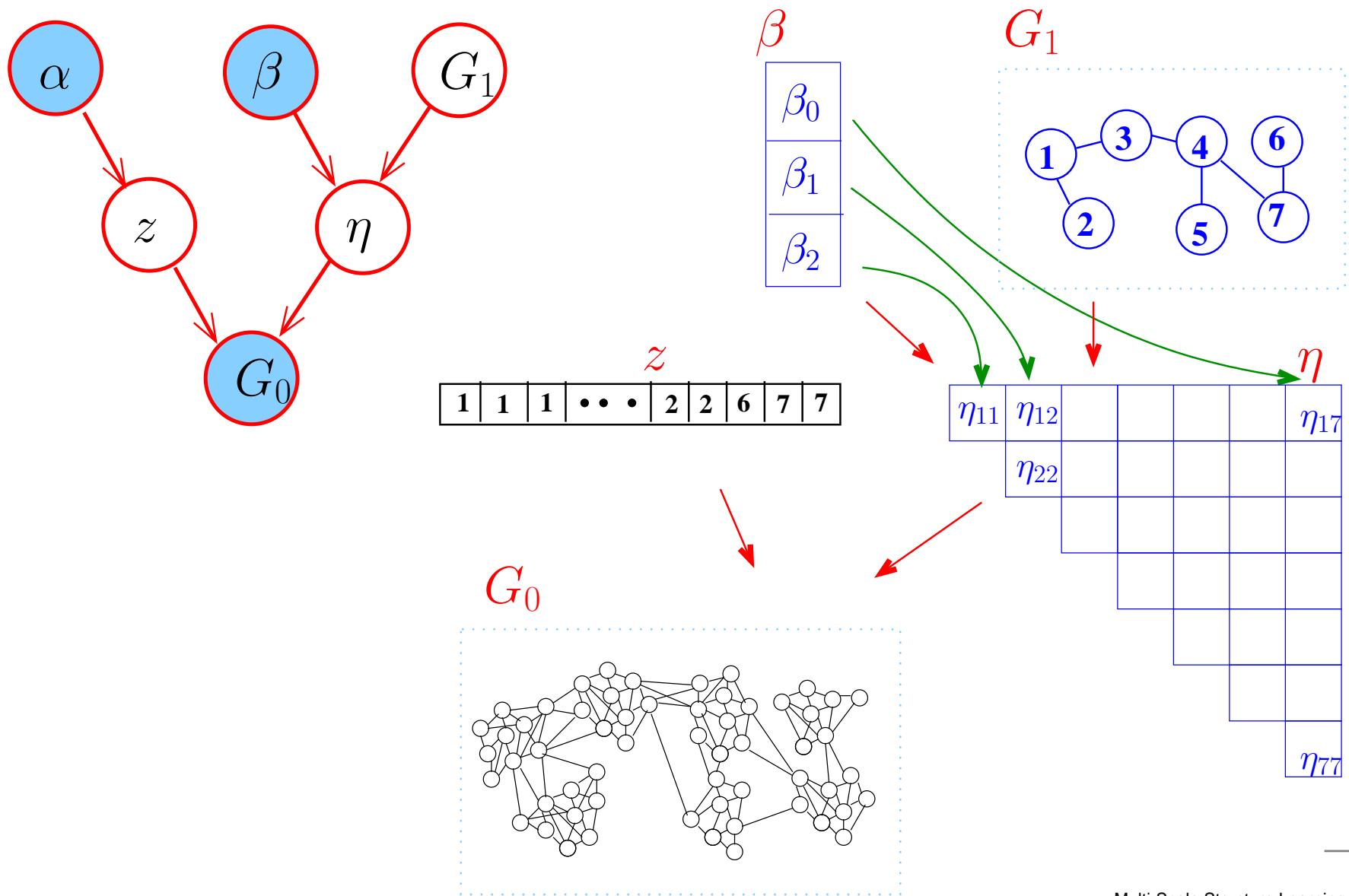
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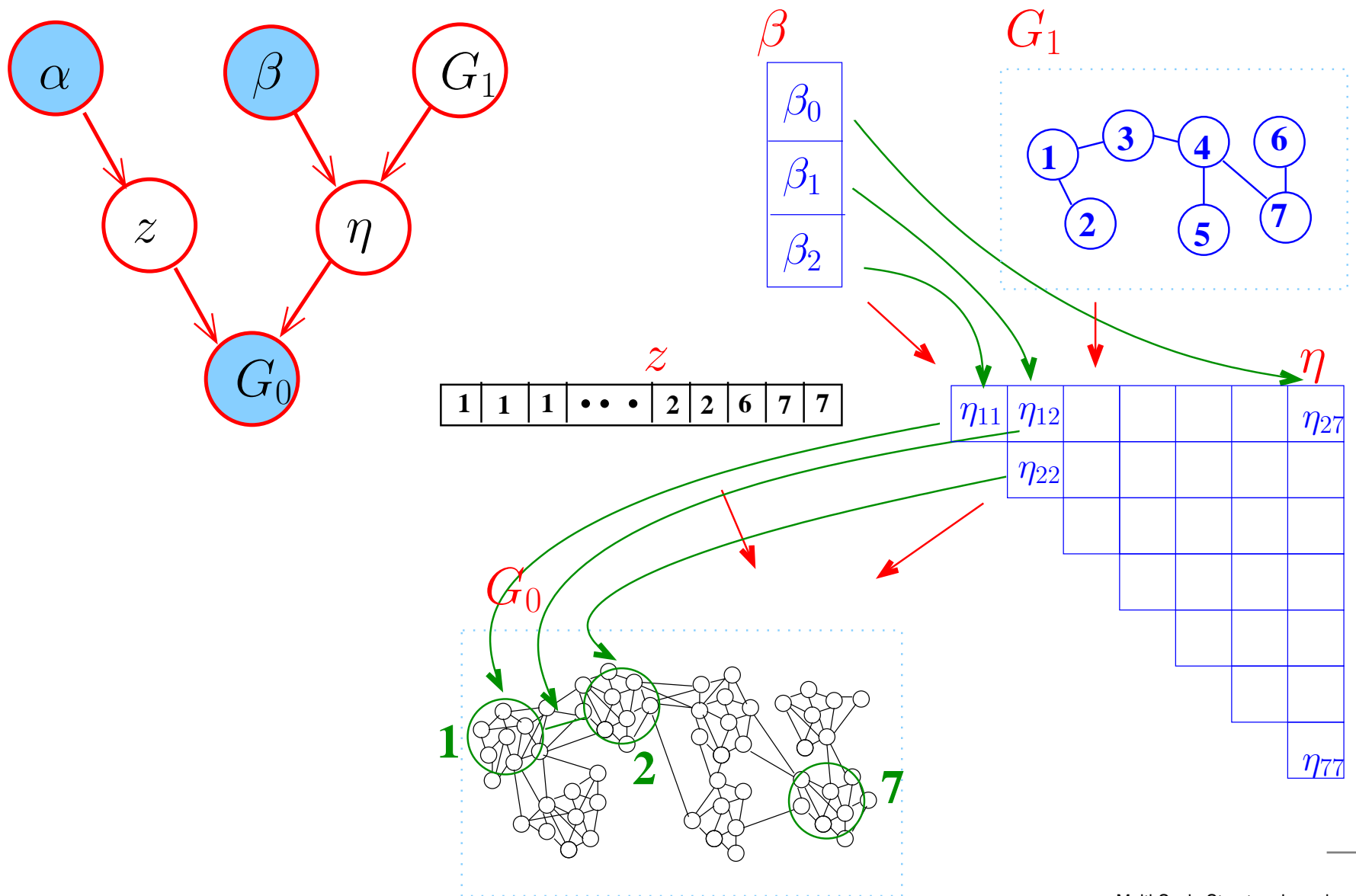
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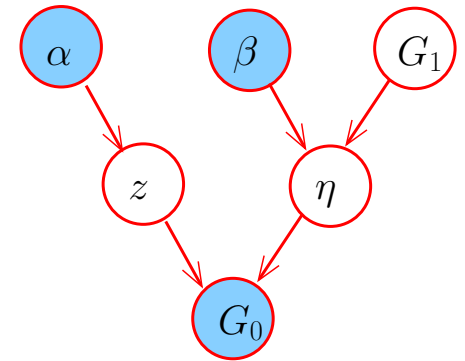
# A Generative Model

$$P(G_0|z, \eta) = \prod_{i=1}^{N-1} \prod_{j=i+1}^N \text{Bernoulli}(G_0^{ij} | \eta_{z_i, z_j})$$

$$P(\eta|\beta, G_1) = \prod_{a=1}^{K-1} \left[ \text{Beta}(\eta_{aa} | \beta_2) \prod_{b=a+1}^K \text{Beta}(\eta_{ab} | \beta_{G_1^{ab}}) \right]$$

$$p(z|\alpha) = \text{Multinomial}(z|\alpha)$$

$$P(G_1|\epsilon) = \prod_{a=1}^{K-1} \prod_{b=a+1}^K \text{Bernoulli}(G_1^{ab} | \epsilon)$$



We consider inferring  $G_1$  and  $z$  given  $G_0$  (collapsed Gibbs sampler).

# Collapsed Gibbs Sampler

We integrate  $\eta$  out, and Gibbs sample  $P(G_1|z)$  and  $P(z|G_1)$ :

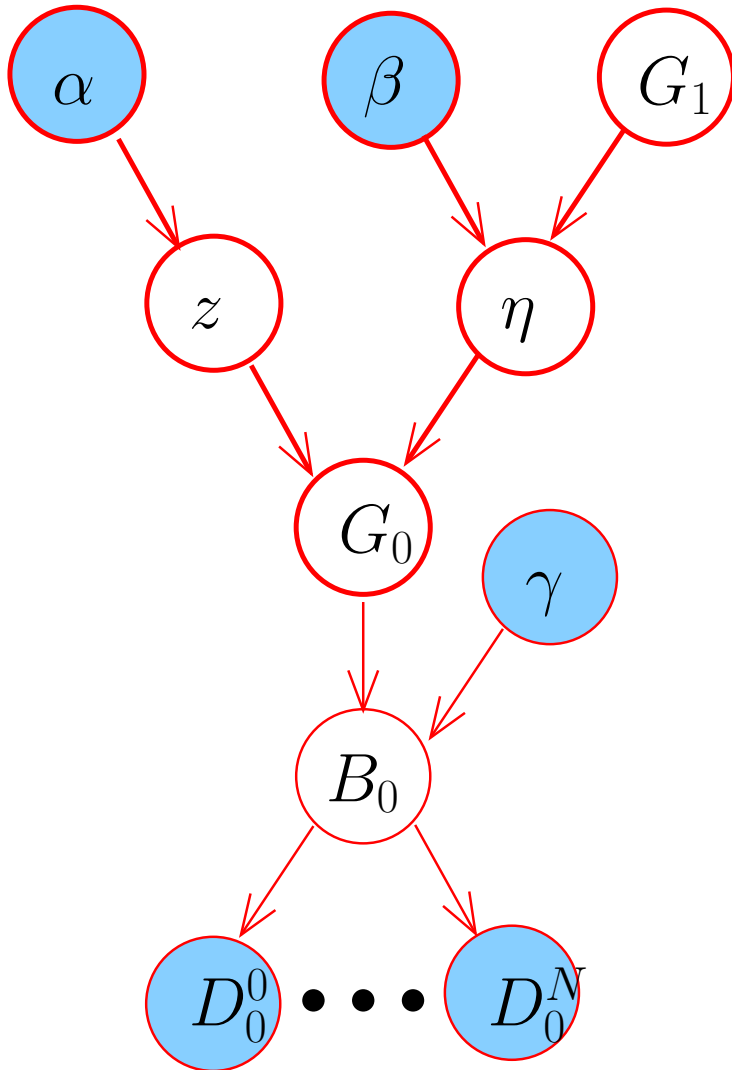
$$P(G_1^{ab} = 1|z) \propto \epsilon B\left(N_{a,b}^+ + \beta_{G_1^{a,b}}^1, N_{a,b}^- + \beta_{G_1^{a,b}}^2\right)$$

where  $N_{a,b}^+$  and  $N_{a,b}^-$  are the number of edges present and absent in  $G_0$  for the class pair  $a$  and  $b$  and  $B(c_1, c_2)$  is the constant of Beta Distribution.

$$P(z_i = k|G_1, G_0, z_{-i}) = \frac{p(G_0|G_1, z)p(z_i = k)}{\sum_j p(G_0|G_1, z)p(z_i = j)}$$

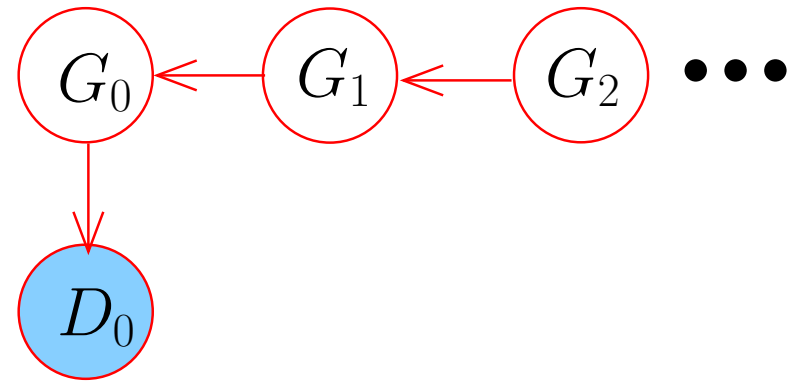
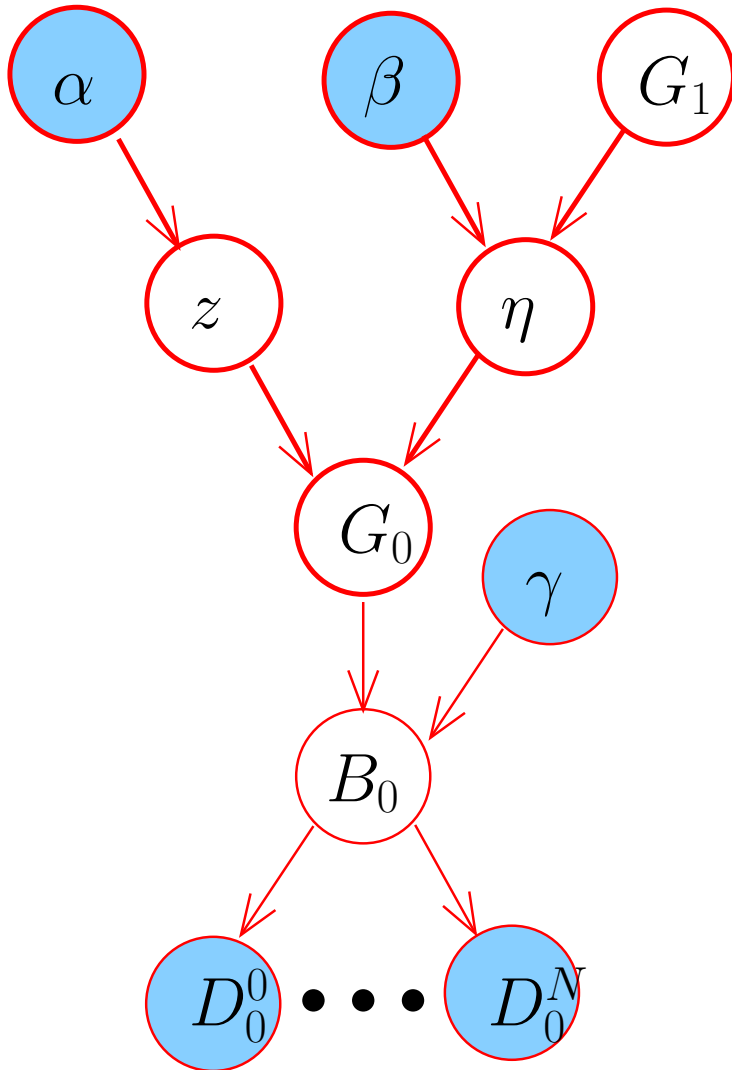
$$p(G_0|G_1, z) = \prod_{a=1}^{K-1} \left\{ \frac{B\left(N_{a,b}^+ + \beta_2^1, N_{a,b}^- + \beta_2^2\right)}{B\left(\beta_2^1, \beta_2^2\right)} \prod_{b=a+1}^K \frac{B\left(N_{a,b}^+ + \beta_{G_1^{a,b}}^1, N_{a,b}^- + \beta_{G_1^{a,b}}^2\right)}{B\left(\beta_{G_1^{a,b}}^1, \beta_{G_1^{a,b}}^2\right)} \right\}$$

# Future Work

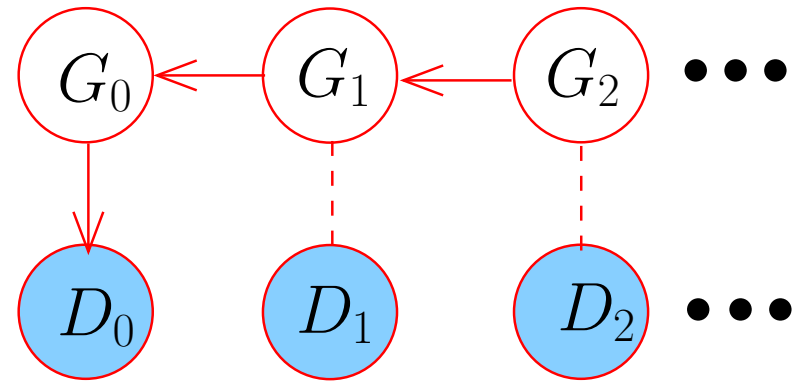
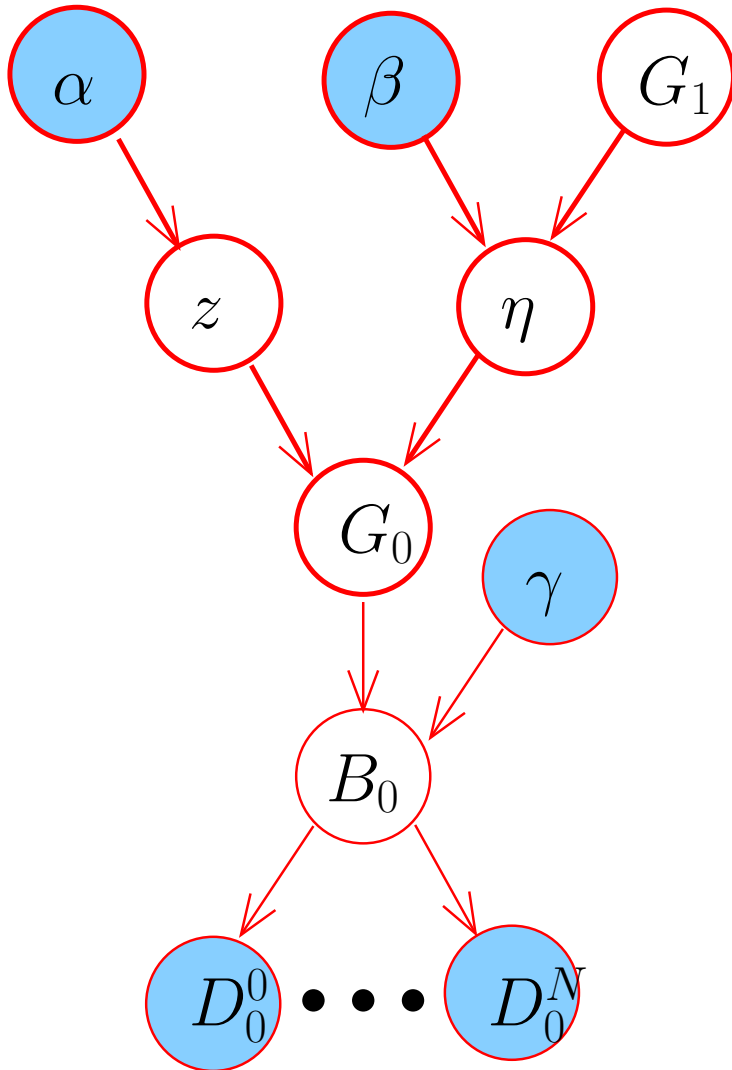




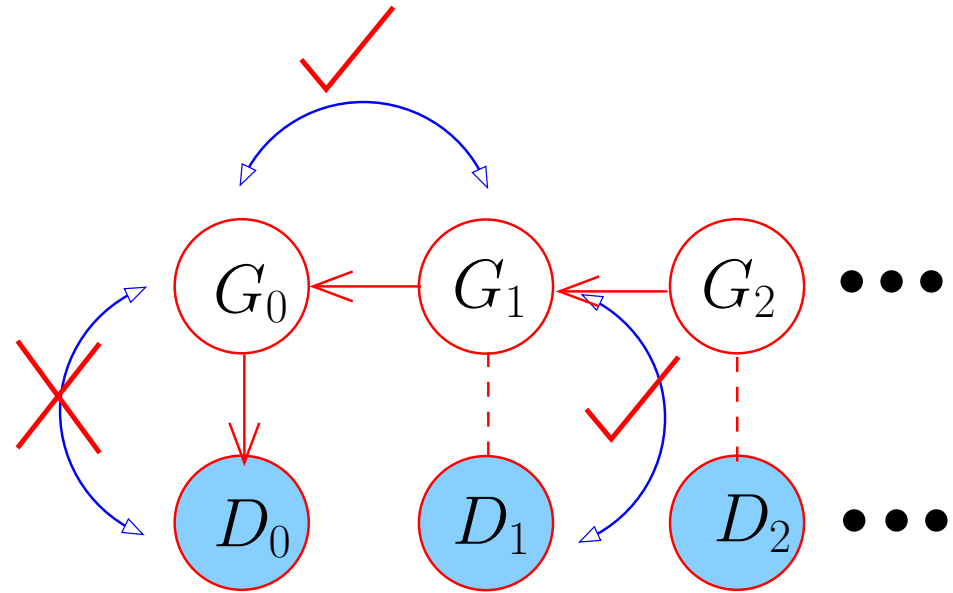
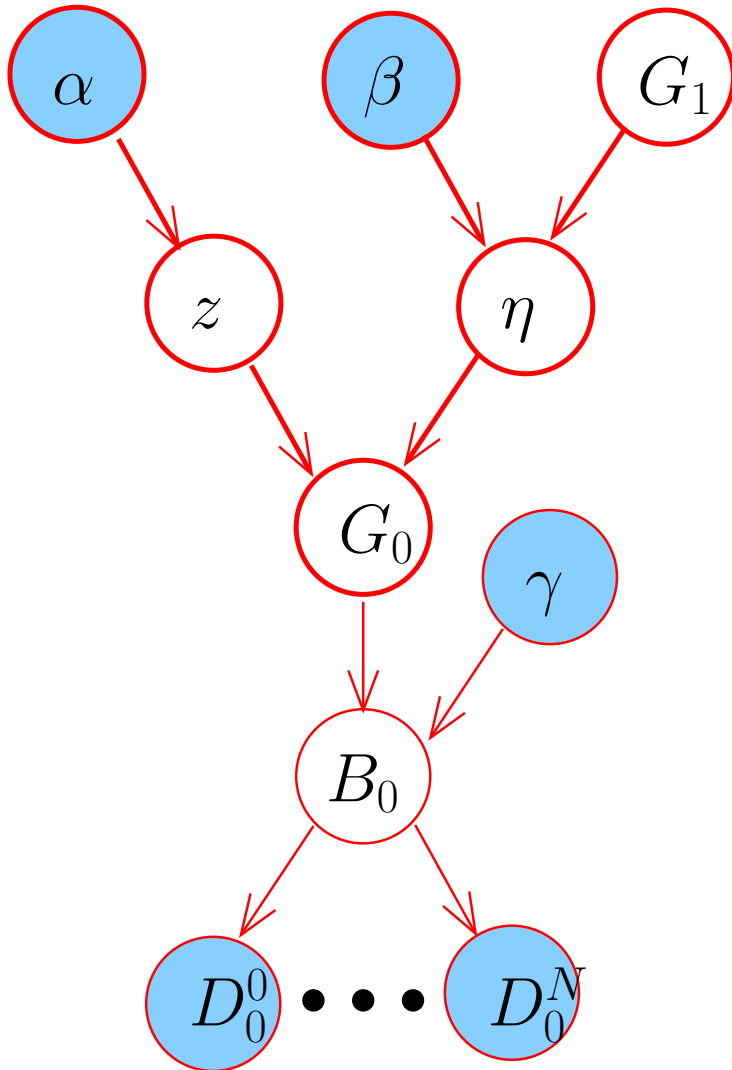
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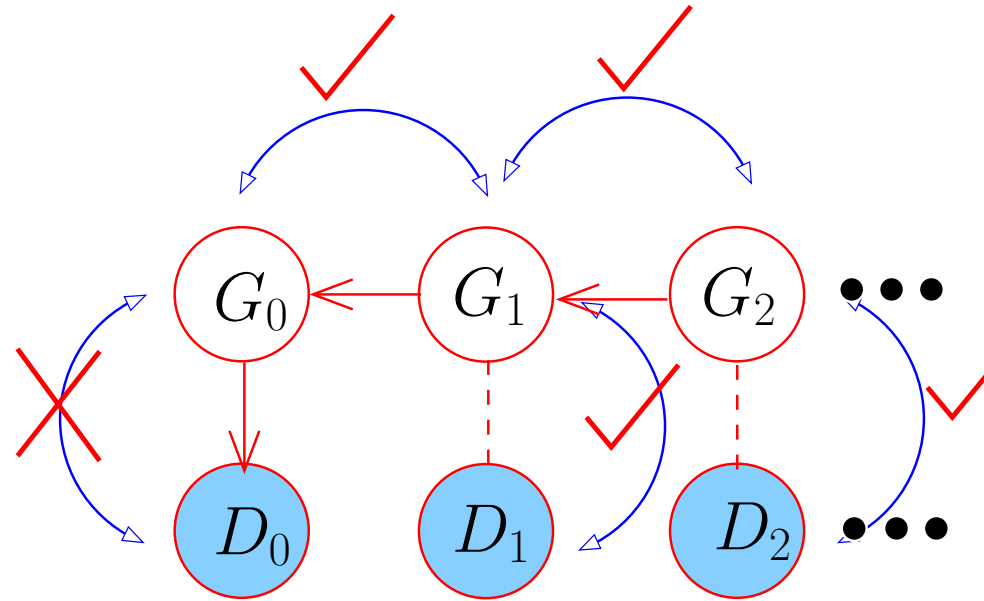
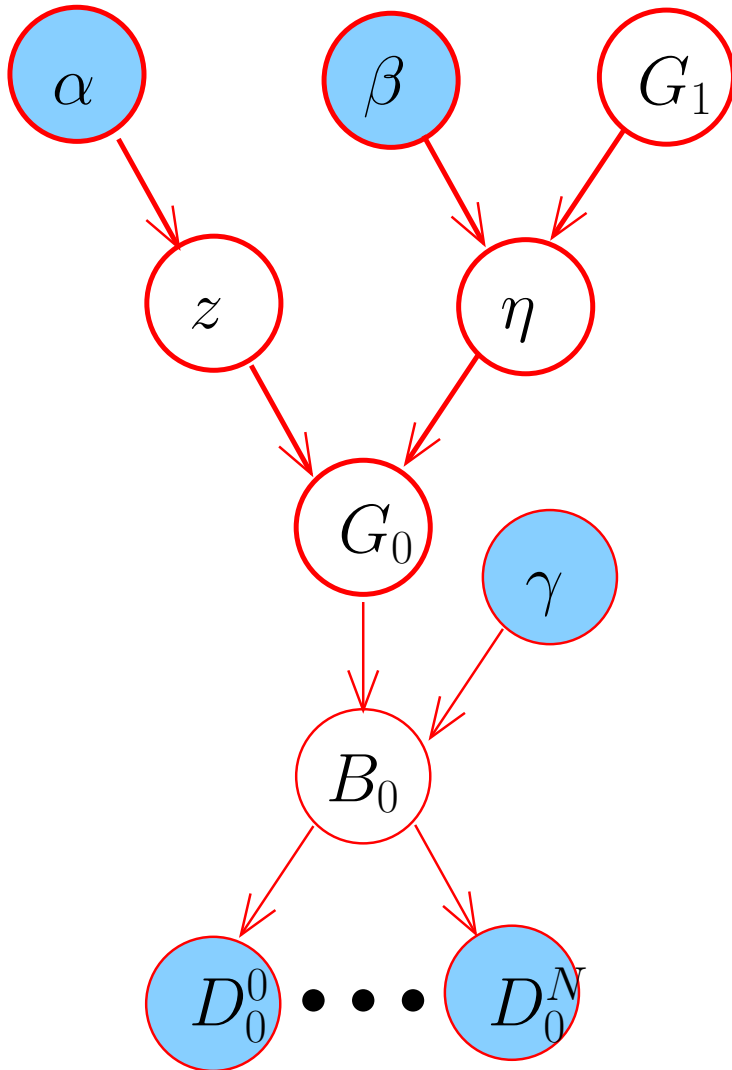
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# That's all!

Questions?