Combined Optimization Scheme for Degree Distributions of LDPC Codes

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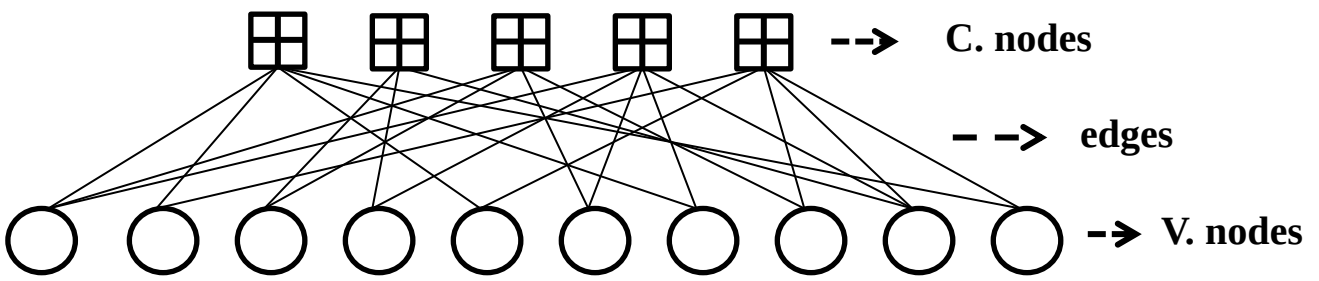


< Example of bipartite graph representation of an LDPC code >

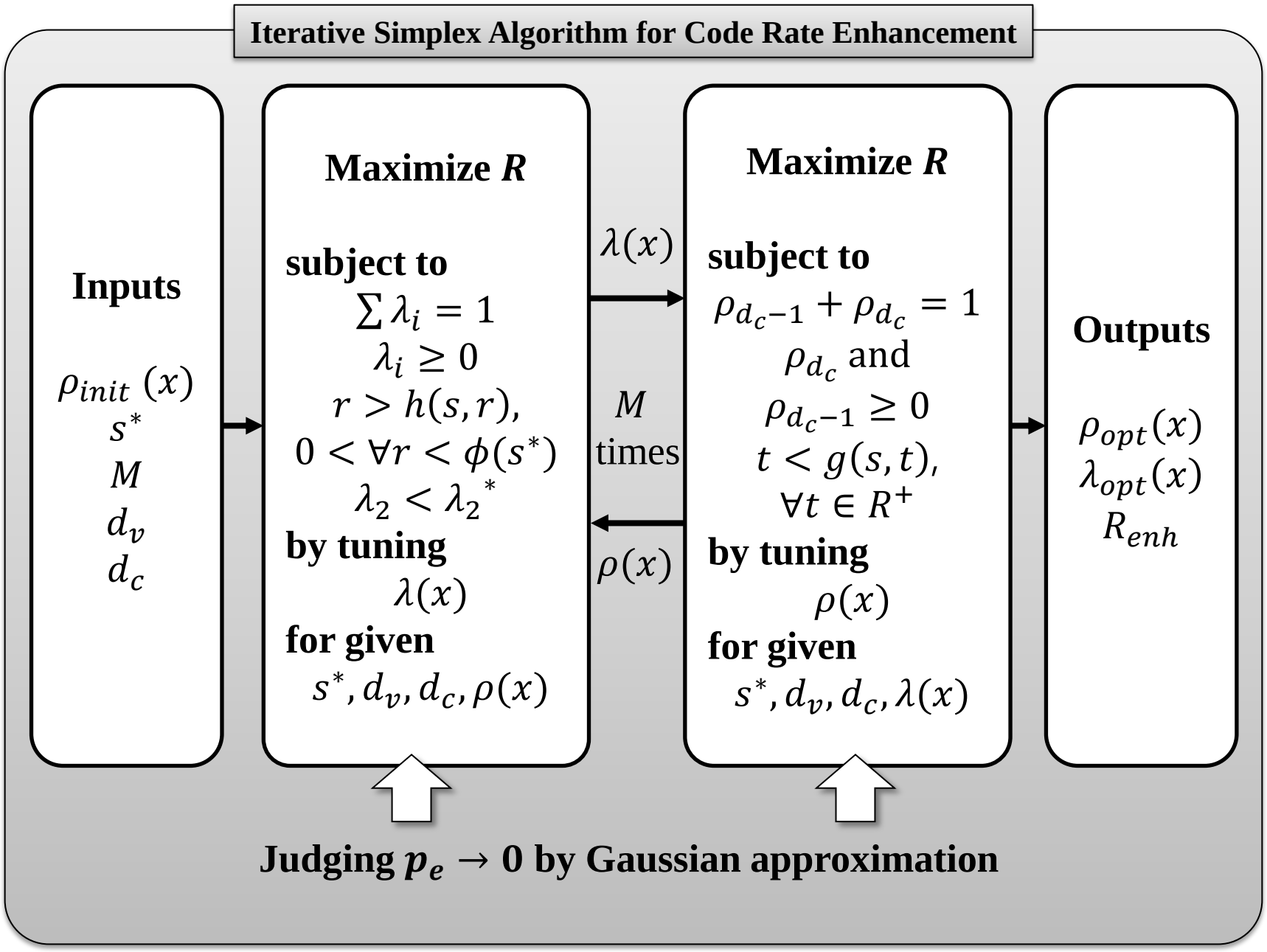
Degree Distribution of LDPC Code

$$\lambda(x) = \sum_{i=2}^{d_v} \lambda_i x^{i-1} \qquad \rho(x) = \sum_{i=2}^{d_c} \rho_i x^{i-1} \qquad \text{Code rate } R = 1 - \frac{\sum_{i=2}^{d_c} \frac{\rho_i}{i}}{\sum_{i=2}^{d_v} \frac{\lambda_i}{i}}$$

Two Objects of LDPC Code Optimization

s^*	Threshold of AWGN Channel
R	Code rate
p_e	Error probability
l	Number of decoding iterations
d_v, d_c	Max degree of variable and check nodes

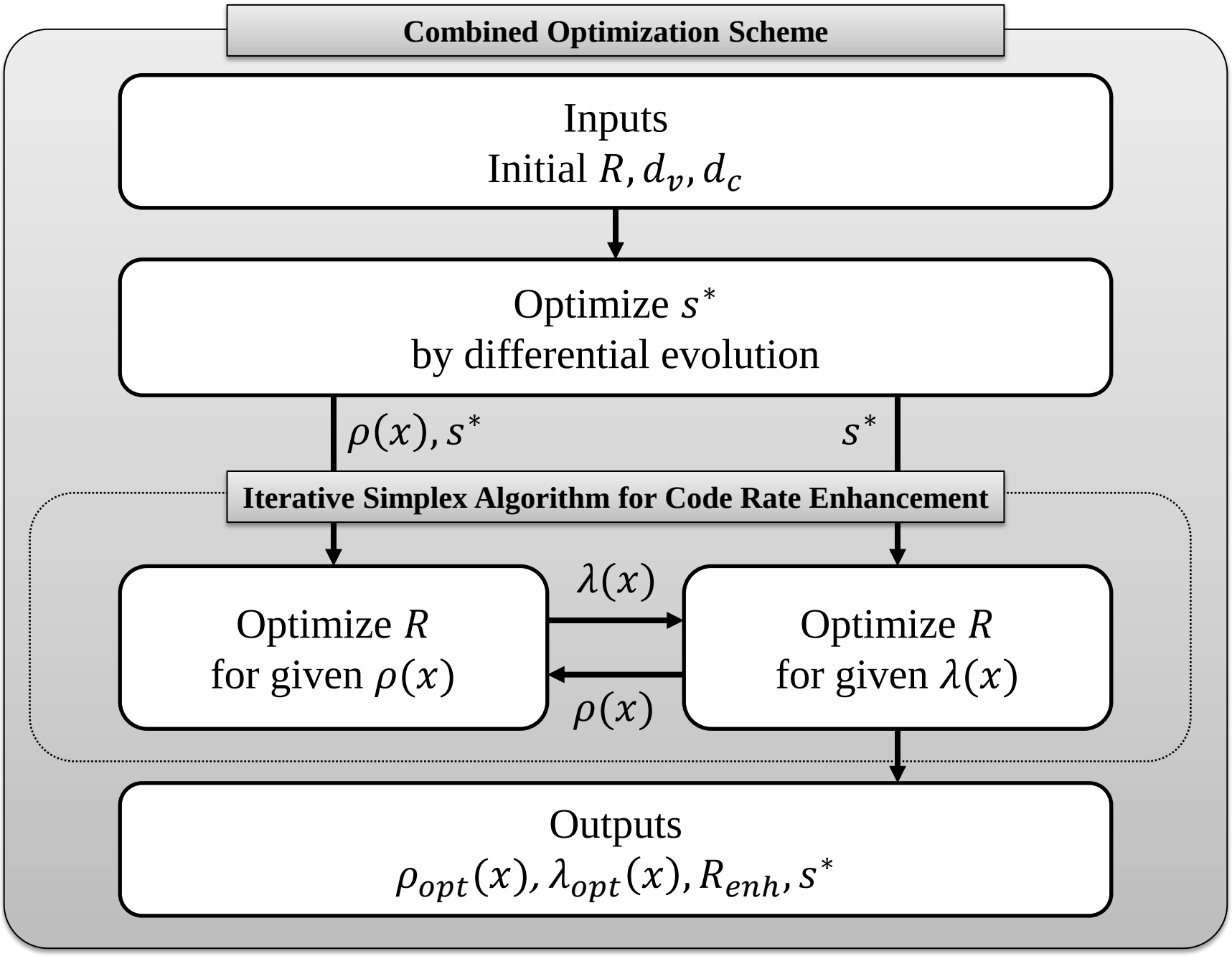
(a) Minimize s^*	(b) Maximize R
subject to	subject to
$p_e \to 0$ as $l \to \infty$ $\sum \rho_i = 1$ and $\sum \lambda_i = 1$	$p_e \to 0$ as $l \to \infty$ $\sum \rho_i = 1$ and $\sum \lambda_i = 1$
by tuning $\rho(x), \lambda(x)$ for given R, d_v, d_c	by tuning $\rho(x), \lambda(x)$ for given s^*, d_v, d_c
Differential Evolution	**Linear Programming**



Results of Code Rate Enhancement

	Richardson [8]				Result of code rate enhancement			
d_v	4	5	6	8	4	5	6	8
λ_2	0.38354	0.32660	0.33241	0.30013	0.38720	0.35140	0.35206	0.30681
λ_3	0.04237	0.11960	0.24632	0.28395	0.03290	0.15408	0.27317	0.26644
λ_4	0.57409	0.18393	0.11014		0.57990			
λ_5		0.36988				0.49450		0.00819
λ_6			0.31112				0.37477	
λ_7								0.03787
λ_8				0.41592				0.38069
ρ_5	0.24123				0.24123			
ρ_6	0.75877	0.78555	0.76611	0.22919	0.75877	0.78555	0.76611	0.22919
ρ_7		0.21445	0.23389	0.77081		0.21445	0.23389	0.77081
R	0.50000	0.50000	0.50839	0.50013	0.50021	0.50436	0.51116	0.50038
$(E_b/N_0)^*_{dB}$	0.8736	0.8318	0.7997	0.5778	0.8727	0.7943	0.7760	0.5756
$(E_s/N_0)^*_{dB}$	-2.1367	-2.1781	-2.1382	-2.4314	-2.1367	-2.1781	-2.1382	-2.4314

[8] T. J. Richardson, A. Shokrollahi, and R. Urbanke, "Design of capacity-approaching irregular low-density parity-check codes," IEEE Trans. on Information Theory, vol. 47, pp. 619-637, Feb., 2001.



Some New Degree Distributions

d_v	7	10	12	14	15
λ_2	0.32721	0.28413	0.25120	0.24250	0.25039
λ_3	0.27415	0.22737	0.18200	0.14597	0.19942
λ_4		0.01930	0.10740		
λ_5		0.09475		0.14764	0.06000
λ_7	0.39864				0.15268
λ_{10}		0.37446			
λ_{12}			0.45944		
λ_{14}				0.42869	
λ_{15}					0.33752
ρ_6	0.52918				
ρ_7	0.47082	0.80939			
ρ_8		0.22737	0.99294	0.76507	0.97786
ρ_9			0.00707	0.23493	0.02214
R	0.50164	0.50030	0.50316	0.50205	0.50443
$(E_b/N_0)^*_{dB}$	0.6473	0.5260	0.5202	0.4910	0.4874