Conventional solution and proof

In node order $(1, 2, 3)$, the link walk is

$$W = \begin{pmatrix} 0 & 1 & 0 \\ 1/2 & 0 & 1/2 \\ 0 & 1 & 0 \end{pmatrix}.$$

Uniform teleportation gives $P_\alpha = (1-\alpha)W + (\alpha/3)\mathbf{1}\mathbf{1}^\top$. Thus

$$P_0 = W, \qquad P_{1/2} = \begin{pmatrix} 1/6 & 2/3 & 1/6 \\ 5/12 & 1/6 & 5/12 \\ 1/6 & 2/3 & 1/6 \end{pmatrix}, \qquad P_1 = \frac{1}{3}\begin{pmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{pmatrix}.$$

These matrices are nonnegative and every row sums to one. The zero-teleport matrix is periodic; the other two have positive diagonal and positive communication between all nodes.

Structural or analytic derivation

The teleport correction is rank one. Its action on a probability vector is simply addition of $\alpha/3$ to each output coordinate, so it need not be stored as a dense matrix in a large graph.

Comparative cost and preferred method

For a graph with E links, one transition-vector product costs $O(E + N)$ using the link representation and rank-one teleportation, instead of $O(N^2)$ dense work. For this three-node question the exact fractions are the principal deliverable and direct computation is preferable.