Examples of Evolving Networks

- **Web** evolves rapidly: pages and hyperlinks are created and deleted; page contents and anchor texts are modified. (see Figure 1)
- **Bibliographic networks** grow at a high pace: new authors and publications appear, interconnecting citations are added.

**Introduction**

Link-based authority ranking techniques are employed to assess authority in a network of entities (e.g., web pages). In the context of web search these authority assessments have proven valuable when producing ranked result lists. However, existing approaches are based on a static snapshot of the network (e.g., its current state), thus neglecting the network’s history and dynamics.

**Our Baseline: PageRank [1]**

- Graph \( G(V,E) \) with nodes \( V \) and edges \( E \)
- PageRank score \( r(y) \) of a node \( y \) defined as \( r(y) = (1 - \epsilon) \left( \sum_{(x,y) \in E} \frac{r(x)}{\text{outdegree}(x)} \right) + \frac{\epsilon}{n} \)

- **Intuition**: Random surfer traverses graph either following outgoing edges or jumping to arbitrary nodes. The latter happens with probability \( \epsilon \). The score of a node is then proportional to the fraction of time the random surfer spends on the node.
- **Math**: Scores correspond to stationary state probabilities of a Markov chain that are determined by solving an eigenvector problem for a very large matrix.

**Time-aware Authority Ranking [2]**

- **Objective**: Assess authority with regard to a user-defined time-window (e.g., year 2004).
- **Our approach T-Rank**: Bias PageRank’s random walk based on temporal aspects.
- **Generalization of PageRank as a baseline**

\[
 r(y) = (1 - \epsilon) \left( \sum_{(x,y) \in E} t(x,y)r(x) \right) + \frac{s(y)}{n}
\]

\( t \) and \( s \) depend on *freshness* and *activity* that capture the timeliness and the frequency of change of nodes and edges.
- **Results**: User studies show improvements in the quality of rankings on different datasets (web, bibliographic, product data). Table 1 depicts Top-5 lists for the 2000s obtained on bibliographic data (DBLP).

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**Trend-based Authority Ranking**

- **Motivation**: PageRank favors old nodes. Consequently, it is hard for new nodes to obtain high authority scores.
- **Objective**: Overcome the bias against new nodes while preserving or improving the quality of ranking.
- **Our approach**: Assess the relative change of a node’s authority value with regard to a time-window. (This is ongoing work)

**References & Publications**