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News Personalization using the CF-IDF Semantic Recommender

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Introduction (1)

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- Recommender systems help users to plough through a massive and increasing amount of information
- Recommender systems:
  - Content-based
  - Collaborative filtering
  - Hybrid
- Content-based systems are often term-based
- Common measure: Term Frequency – Inverse Document Frequency (**TF-IDF**) as proposed by Salton and Buckley [1988]

Introduction (2)

- TF-IDF steps:
  - Filter stop words from document
  - Stem remaining words to their roots
  - Calculate term frequency (i.e., the importance of a term or word within a document)
  - Calculate inverse document frequency (i.e., the inverse of the general importance of a term in a set of documents)
  - Multiply term frequency with the inverse document frequency
- TF-IDF performance tends to decrease as documents get larger

Introduction (3)

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- The Semantic Web offers new possibilities
- Utilizing concepts instead of terms:
  - Reduces noise caused by non-meaningful terms
  - Yields less terms to evaluate
  - Allows for semantic features, e.g., synonyms
- Therefore, we propose Concept Frequency – Inverse Document Frequency (**CF-IDF**)
- CF-IDF is implemented in **Athena** (an extension for **Hermes** [Frasincar et al., 2009], a news processing framework)
- Results are evaluated in comparison with TF-IDF

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Introduction (4)

- Earlier work has been done:
  - CF-IDF-like methods: Baziz et al. [2005], Yan and Li [2007]
  - Frameworks: OntoSeek [Guarino et al., 1999], Quickstep [Middleton et al., 2004], News@hand [Cantador et al., 2008]
- Although some work shows overlap:
  - Methods are not thoroughly compared with TF-IDF
  - Often, WSD and synonym handling is lacking

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Outline

- TF-IDF
- CF-IDF
- Recommendations
- Implementation:
  - Hermes
  - Athena
- Evaluation
- Conclusions

TF-IDF

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- Term Frequency: the occurrence of a term t_i in a document d_j, i.e.,

$$tf_{i,j} = \frac{n_{i,j}}{\sum_k n_{k,j}}$$

- Inverse Document Frequency: the occurrence of a term t_i in a set of documents D, i.e.,

$$idf_i = \log \frac{|D|}{|\{j : t_i \in d_j\}|}$$

- And hence

$$tf\text{-}idf_{i,j} = tf_{i,j} \times idf_i$$

CF-IDF

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- Concept Frequency: the occurrence of a concept c_i in a document d_j, i.e.,

$$cf_{i,j} = \frac{n_{i,j}}{\sum_k n_{k,j}}$$

- Inverse Document Frequency: the occurrence of a concept c_i in a set of documents D, i.e.,

$$idf_i = \log \frac{|D|}{|\{j : c_i \in d_j\}|}$$

- And hence

$$cf\text{-}idf_{i,j} = cf_{i,j} \times idf_i$$

Recommendations

- Ontology contains a set of concepts and relations
- User profile consists of (a subset of) these concepts and relations
- Each concept and relation is associated with all news articles
- Each article is represented as:
  - TF-IDF: a set containing all terms
  - CF-IDF: a set containing all concepts
- Then, for each article, weights are calculated
- Weights of a new article are compared to the user profile using cosine similarity

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Implementation: Hermes

- Hermes framework is utilized for building a news personalization service
- Its implementation Hermes News Portal (**HNP**):
  - Is ontology-based
  - Is programmed in Java
  - Uses OWL / SPARQL / Jena / GATE / WordNet
- Input: RSS feeds of news items
- Internal processing:
  - Classification
  - News querying
- Output: news items

Implementation: Athena (1)

- Athena is a plug-in for HNP
- Main focus is on recommendation support
- User profiles are constructed
- TF-IDF (using a stemmer as proposed in [Krovetz, 1993]) and CF-IDF recommendation calculations can be performed

Implementation: Athena (2)

- Interface:
  - News browser
  - Recommendations
  - Evaluation

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Implementation: Athena (3)

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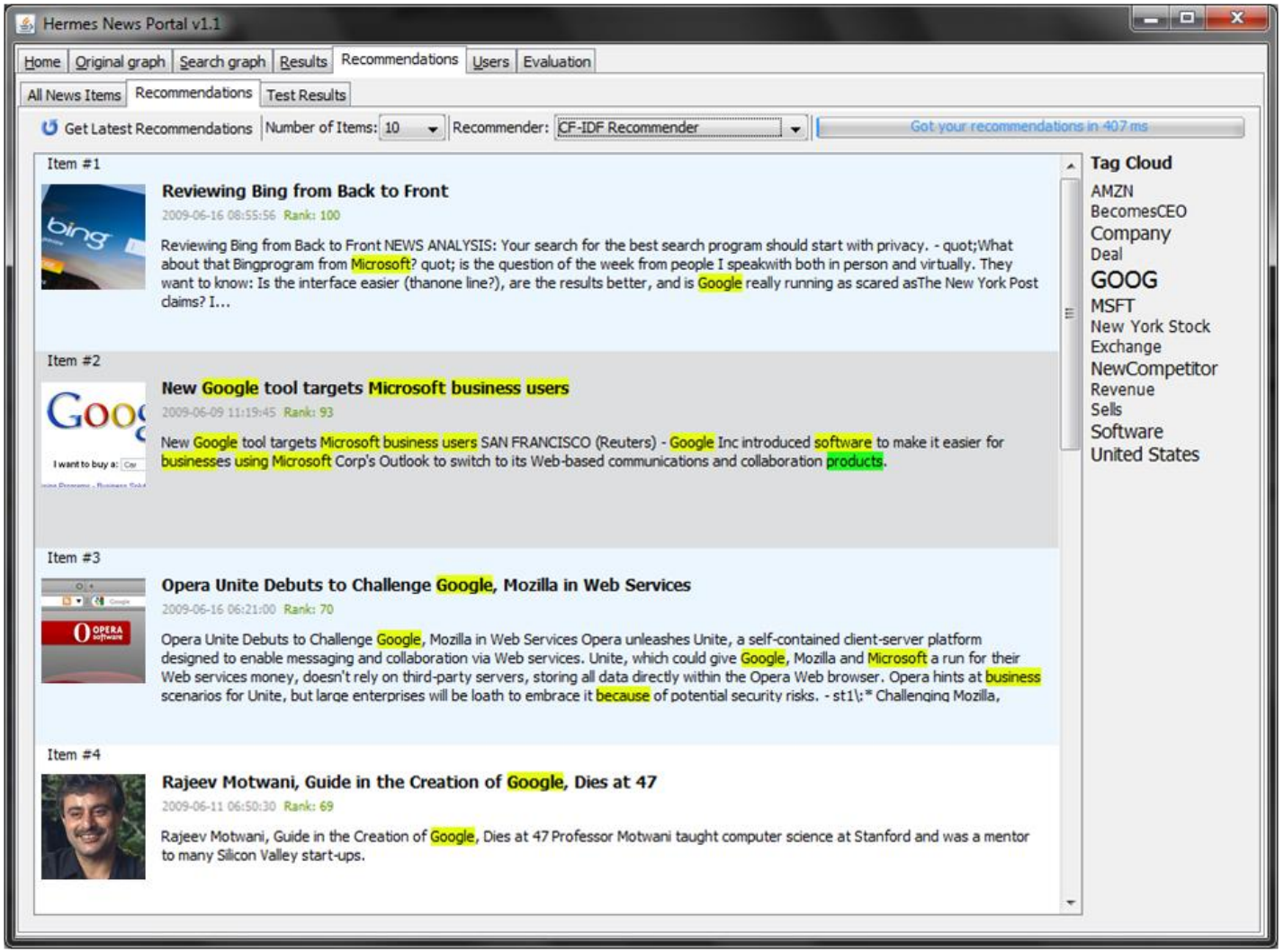

Implementation: Athena (4)

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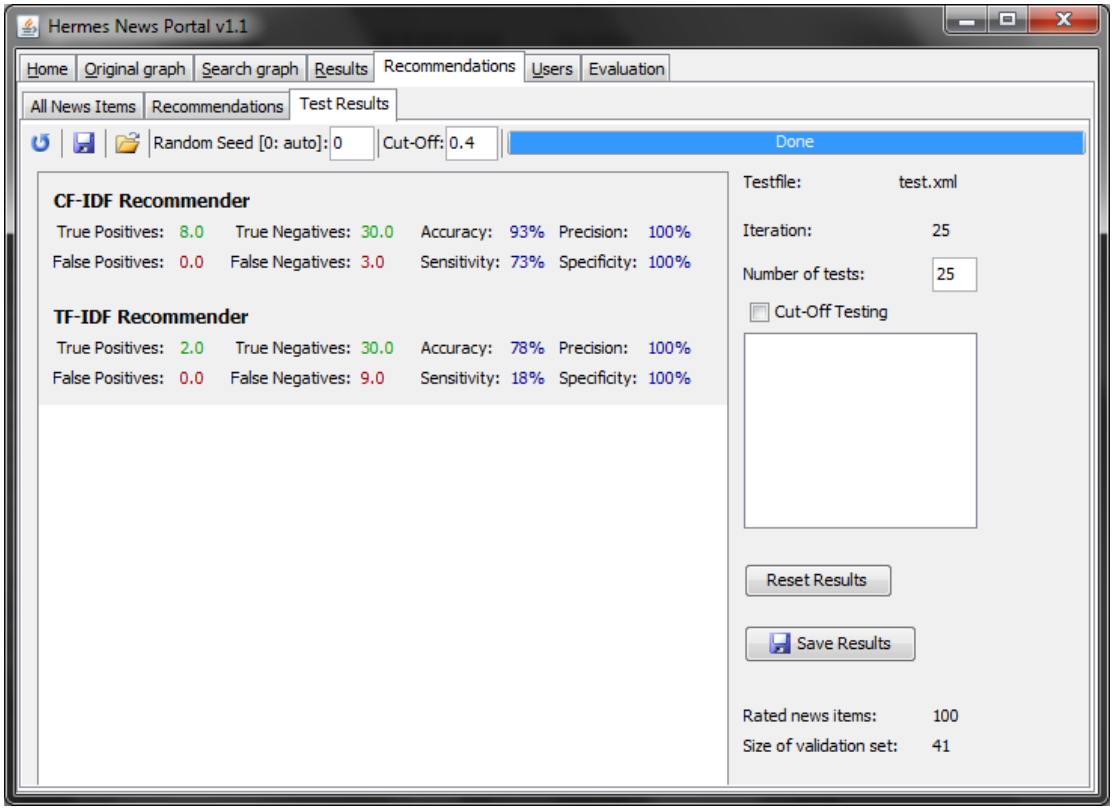

Evaluation (1)

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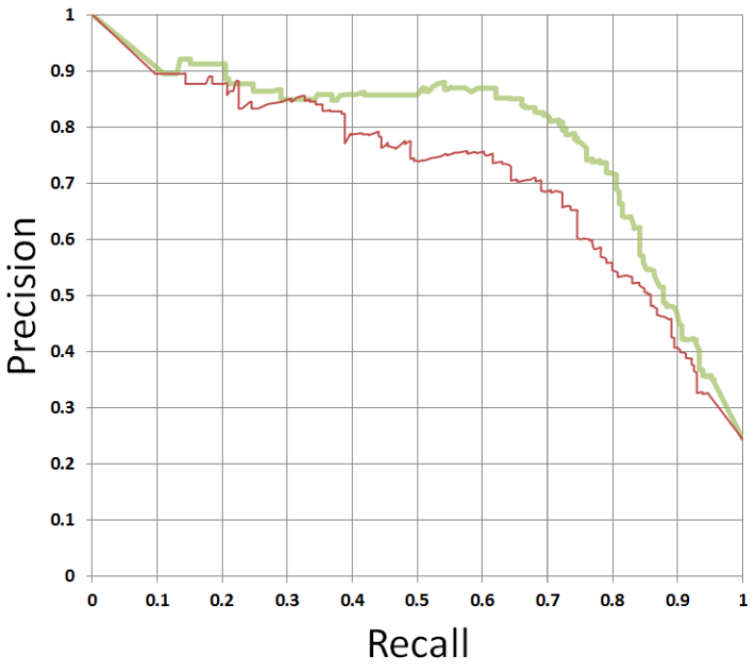
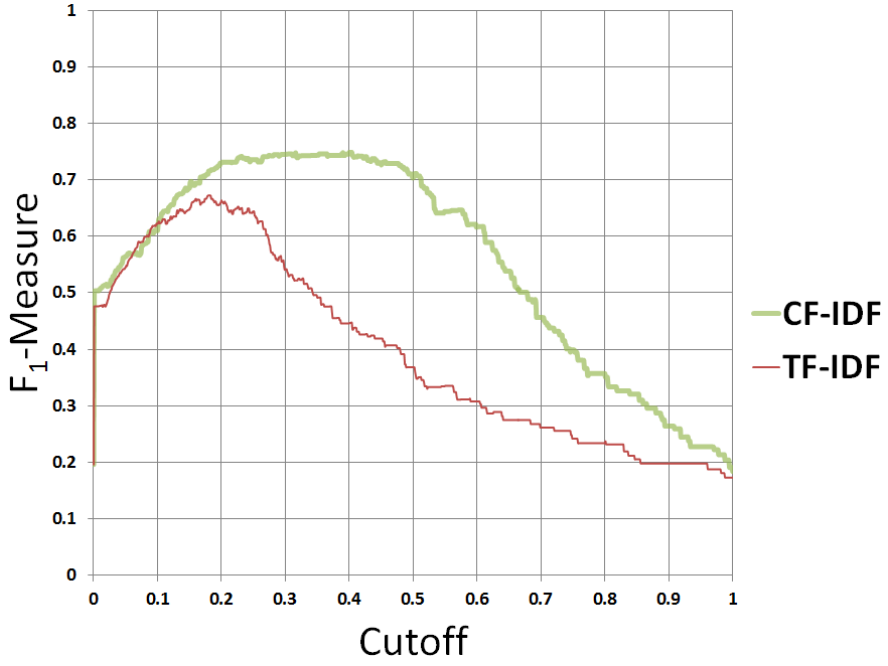
- Experiment:
  - We let 19 participants evaluate 100 news items
  - User profile: all articles that are related to Microsoft, its products, and its competitors
  - Athena computes TF-IDF and CF-IDF and determines interestingness using several cutoff values
  - Measurements:
    - Accuracy
    - Precision
    - Recall
    - Specificity
    - F_1-measure
    - Kappa statistic
    - Receiver Operating Characteristic (ROC) curves
    - *t*-tests for determining significance

Evaluation (2)

- Results:
  - CF-IDF performs significantly better than TF-IDF for accuracy (**+4.7%**), recall (**+24.4%**), and F_1 (**+21.9%**) for threshold 0.5
  - Precision and specificity are not significantly different





Evaluation (3)

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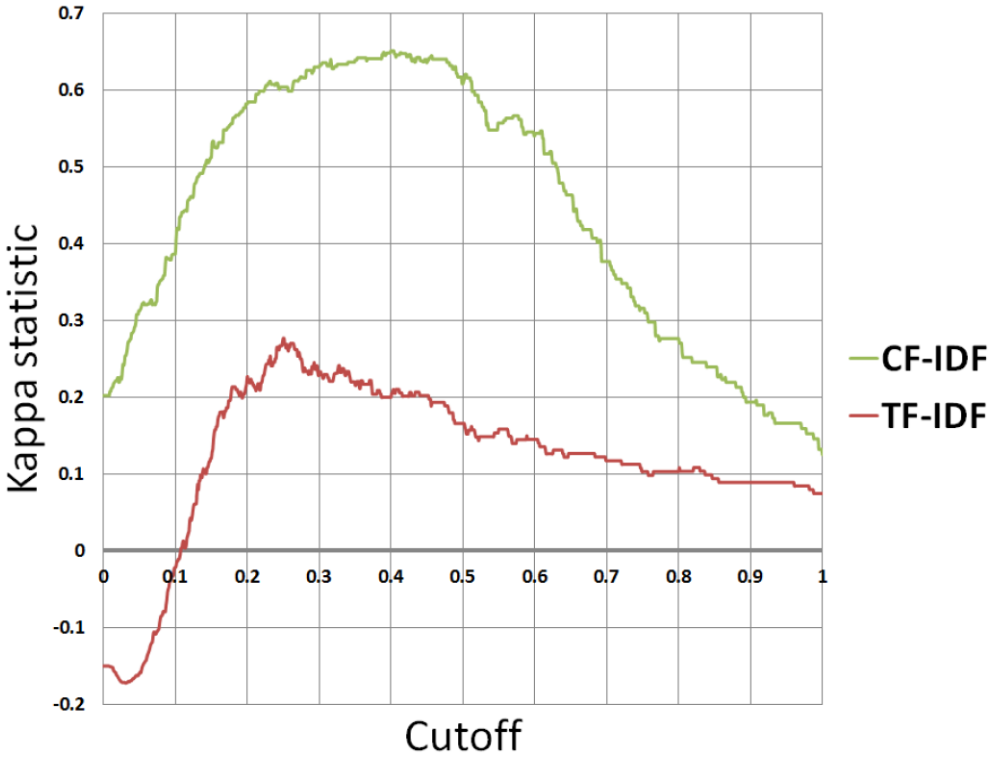

Evaluation (4)

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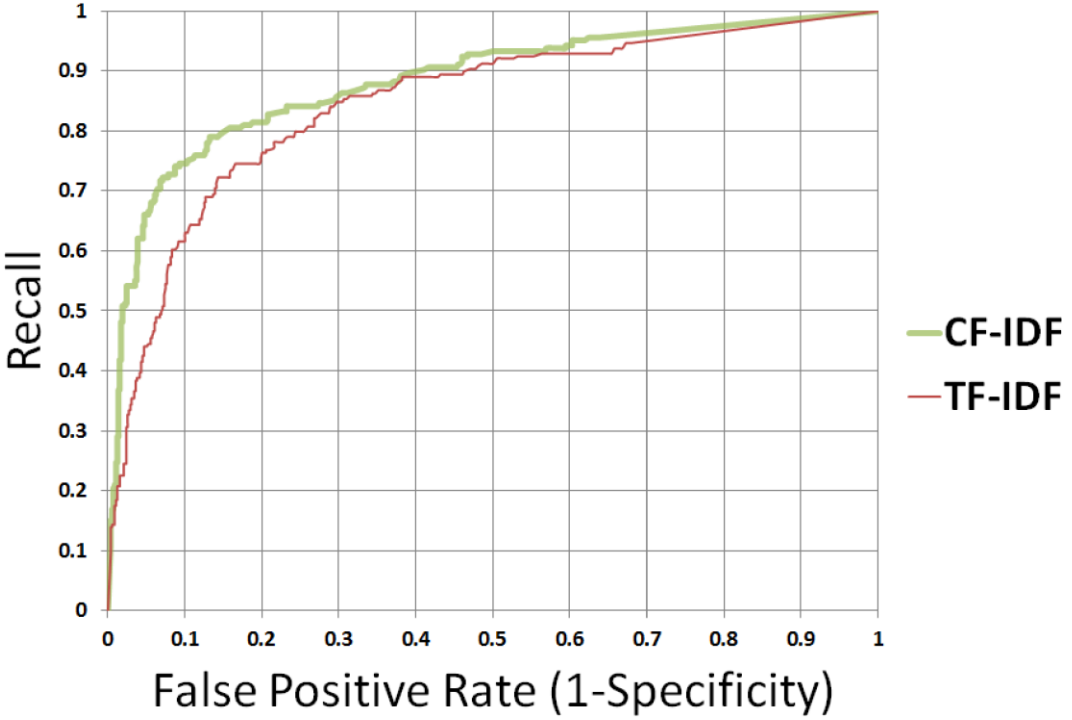

Conclusions

- CF-IDF outperforms TF-IDF significantly for many measures: accuracy, recall, F_1, Kappa, and ROC (AUC)
- Hence, using key concepts and semantics instead of analyzing all terms could be beneficial for recommender systems
- Future work:
  - Use different stemmers for TF-IDF
  - Investigate and compare with TF-IDF variants that account for some limitations (e.g., Okapi BM25)
  - Implement various concept relationship types

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Questions

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