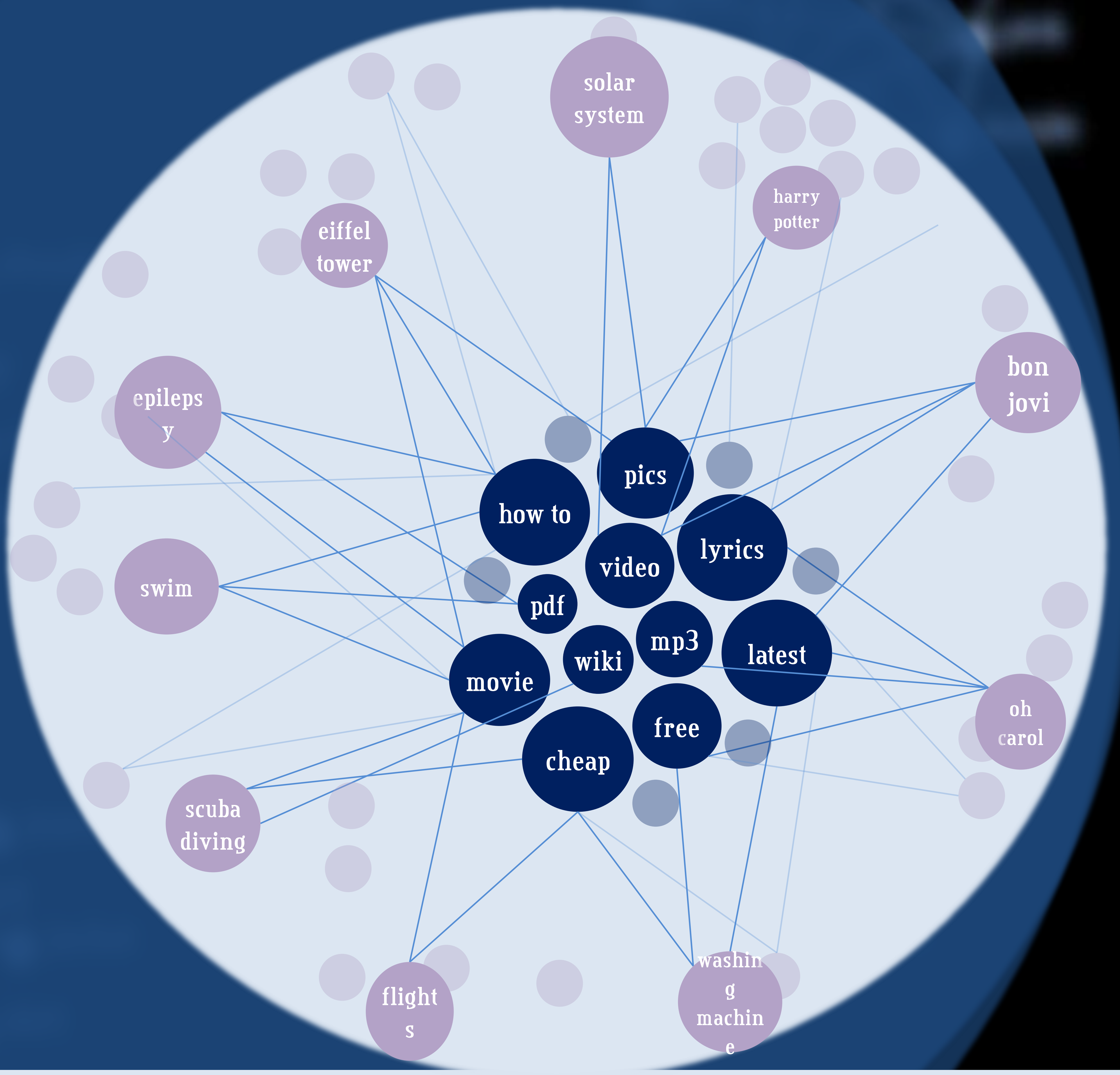
Complex Network Analysis of Word Co-occurrence Networks

Natural Language	Queries
|K| = 5000 units	|K| = 1000 units
|P| = 84,000 units	|P| = 1,200,000 units
Sentences formed by units from K and P, or only K	Queries mostly formed by units from K and P, or only P
Intra-K edges dominate	K to P edges dominate
K more tightly coupled	K less tightly coupled

Property	NL	Queries
Degree Distribution	2-regime	2-regime
Clustering coefficient	0.437	0.630
Average shortest path	2.670	3.305



Structural Complexity of Web Search Queries

through the Lenses of Positionality, Language Models and Networks

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Change in Segment Positions

- For 2006 and 2010 logs, segments with the highest co-occurrence counts are labeled *intent*, and the rest as *content*
- For each segment, query beginning probability P_b, ending probability P_e and that of occurring in the middle P_m are computed
- Navigational queries like *imdb* and *youtube* are now appended as intent (P_b drops)
- Intent segments (*how to, news*) stabilizing towards ends of query (P_b rises or P_e rises)
- Stacking of intent segments gradually making search queries longer

Perplexity of Language Models

Model	NL	Queries	NL	Queries
	(Perplexity)	(Perplexity)	(Counts)	(Counts)
1-gram	1,406.59	6,417.28	0.3M	0.2M
2-gram	193.722	104.337	3.5M	1M
3-gram	17.663	5.43	9.7M	1.1M
2-set	893.851	384.945	48.1M	4.2M
3-set	N.A.	23.36	N.A.	24.8M

- Perplexity is an information theoretic measure of how perplexed a user is in predicting the n^{th} word
- Perplexity of unigram model much larger for queries
- In contrast, bigram and trigram perplexity much lower for queries`

Conclusions

- Web search queries provide a very interesting case of a complex self-organizing communication system which has its unique characteristics
- Queries structurally simpler than NL, but more complex than bags-of-words model
- Several similarities with NL that make this system interesting to study from a language evolution perspective

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