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Analyzing the DarkNetMarkets Subreddit for Evolutions of Tools and Trends Using Latent Dirichlet Allocation

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The DarkWeb and Darknet Markets

- The darkweb are websites which can only be accessed through anonymity networks such as Tor.
- Well known for hosting online criminal market places, “Darknet Markets”.
  - Vendors use markets as a platform for selling drugs, weapons, malware, and other illicit items.
- In July 2017, there were significant law enforcement busts that shut down the two most popular markets, Hansa and Alphabay.

This Research

- How can we relatively quickly understand how the bust affected the markets, users, and tools of DNM users?
- Let’s crawl for a years worth of content from a darknet market oriented subreddit (forum), called “darknetmarkets”.
- That’s a of information, let’s try topic modelling on each month of the extracted content.
- The topics produced can be used as a sort of text summarization for a large number of documents.

Topic Modeling?

- Given a corpus of documents and N topics, a Latent Dirichlet Allocation algorithm can generate N topics that the corpus is composed of.
- Trivial topic modelling example:
  - Topic 1: {dog, leash, kibble, walk, cat, …},
    Topic 2: {Trees, nature, walk, park, …}
- These topic-word distributions are one of the latent items learn that we learn.
  - Which we use for our work.

How can we use these topics?

- To quickly see how things changed from pre-bust to post-bust.
- To understand criminal community
- To Identify useful keywords in generated topics (tools, vendors, markets, etc).
  - Hopefully data pops out at us.

Caveats to this story (1)

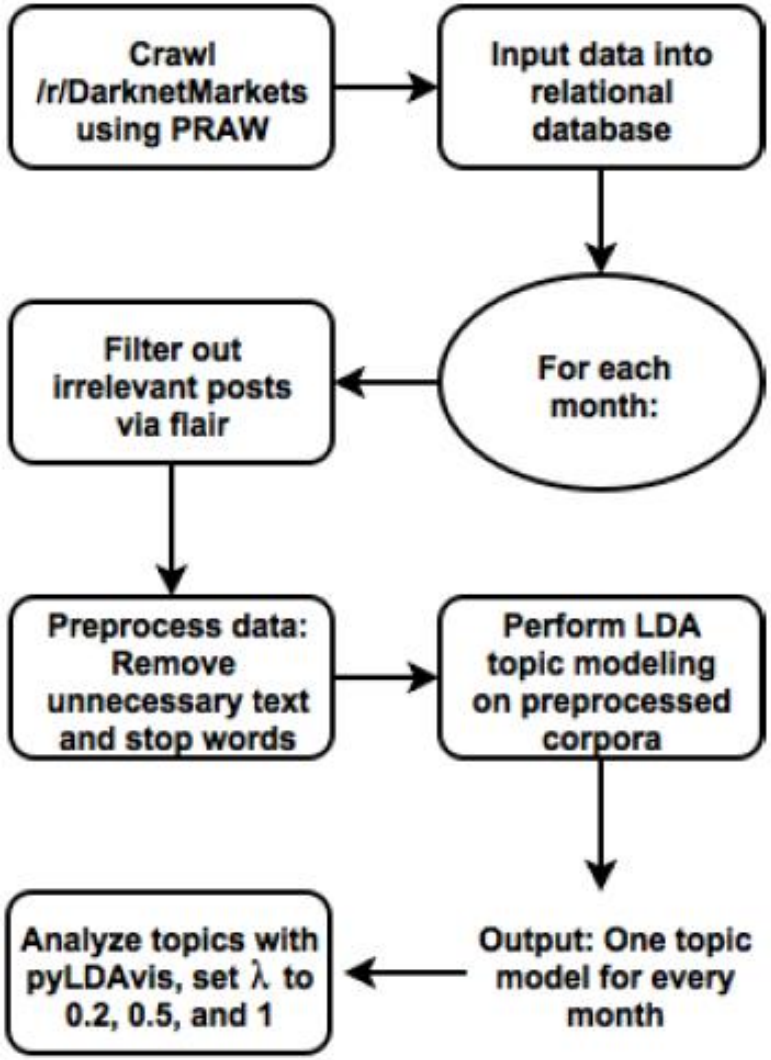
- The DarknetMarkets subreddit was banned by Reddit in March 2018.

https://motherboard.vice.com/en_us/article/ne9v5k/reddit-bans-subreddits-dark-web-drug-markets-and-guns

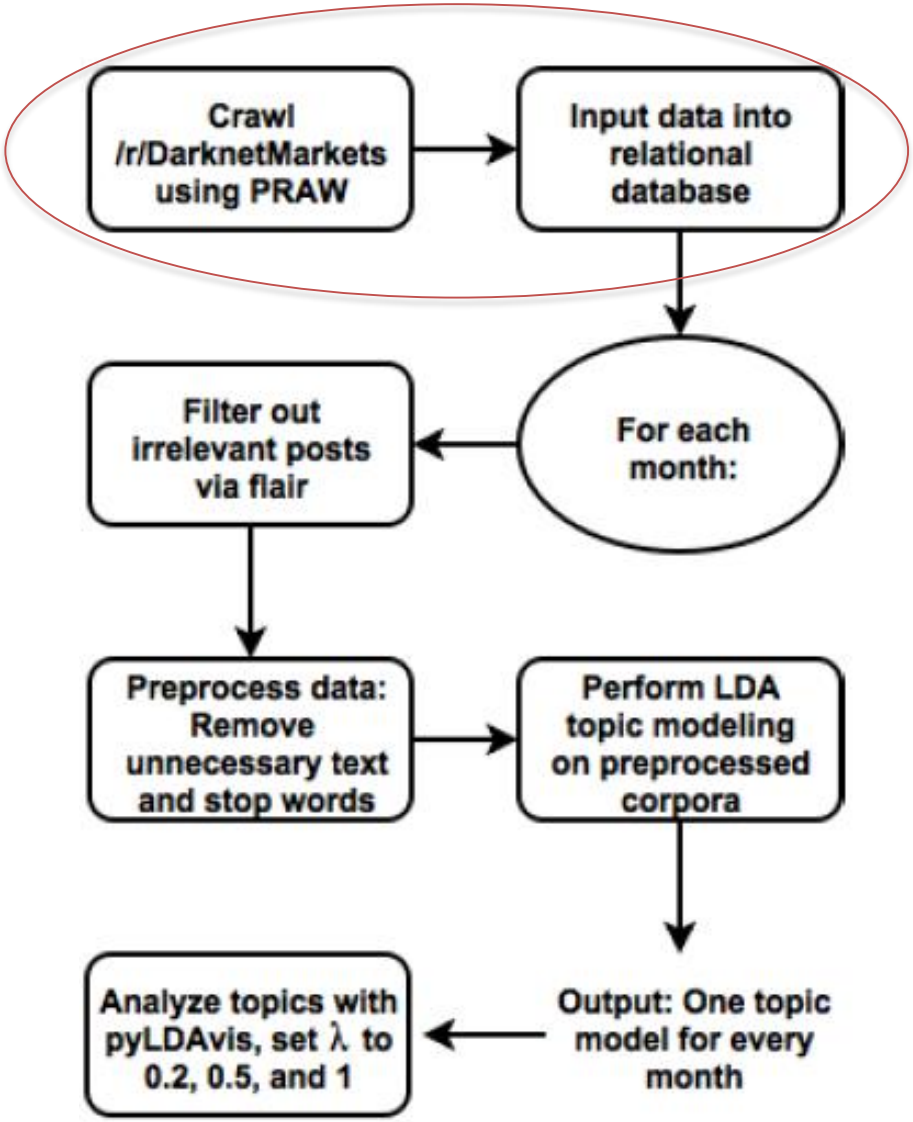
Caveats to this story (2)

- The Reddit Search API no longer allows searching historical posts via timestamps.
- Therefore, PRAW (Python Reddit API Wrapper) cannot get historical data.
  - PushShift API can potentially serve as an alternative?
- Our findings still have potential uses:
  - If you happen to already have Reddit corpora, or build it over time, then the analysis we did here is still possible.

Experimental Outline

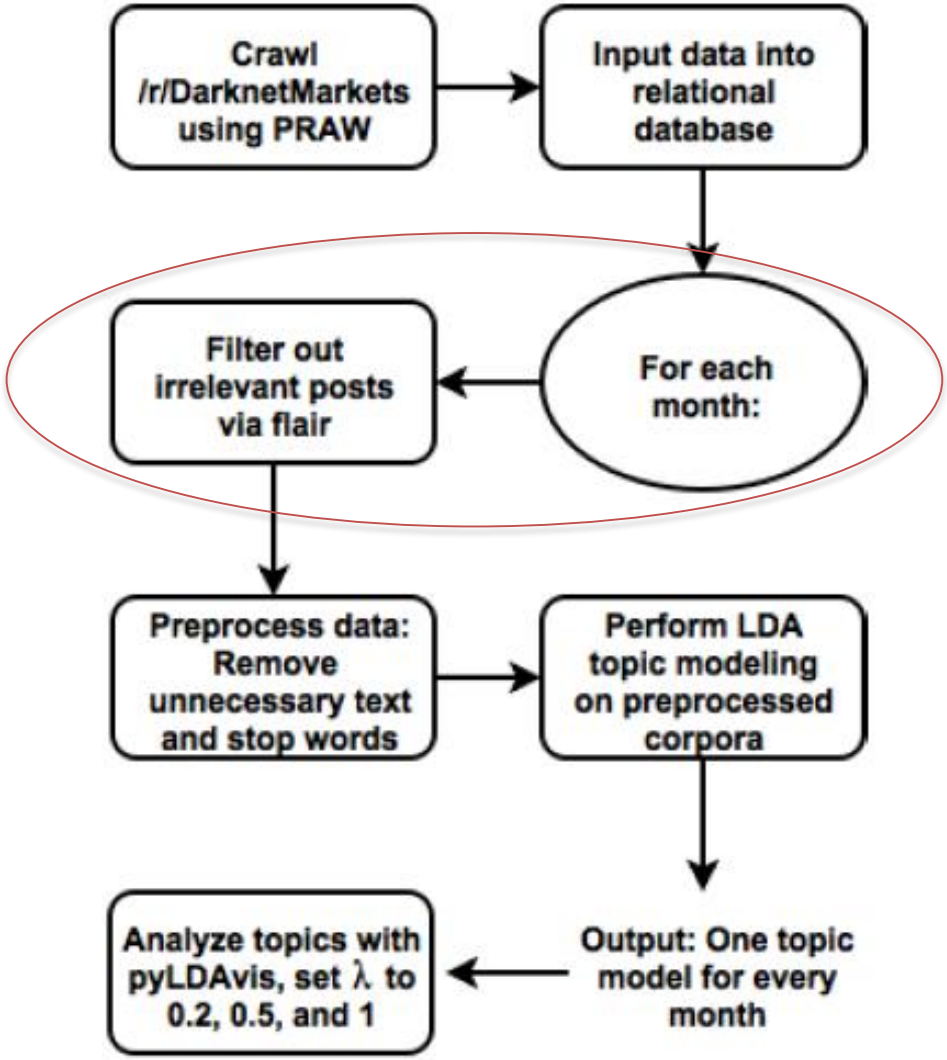


Experimental Outline

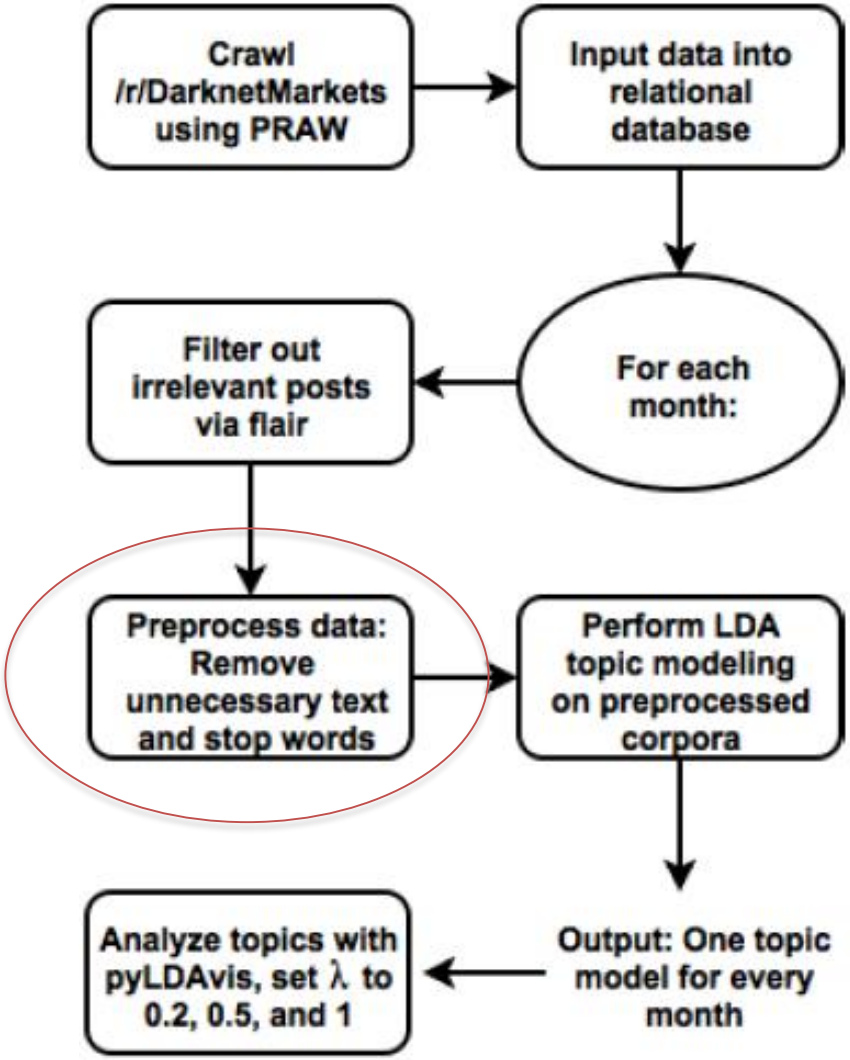


*https://praw.readthedocs.io/en/latest

Experimental Outline

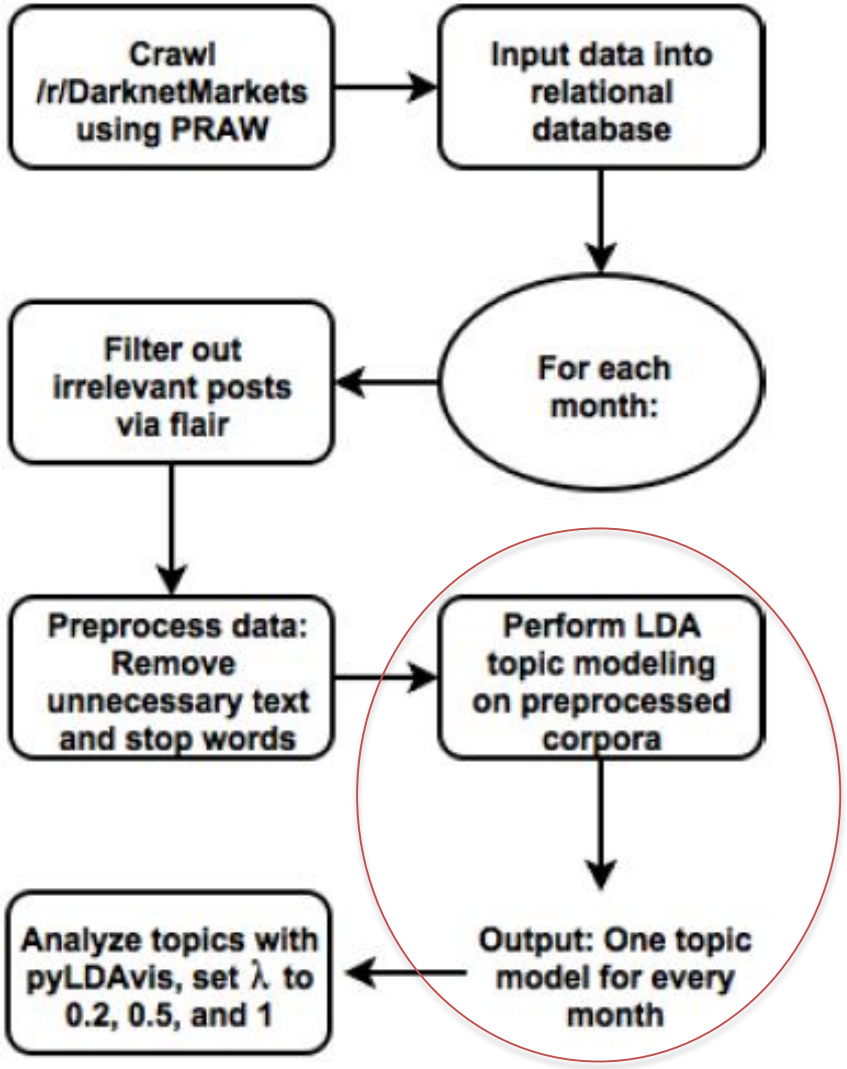


Experimental Outline



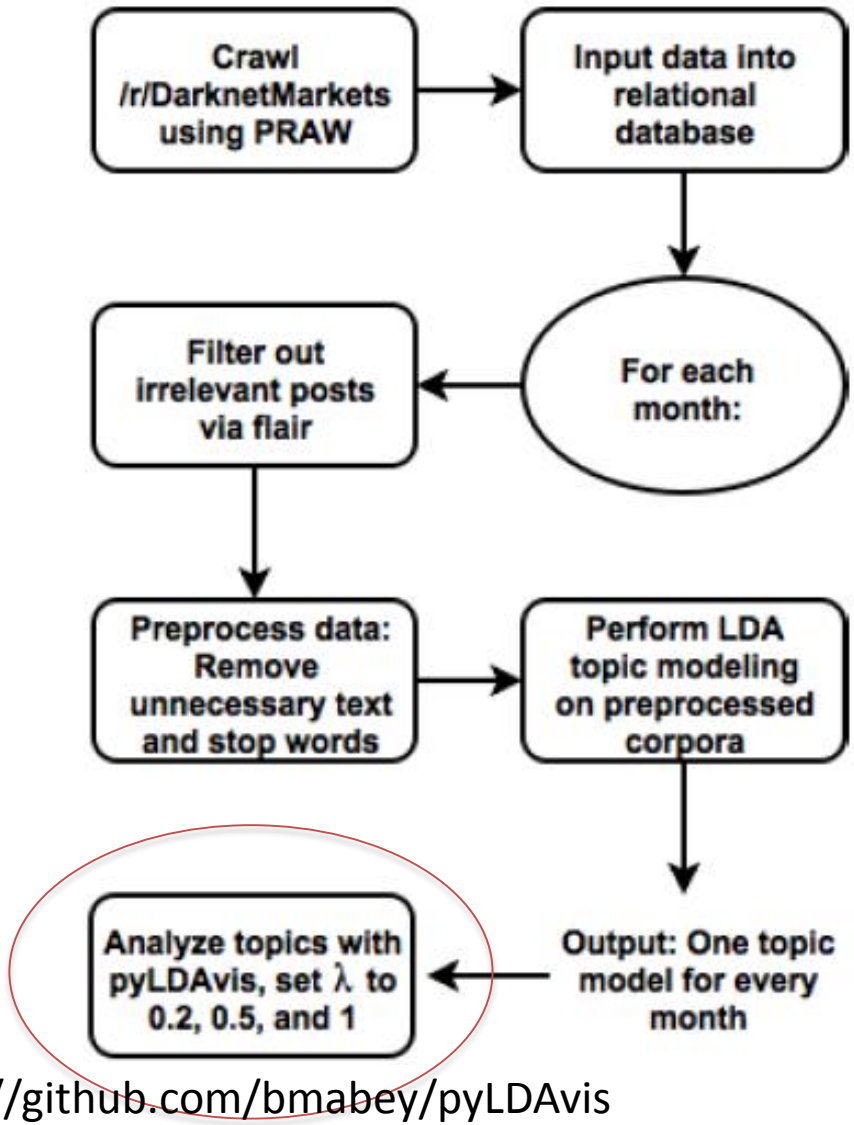
*Standard stop-words from Python NLTK libary (http://www.nltk.org/)

Experimental Outline



*LDA using gensim https://radimrehurek.com/gensim/

Experimental Outline



*pyLDAvis: https://github.com/bmabey/pyLDAvis

Relevancy Metric (1)

- After generating the topic model of a corpus, we can adjust the weight λ to influence word ranking per topic according to relevance.

$$\text{rel}(\text{term w} \mid \text{topic t}) = \lambda * p(w \mid t) + (1 - \lambda) * p(w \mid t)/p(w)$$

- λ = 1 is standard ranking (conditional probability of word given a topic). As λ approaches 0, words with high overall probability are ranked lower.
- We set lambda to λ = 1, 0.5, 0.2 to explore topics.

Results

- In general, the topics did not change significantly from month to month.
  - Largest topics were usually discussions about vendors/markets.
  - Cryptocurrency usually was its own topic
  - Security/anonymity was not always a topic
  - If a news story was large enough, it usually ended up as a topic
- The significant changes were the topic-word distributions.

Results (General)

- General state of the DNM (from the view of Reddit users) went from relatively casual to concerned, uncertain, and more security-minded after the July 2017 busts.
- In particular, we saw in increase in the use of law enforcement terms

Results (May 2017)

1	General vendor discussion	$\lambda = 1$: vendor, order, time, ordered, pack, vendors, never, days, lol, said, name, deleted, dispute, package, drugs, day, anything, back, orders, feedback $\lambda = 0.5$: order, vendor, dispute, ordered, pack, packs, feedback, vendors, bars, orders, name, box, mail, lol, ordering, never, said, xanax, package, house

Results (July 2017)

1	Markets and vendors	$\lambda = 1$: market, vendor, vendors, **hansa**, **dream**, time, **le**, **pgp**, order, key, **ab**, markets, deleted, never, new, back, address, used, 2, message $\lambda = 0.2$: vendors, **dream**, key, **pgp**, **compromised**, **le**, vendor, **hansa**, market, encrypt, order, buyers, auto, **2fa**, address, markets, **escrow**, **ab**, orders, decrypt

Results (August 2017)

1	Markets and vendors	$\lambda = 1$: market, vendor, **dream**, vendors, time, order, markets, **le**, never, account, 2, **pgp**, site, back, post, **hansa**, deleted, address, money, anyone $\lambda = 0.2$: market, **dream**, **multisig**, markets, password, site, **hansa**, vendors, **sig**, support, **scam**, **compromised**, **phishing**, **2fa**, **multi**, **sourcery**, **le**, passwords, admin, **escrow**

Results (October 2017)

1	Markets and vendors	$\lambda = 1$: market, vendor, **dream**, vendors, time, markets, never, money, **tr**, back, order, **scam**, **le**, **exit**, new, **aero**, site, reddit, 2, something $\lambda = 0.5$: market, **dream**, vendors, markets, money, time, **scam**, **exit**, **tr**, never, back, **le**, site, **aero**, order, **escrow**, everyone, coins, **btc**

Tools: Cryptocurrency (July 2017)

- Popular cryptocurrencies are Bitcoin and Monero.
- Identified popular mixing services and cryptocurrency exchanges.

7	Cryptocurr.	$\lambda = 0.2$: **bitcoin**, aktif, **bcc**, blockchain, **fork**, **coinbase**, bch, **btc**, **monero**, exchanges, **electrum**, **bitmixer**, **localbitcoins**, wallet, **shapeshift**, **tumbling**, **helix**, aug, **tumble**, uahf

Tools: Anonymity (March 2017)

- Common operating system is Tails (all software configured to connect to internet through Tor).
- Common use of VPN, and PGP.

5	Anonymity, drugs, and general conversation	$\lambda = 1$: **tor**, **tails**, time, deleted, 2, cocaine, **vpn**, first, 1, new, used, every, 3, 5, 0, around, water, **cia**, work, man $\lambda = 0.2$: **tails**, **vpn**, **isp**, **usb**, **browser**, **miners**, **tor**, **wpa**, **windows**, **fingerprinting**, **qubes**, **vpns**, cia, **reaver**, **xiopan**, **linux**, persistence, **veracrypt**, filter, democrats

Tools: General

- Tools did not seem to evolve.
- The only trend in tool use we could see is that they become more popular in discussion when real world events (busts/exit-scams/bit-coin price hikes) happen.

Benefits of analyzing topics

- Useful for developing hypotheses of content within the subreddit, that can later be confirmed by searching for it.
- Most useful: the topics put many terms into context.
  - There are many words for markets, users, tools, and services we would not have recognized if not contextualized by the topics.
  - Perhaps can be used as keywords for further investigation

Limitations of this Research

- The generated topics are only made practical when paired with the original data source.
  - Easy to misinterpret.
- Choice of subreddit is important.
- Applying topic modelling on large datasets can take hours.
  - Applying it to our corpora took a matter of minutes due to its size.
- Even though analyzing topics can hasten the search processes, the analysis still takes a generous amount of time.

Conclusion

- Our analysis showed a shift in tone (of Reddit users) from more casual to being more uncertain, concerned, and security-minded after the busts.
- Tools didn’t seem to evolve.
  - The trend is that their discussions occur in reaction to real world events.
- This information may be useful to law enforcement to understand how real world events have effects on online criminal communities or find keywords in a relatively quick manner.

Questions?

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