**Results of Network Analysis**

**Co-hashtag** (top 2000 nodes) (check meanings of some hashtags at the appendix)

**1. basic info**

|  |  |  |  |
| --- | --- | --- | --- |
| network type | # edges | # nodes | network density |
| undirected | 36669 | 1999 | 0.01834367183591796 |

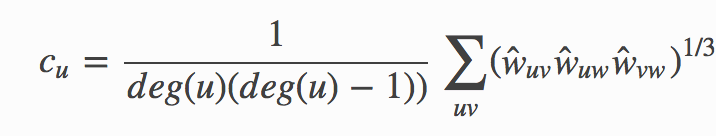
**2. edges with most weight** (top 50)

|  |  |  |  |
| --- | --- | --- | --- |
| **edges** | **weight** | **edges** | **weight** |
| **('alexa', 'amazon')** | 32874 | **('echo', 'virtualassistants')** | 1342 |
| **('alexa', 'talkradio')** | 5128 | **('alexa', 'jeffbezos')** | 1323 |
| **('alexa', 'apple')** | 3719 | **('alexa', 'blog')** | 1313 |
| **('heygoogle', 'ad')** | 3393 | **('amazon', 'echo')** | 1286 |
| **('alexa', 'googlehome')** | 3162 | **('alexa', 'aws')** | 1238 |
| **('alexa', 'homeautomation')** | 2971 | **('siri', 'apple')** | 1223 |
| **('siri', 'cortana')** | 2736 | **('website', 'blog')** | 1220 |
| **('amazonecho', 'homeautomation')** | 2640 | **('amazon', 'tech')** | 1161 |
| **('alexa', 'camiq')** | 2579 | **('alexa', 'win')** | 1085 |
| **('technews', 'camiq')** | 2578 | **('iot', 'amazon')** | 1022 |
| **('apple', 'technews')** | 2558 | **('cortana', 'microsoft')** | 989 |
| **('alexa', 'tech')** | 2517 | **('smart', 'virtualassistants')** | 967 |
| **('alexa', 'google')** | 2131 | **('amazon', 'echodot')** | 962 |
| **('alexa', 'smarthome')** | 2109 | **('smart', 'usa')** | 956 |
| **('siri', 'artificialintelligence')** | 2094 | **('google', 'apple')** | 947 |
| **('siri', 'virtualassistants')** | 1969 | **('alexa', 'amazonalexa')** | 942 |
| **('alexa', 'superbowl')** | 1634 | **('alexa', 'privacy')** | 933 |
| **('alexa', 'website')** | 1575 | **('alexa', 'prize')** | 927 |
| **('alexa', 'seo')** | 1571 | **('siri', 'homepod')** | 922 |
| **('iot', 'siri')** | 1524 | **('free', 'prize')** | 913 |
| **('alexa', 'voice')** | 1447 | **('alexa', 'cloudcomputing')** | 876 |
| **('amazon', 'google')** | 1373 | **('siri', 'cloudcomputing')** | 844 |
| **('amazon', 'jeffbezos')** | 1359 | **('virtualassistants', 'cloudcomputing')** | 844 |
| **('alexa', 'googleassistant')** | 1347 | **('cortana', 'cloudcomputing')** | 839 |
| **('echo', 'usa')** | 1343 | **('artificialintelligence', 'cloudcomputing')** | 838 |

**3. clustering coefficient** (weighted)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **node** | alexa | heygoogle | siri | cortana | entire network average |
| **coefficient** | 2.141190746740446e-05 | 2.42860793988339e-05 | 1.9303507474375952e-05 | 2.690836009174613e-05 | 0.0004951335175398307 |

notes: a clustering coefficient is a measure of the degree to which nodes in a graph tend to cluster together. Evidence suggests that in most real-world networks, and in particular social networks, nodes tend to create tightly knit groups characterised by a relatively high density of ties; this likelihood tends to be greater than the average probability of a tie randomly established between two nodes. For weighted graphs, the clustering is defined as the geometric average of the subgraph edge weights,



**4. distance measurement**

average shortest path length: 2.029621310655328

eccentricity: The eccentricity of a node v is the maximum distance from v to all other nodes in G.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| node | siri | alexa | heygoogle | cortana |
| eccentricity | 2 | 2 | 2 | 2 |

radius: 2 (minimum eccentricity)

diameter: 3 (maximum eccentricity)

Periphery: the set of nodes with eccentricity equal to the diameter

center: the set of nodes with eccentricity equal to the radius

**center**: 'alexa', 'ai', ‘iot', 'speaker', 'amazon', 'siri', 'amazonecho', 'smarthome', 'cortana', 'tech', 'googlehome', 'virtualassistant', 'echo', 'echodot', 'bixby', 'samsung', 'assistant', 'health', 'news', 'ml', 'bots', 'machinelearning', 'voicefirst', 'google', 'windows', 'android', 'halo', 'home', 'voice', 'developer', 'googleassistant', 'voicesearch', 'heygoogle', 'howto', 'technology', 'automation', 'future', 'apple', 'seo', 'ifttt', 'iphone', 'smartassistant', 'microsoft', 'homepod', 'spotify', 'nyc', 'mom', 'homeautomation', 'app', 'startup', 'youtube', 'bigdata', 'smartspeaker', 'india', 'artificialintelligence', iphonex', 'ios', 'podcast', 'twitter', 'music', 'androiddev', 'video', 'womenintech', 'intel', 'digital', 'love', 'robot', 'digitalassistant', 'privacy', 'computer', 'amazonalexa', 'watson', 'vui', 'cx', 'data', 'technews', 'digitalmarketing', 'wtf', 'search', 'marketing', 'help', 'vr', 'mobile', 'nest', 'sales', 'funny', 'mac', 'innovation', 'blockchain', 'retail', 'hue', 'facebook', 'customerexperience', 'thursdaythoughts', 'stem', 'blackfriday', 'voiceassistant', 'uber', 'fun', 'okgoogle', 'holiday', 'chrome', 'trends', 'smarthomes', 'dev', 'trump', 'smart', 'thanks', 'smartspeakers', 'useless', 'highered', 'free', 'fridayfeeling', 'blog', 'hilarious', 'email', 'netflix', 'googlehomemini', 'design', 'ar', 'creepy', 'personalassistant', 'learning', 'humor', 'pixel2', 'travel', 'heysiri', 'black', 'datascience', 'mondaymotivation', 'the', 'cybersecurity', 'dad', 'joke', 'bitcoin', 'nfl', 'huawei',

'googlenow', 'azure', 'ces2018', 'mrx', 'okaygoogle', 'christmas', 'awesome', 'savage', 'xbox', 'internet', 'instagram', 'ces', 'ces18',

'donaldtrump', 'wow', 'hey', 'monday', 'commercial', 'demo', 'qanon', 'singularity', 'notifications', 'scottish', 'feedly', 'hal', 'lg', 'chromebook', 'valentinesday', 'superbowl', 'lgbt', 'oscars', 'mwc18', 'googleio', 'io18'

notes:

The key words mostly are about voice-first and related products, AI conference, e-commerce, digital marketing research, IT concepts, home automation, digital entertainment, political jokes, information security, perspectives on the future of high-tech society, sports and other miscellaneous topics.

**5. network robustness**

is connected: True, each node has a path to any other node in the graph

node connectivity: 1

Node connectivity is equal to the minimum number of nodes that must be removed to disconnect the graph.

edge connectivity: 1

Edge connectivity is equal to the minimum number of nodes that must be removed to disconnect the graph.

**6. different centrality**

***degree centrality***: the fraction of nodes they are connected to.

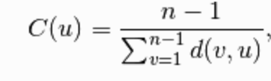
|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| node | alexa | siri | heygoogle | cortana |
| degree centrality | 0.9374687343671835 | 0.6263131565782891 | 0.15107553776888444 | 0.336168084042021 |

nodes ranked by degree centrality (top 50):

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| node | centrality | node | centrality | node | centrality |
| **alexa** | 0.93746873 | **googleassistant** | 0.17408704 | **video** | 0.10655328 |
| **amazon** | 0.62981491 | **iphone** | 0.17158579 | **ces2018** | 0.10155078 |
| **siri** | 0.62631316 | **heygoogle** | 0.15107554 | **security** | 0.09654827 |
| **ai** | 0.41670835 | **microsoft** | 0.14407204 | **gadgets** | 0.09404702 |
| **tech** | 0.35267634 | **echodot** | 0.14307154 | **innovation** | 0.09304652 |
| **echo** | 0.34017009 | **music** | 0.14057029 | **digital** | 0.09204602 |
| **cortana** | 0.33616808 | **ios** | 0.13656828 | **app** | 0.09004502 |
| **google** | 0.33416708 | **voicefirst** | 0.13606803 | **funny** | 0.08954477 |
| **apple** | 0.30765383 | **artificialintelligence** | 0.12956478 | **privacy** | 0.08904452 |
| **amazonecho** | 0.27313657 | **technews** | 0.12856428 | **vui** | 0.08904452 |
| **technology** | 0.26763382 | **business** | 0.12806403 | **aws** | 0.08904452 |
| **voice** | 0.26163082 | **assistant** | 0.12556278 | **marketing** | 0.08804402 |
| **iot** | 0.24362181 | **android** | 0.12056028 | **tv** | 0.08704352 |
| **smarthome** | 0.22461231 | **homepod** | 0.12056028 | **mobile** | 0.08704352 |
| **googlehome** | 0.2126063 | **home** | 0.11555778 | **speaker** | 0.08554277 |
| **amazonalexa** | 0.20510255 | **smart** | 0.11455728 | **skills** | 0.08504252 |
| **news** | 0.19009505 | **machinelearning** | 0.10705353 |  |  |

Notes: The hashtags are mostly key words related to technology, marketing, and homeautomation.

***closeness centrality***: Closeness centrality of a node u is the reciprocal of the sum of the shortest path distances from u to all n-1 other nodes. Since the sum of distances depends on the number of nodes in the graph, closeness is normalized by the sum of minimum possible distances n-1.



|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| node | alexa | siri | heygoogle | cortana |
| closeness centrality | 0.9411487758945386 | 0.7279679533867444 | 0.5408549783549783 | 0.6010222489476849 |

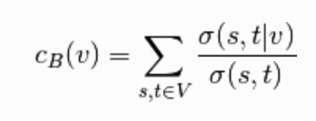
nodes ranked by closeness centrality (top 50):

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| node | centrality | node | centrality | node | centrality |
| **alexa** | 0.94114878 | **googleassistant** | 0.54767123 | **video** | 0.52813738 |
| **amazon** | 0.7298284 | **iphone** | 0.54692202 | **ces2018** | 0.52674572 |
| **siri** | 0.72796795 | **heygoogle** | 0.54085498 | **security** | 0.52480966 |
| **ai** | 0.63159558 | **microsoft** | 0.53881402 | **innovation** | 0.52439664 |
| **tech** | 0.60704525 | **echodot** | 0.53852371 | **gadgets** | 0.52425911 |
| **echo** | 0.60247137 | **music** | 0.5377993 | **digital** | 0.52412166 |
| **cortana** | 0.60102225 | **ios** | 0.5366443 | **app** | 0.52357255 |
| **google** | 0.6003003 | **voicefirst** | 0.53650027 | **funny** | 0.52343545 |
| **apple** | 0.59089565 | **artificialintelligence** | 0.53463493 | **privacy** | 0.52329843 |
| **amazonecho** | 0.57908459 | **technews** | 0.5343491 | **vui** | 0.52329843 |
| **technology** | 0.57724516 | **business** | 0.53392094 | **aws** | 0.52302459 |
| **voice** | 0.5752518 | **assistant** | 0.53349346 | **marketing** | 0.52302459 |
| **iot** | 0.56935346 | **android** | 0.53207346 | **mobile** | 0.52275105 |
| **smarthome** | 0.56325726 | **homepod** | 0.53207346 | **speaker** | 0.52234126 |
| **googlehome** | 0.55947383 | **home** | 0.530661 | **tv** | 0.52206843 |
| **amazonalexa** | 0.55713489 | **smart** | 0.53037941 | **skills** | 0.52193211 |
| **news** | 0.5525152 | **machinelearning** | 0.52827696 |  |  |

Notes: The list of top 50 nodes measured by closeness centrality is exactly the same as degree centrality.

***betweenness centrality (weighted)***:

node: Betweenness centrality of a node v is the sum of the fraction of all-pairs shortest paths that pass through v.

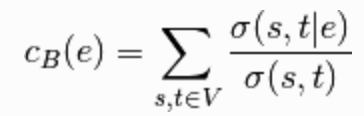


|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| node | alexa | siri | heygoogle | cortana |
| betweenness cen | 0.14598287574813562 | 0.08832168346530446 | 0.022140905426458985 | 0.04979213514637725 |

nodes ranked by betweenness centrality (top 50):

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| node | centrality | node | centrality | node | centrality |
| **alexa** | 0.14598288 | **iphone** | 0.01646159 | **app** | 0.00689179 |
| **siri** | 0.08832168 | **iot** | 0.01641783 | **usa** | 0.00670677 |
| **amazon** | 0.05345581 | **googleassistant** | 0.01516267 | **homepod** | 0.00663434 |
| **cortana** | 0.04979214 | **video** | 0.01309953 | **skills** | 0.00639898 |
| **tech** | 0.0390155 | **echodot** | 0.011936 | **smartspeaker** | 0.00620893 |
| **google** | 0.03824042 | **voicefirst** | 0.01188978 | **retail** | 0.00613267 |
| **apple** | 0.03353029 | **artificialintelligence** | 0.0114119 | **skill** | 0.00607152 |
| **ai** | 0.02989616 | **microsoft** | 0.0109272 | **facebook** | 0.00605032 |
| **voice** | 0.02944664 | **business** | 0.01091416 | **ads** | 0.00604705 |
| **echo** | 0.02895732 | **ios** | 0.01086149 | **marketing** | 0.00600175 |
| **amazonecho** | 0.02676855 | **technews** | 0.00920342 | **free** | 0.0059702 |
| **technology** | 0.02591095 | **funny** | 0.00878474 | **alexaskills** | 0.00587415 |
| **heygoogle** | 0.02214091 | **music** | 0.00871478 | **smart** | 0.00580343 |
| **googlehome** | 0.02174124 | **android** | 0.00818332 | **aws** | 0.00544486 |
| **amazonalexa** | 0.02062301 | **assistant** | 0.00818196 | **new** | 0.00523173 |
| **smarthome** | 0.01941338 | **home** | 0.00734097 | **search** | 0.00522871 |
| **news** | 0.01834668 | **tv** | 0.0070517 |  |  |

edge: Betweenness centrality of an edge e is the sum of the fraction of all-pairs shortest paths that pass through e



|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| edge | centrality | edge | centrality | edge | centrality |
| **('alexa', 'learningdisabilities')** | 0.00395849 | **('alexa', 'electronics')** | 0.00193575 | **('alexa', 'hard')** | 0.0015941 |
| **('alexa', 'retail')** | 0.00329417 | **('siri', 'video')** | 0.00190234 | **('alexa', 'computers')** | 0.00158401 |
| **('alexa', 'free')** | 0.00322714 | **('alexa', 'family')** | 0.0018877 | **('alexa', 'insight')** | 0.00151176 |
| **('alexa', 'grasmere')** | 0.002997 | **('alexa', 'london')** | 0.0018685 | **('iot', 'cortana')** | 0.00150957 |
| **('cortana', 'eurovision')** | 0.00279525 | **('alexa', 'digitalassistants')** | 0.00186555 | **('alexa', 'text')** | 0.00150319 |
| **('alexa', 'echoshow')** | 0.00266068 | **('siri', 'bigboobs')** | 0.0018528 | **('alexa', 'ps4')** | 0.00149222 |
| **('alexa', 'smartphone')** | 0.00230241 | **('alexa', 'halo')** | 0.00185157 | **('smartspeaker', 'blogpost')** | 0.00148371 |
| **('cortana', 'dorkypickuplines')** | 0.00224311 | **('talkradio', 'trumpkimsummit')** | 0.00184088 | **('alexa', 'features')** | 0.00147621 |
| **('alexa', 'black')** | 0.00219464 | **('alexa', 'mother')** | 0.0018389 | **('china', 'scotus')** | 0.00147358 |
| **('alexa', 'sales')** | 0.00218436 | **('alexa', 'big')** | 0.00182092 | **('alexa', 'bbc')** | 0.0014731 |
| **('alexa', 'phone')** | 0.00215659 | **('autism', 'love')** | 0.00180046 | **('feminism', 'snl')** | 0.00146372 |
| **('alexa', 'podcasts')** | 0.00203805 | **('alexa', 'invoke')** | 0.00173279 | **('seotools', 'ads')** | 0.00145303 |
| **('alexa', 'fail')** | 0.0020331 | **('alexa', 'voicerecognition')** | 0.00171755 | **('alexa', 'xboxone')** | 0.00144787 |
| **('siri', 'talkradio')** | 0.00201481 | **('onairnow', 'eurovision')** | 0.00168363 | **('alexa', 'lights')** | 0.00143864 |
| **('alexa', 'porn')** | 0.00200163 | **('alexa', 'wwdc')** | 0.00167981 | **('siri', 'ads')** | 0.00142234 |
| **('cortana', 'csharpcon18')** | 0.001999 | **('siri', 'healthyliving')** | 0.0016224 | **('alexa', 'financial')** | 0.00140149 |
| **('thermostat', 'heating')** | 0.001999 | **('usa', 'spygate')** | 0.00161909 |  |  |

**notes:**

1. Many of the important nodes identified by different centrality algorithms actually have very low rate of appearance with below 50 tweets.

2. Unlike other centrality, nodes with high betweenness edge centrality are pertinent to more diverse fileds, related to healthcare, political talk radio, finance and etc.

top edges with high edge betweenness centrality by nodes:

**Alexa**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| edge | centrality | edge | centrality | edge | centrality |
| **('alexa', 'learningdisabilities')** | 0.00395849 | **('alexa', 'sales')** | 0.00218436 | **('alexa', 'london')** | 0.0018685 |
| **('alexa', 'retail')** | 0.00329417 | **('alexa', 'phone')** | 0.00215659 | **('alexa', 'digitalassistants')** | 0.00186555 |
| **('alexa', 'free')** | 0.00322714 | **('alexa', 'podcasts')** | 0.00203805 | **('alexa', 'halo')** | 0.00185157 |
| **('alexa', 'grasmere')** | 0.002997 | **('alexa', 'fail')** | 0.0020331 | **('alexa', 'mother')** | 0.0018389 |
| **('alexa', 'echoshow')** | 0.00266068 | **('alexa', 'porn')** | 0.00200163 | **('alexa', 'big')** | 0.00182092 |
| **('alexa', 'smartphone')** | 0.00230241 | **('alexa', 'electronics')** | 0.00193575 | **('alexa', 'invoke')** | 0.00173279 |
| **('alexa', 'black')** | 0.00219464 | **('alexa', 'family')** | 0.0018877 |  |  |

**Siri**

|  |  |  |  |
| --- | --- | --- | --- |
| edge | centrality | edge | centrality |
| **('siri', 'talkradio')** | 0.00201481 | **('siri', 'marketing')** | 0.00120972 |
| **('siri', 'video')** | 0.00190234 | **('siri', 'windows')** | 0.00107732 |
| **('siri', 'bigboobs')** | 0.0018528 | **('siri', 'superbowl')** | 0.00107228 |
| **('siri', 'healthyliving')** | 0.0016224 | **('siri', 'beautiful')** | 0.00100259 |
| **('siri', 'ads')** | 0.00142234 | **('siri', 'wrestlemania')** | 0.00100096 |
| **('siri', 'skill')** | 0.00133981 | **('siri', 'serp')** | 0.00100057 |
| **('siri', 'rickross')** | 0.00133004 |  |  |

**HeyGoogle**

|  |  |  |  |
| --- | --- | --- | --- |
| edge | centrality | edge | centrality |
| **('heygoogle', 'biggov')** | 0.00100003 | **('heygoogle', 'iphone')** | 0.00064469 |
| **('heygoogle', 'rhop')** | 0.0009928 | **('heygoogle', 'lenovoces')** | 0.00063718 |
| **('heygoogle', 'podernfamily')** | 0.00093767 | **('heygoogle', 'artificialintelligence')** | 0.00063469 |
| **('heygoogle', 'releasethememo')** | 0.00076033 | **('heygoogle', 'zwave')** | 0.00060334 |
| **('heygoogle', 'croatia')** | 0.00074965 |  |  |
| **('heygoogle', 'jesuschrist')** | 0.0007463 |  |  |
| **('heygoogle', 'maythe4thbewithyou')** | 0.00068802 |  |  |

**Cortana**

|  |  |  |  |
| --- | --- | --- | --- |
| edge | centrality | edge | centrality |
| **('cortana', 'eurovision')** | 0.00279525 | **('cortana', 'vaporwave')** | 0.00107245 |
| **('cortana', 'dorkypickuplines')** | 0.00224311 | **('cortana', 'fifa2018')** | 0.001 |
| **('cortana', 'csharpcon18')** | 0.001999 | **('cortana', 'w10')** | 0.0009995 |
| **('iot', 'cortana')** | 0.00150957 | **('cortana', 'bluescreenofdeath')** | 0.0009995 |
| **('cortana', 'singapore')** | 0.00118228 | **('cortana', 'azurefunctions')** | 0.00098854 |
| **('cortana', 'echodot')** | 0.00109716 | **('cortana', 'alexainternet')** | 0.00090792 |
| **('cortana', 'wrestlemania')** | 0.00109156 | **('cortana', 'voiceover')** | 0.00085706 |

***eigenvector centrality (weighted)***:

Eigenvector centrality computes the centrality for a node based on the centrality of its neighbors. The eigenvector centrality for node ***i*** is the ***i***-th element of the vector x defined by the equation Ax=λx, where A is the adjacency matrix of the graph G with the largest eigenvalue λ.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| node | alexa | siri | heygoogle | cortana |
| eigenvector cent | 0.6984399740042048 | 0.017954912161364453 | 0.0020185169227929026 | 0.013613344260788328 |

nodes ranked by eigenvector centrality (top 50):

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| node | centrality | node | centrality | node | centrality |
| **alexa** | 0.69843997 | **amazonalexa** | 0.03036943 | **enter** | 0.01475436 |
| **amazon** | 0.66633035 | **googleassistant** | 0.03017828 | **cumbria** | 0.01452313 |
| **talkradio** | 0.10145503 | **blog** | 0.02743217 | **reinvent** | 0.01444889 |
| **apple** | 0.07896276 | **win** | 0.02714466 | **morning** | 0.01439166 |
| **tech** | 0.07448921 | **iot** | 0.02673844 | **podcast** | 0.0141087 |
| **google** | 0.07175086 | **privacy** | 0.02535987 | **microsoft** | 0.01382327 |
| **googlehome** | 0.06507739 | **echodot** | 0.02147969 | **cortana** | 0.01361334 |
| **homeautomation** | 0.0611473 | **cloudcomputing** | 0.01957499 | **chance** | 0.0135349 |
| **jeffbezos** | 0.05189422 | **healthcare** | 0.01874887 | **bots** | 0.0130856 |
| **camiq** | 0.05185997 | **homepod** | 0.01859966 | **chatbots** | 0.01287239 |
| **smarthome** | 0.04590745 | **prize** | 0.01852933 | **shopping** | 0.01260771 |
| **aws** | 0.03948047 | **siri** | 0.01795491 | **lakedistrict** | 0.01260385 |
| **superbowl** | 0.03656844 | **intelligent** | 0.01676521 | **ifttt** | 0.01260285 |
| **echo** | 0.03355123 | **home** | 0.01638718 | **chatbot** | 0.01204643 |
| **seo** | 0.03290716 | **parenting** | 0.01564914 | **technews** | 0.01150814 |
| **voice** | 0.03269775 | **fire** | 0.0150185 | **cloud** | 0.01103711 |
| **website** | 0.0323296 | **virtualassistants** | 0.01477278 |  |  |

Notes: they are mostly key words about virtual assistants’ skills (parenting, sports, trip planning, shopping, etc.)

***katz centrality (weighted)***:

Katz centrality computes the relative influence of a node within a network by measuring the number of the immediate neighbors (first degree nodes) and also all other nodes in the network that connect to the node under consideration through these immediate neighbors.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| node | alexa | siri | heygoogle | cortana |
| katz cent | -0.00062072767101663 | -0.000327052968626332 | -0.000172974021617173 | -0.0040723432000113 |

nodes ranked by katz centrality (top 50):

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| node | centrality | node | centrality | node | centrality |
| **amazonaffiliate** | 0.14225219 | **winners** | 0.0826089 | **bigboobs** | 0.06153099 |
| **investing** | 0.12803952 | **nlu** | 0.08032365 | **commerce** | 0.06103929 |
| **hear** | 0.11988277 | **lingerie** | 0.07872609 | **techupdates** | 0.06081739 |
| **philipshue** | 0.11328412 | **brand** | 0.07741599 | **crm** | 0.0590285 |
| **echoplus** | 0.11221277 | **ios11** | 0.07562748 | **livestream** | 0.05840201 |
| **fire7** | 0.11105104 | **asr** | 0.07546137 | **blowjob** | 0.0581958 |
| **p2p** | 0.10577709 | **voip** | 0.07467321 | **ass** | 0.05739934 |
| **chess** | 0.10524782 | **unboxing** | 0.07180981 | **control** | 0.0564562 |
| **humans** | 0.10411262 | **mood** | 0.07095563 | **tgif** | 0.05531732 |
| **whisfc18** | 0.10383492 | **in** | 0.0708407 | **commercials** | 0.05495825 |
| **firetvcube** | 0.10158014 | **wallstreet** | 0.07060195 | **appliances** | 0.05479175 |
| **ge** | 0.09659404 | **webcam** | 0.06885604 | **smarttv** | 0.05425648 |
| **amazonappsummit** | 0.09509143 | **mvb** | 0.06615659 | **worldcup** | 0.05377648 |
| **london** | 0.08661255 | **jpmorgan** | 0.06576989 | **flogo** | 0.05361032 |
| **perfect** | 0.08337285 | **outlet** | 0.0654692 | **fcc** | 0.05349054 |
| **ehealth** | 0.08324304 | **ioe** | 0.06238892 | **northkorea** | 0.05191417 |
| **rp** | 0.08303766 | **productive** | 0.06161607 |  |  |

**Notes:**

The hashtags related to porn (lingerie, bigboobs, etc) should be concerned with a porn star named after Alexa or a porn website named after Siri.

The list turns out to be divergent from the previous ranks, and news events, e-commerce.

***page rank***: PageRank computes a ranking of the nodes in the graph G based on the structure of the incoming links. It was originally designed as an algorithm to rank web pages.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| node | alexa | siri | heygoogle | cortana |
| page rank | 0.12730511660795654 | 0.03657036907162423 | 0.004649746881037206 | 0.011030220036231511 |

nodes ranked by closeness centrality (top 50):

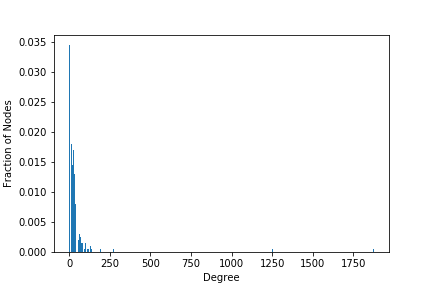
|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| node | centrality | node | centrality | node | centrality |
| **alexa** | 0.12730512 | **artificialintelligence** | 0.00416345 | **music** | 0.00291996 |
| **amazon** | 0.04778184 | **technews** | 0.00400576 | **iphone** | 0.00288002 |
| **siri** | 0.03657037 | **voice** | 0.00399167 | **aws** | 0.00277594 |
| **ai** | 0.01343319 | **homeautomation** | 0.00398341 | **ad** | 0.00274471 |
| **cortana** | 0.01103022 | **talkradio** | 0.00389946 | **windows** | 0.00273758 |
| **iot** | 0.01088368 | **seo** | 0.00379633 | **website** | 0.00261702 |
| **apple** | 0.01049071 | **homepod** | 0.00366187 | **podcast** | 0.00249675 |
| **echo** | 0.00955904 | **amazonalexa** | 0.00365806 | **rankbio** | 0.00238958 |
| **tech** | 0.00925842 | **echodot** | 0.00354701 | **vr** | 0.00234675 |
| **google** | 0.00761358 | **technology** | 0.00339874 | **fintech** | 0.00233252 |
| **smarthome** | 0.00688843 | **win** | 0.00311647 | **reinvent** | 0.0022133 |
| **amazonecho** | 0.00677776 | **camiq** | 0.00309259 | **speaker** | 0.0021942 |
| **googlehome** | 0.00604525 | **smart** | 0.00301451 | **home** | 0.00216442 |
| **virtualassistants** | 0.00559832 | **ces2018** | 0.00300227 | **fire** | 0.00215615 |
| **heygoogle** | 0.00464975 | **machinelearning** | 0.00298256 | **usa** | 0.00213307 |
| **microsoft** | 0.00464454 | **cloudcomputing** | 0.00297337 | **superbowl** | 0.00212213 |
| **voicefirst** | 0.0043839 | **googleassistant** | 0.00292108 |  |  |

**7. degree distribution (highest = 1874)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| node | alexa | siri | heygoogle | cortana |
| page rank | 1874 | 1252 | 302 | 672 |

nodes ranked by degree (top 50):

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| node | centrality | node | centrality | node | centrality |
| **alexa** | 0.12730512 | **artificialintelligence** | 0.00416345 | **music** | 0.00291996 |
| **amazon** | 0.04778184 | **technews** | 0.00400576 | **iphone** | 0.00288002 |
| **siri** | 0.03657037 | **voice** | 0.00399167 | **aws** | 0.00277594 |
| **ai** | 0.01343319 | **homeautomation** | 0.00398341 | **ad** | 0.00274471 |
| **cortana** | 0.01103022 | **talkradio** | 0.00389946 | **windows** | 0.00273758 |
| **iot** | 0.01088368 | **seo** | 0.00379633 | **website** | 0.00261702 |
| **apple** | 0.01049071 | **homepod** | 0.00366187 | **podcast** | 0.00249675 |
| **echo** | 0.00955904 | **amazonalexa** | 0.00365806 | **rankbio** | 0.00238958 |
| **tech** | 0.00925842 | **echodot** | 0.00354701 | **vr** | 0.00234675 |
| **google** | 0.00761358 | **technology** | 0.00339874 | **fintech** | 0.00233252 |
| **smarthome** | 0.00688843 | **win** | 0.00311647 | **reinvent** | 0.0022133 |
| **amazonecho** | 0.00677776 | **camiq** | 0.00309259 | **speaker** | 0.0021942 |
| **googlehome** | 0.00604525 | **smart** | 0.00301451 | **home** | 0.00216442 |
| **virtualassistants** | 0.00559832 | **ces2018** | 0.00300227 | **fire** | 0.00215615 |
| **heygoogle** | 0.00464975 | **machinelearning** | 0.00298256 | **usa** | 0.00213307 |
| **microsoft** | 0.00464454 | **cloudcomputing** | 0.00297337 | **superbowl** | 0.00212213 |
| **voicefirst** | 0.0043839 | **googleassistant** | 0.00292108 |  |  |

****

**8. community detection**

Compute the partition of the graph nodes which maximises the modularity (or try..) using the Louvain heuristics.

size: 28

community indices and number of nodes (see the file data/cohashtag/community\_list.csv to get the whole lists of nodes)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| community | size | community | size | community | size | community | size |
| **0** | 660 | **7** | 35 | **14** | 29 | **21** | 6 |
| **1** | 185 | **8** | 62 | **15** | 31 | **22** | 3 |
| **2** | 446 | **9** | 41 | **16** | 5 | **23** | 5 |
| **3** | 105 | **10** | 37 | **17** | 4 | **24** | 3 |
| **4** | 153 | **11** | 6 | **18** | 2 | **25** | 3 |
| **5** | 47 | **12** | 76 | **19** | 15 | **26** | 4 |
| **6** | 19 | **13** | 9 | **20** | 4 | **27** | 5 |