

(APNIC Project)

**Developing a Collaborative BGP Routing
Analyzing and Diagnosing Platform**

--Paper Discussion

Oct 13, 2022

Outline

- Title
- Abstract
- Regional Survivability
- Optimizing Regional Survivability
- Evaluation
- Future Work

Paper Title

Evaluating and Improving Regional Network Robustness
from AS TOPO Perspective

Abstract

Currently, regional networks are subject to various security attacks and threats, which will cause the network to fail.

This paper borrows the quantitative ranking idea from the fields of **statistics** and proposes a ranking method for evaluating regional resilience.

Large-scale **simulated failure events** based on **probabilistic sampling** is performed, and a **significance tester** that measures the impact of events from the overall level and variance aspect is also implemented.

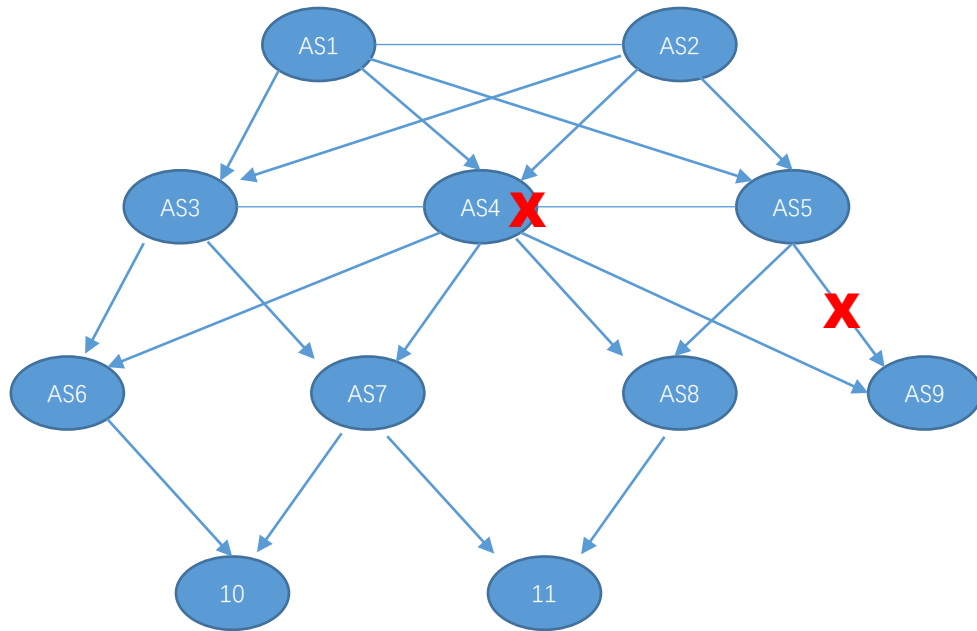
To improve a region's robustness, this paper proposes a **greedy algorithm to optimize the resilience** of regions by adding key links among AS.

Abstract

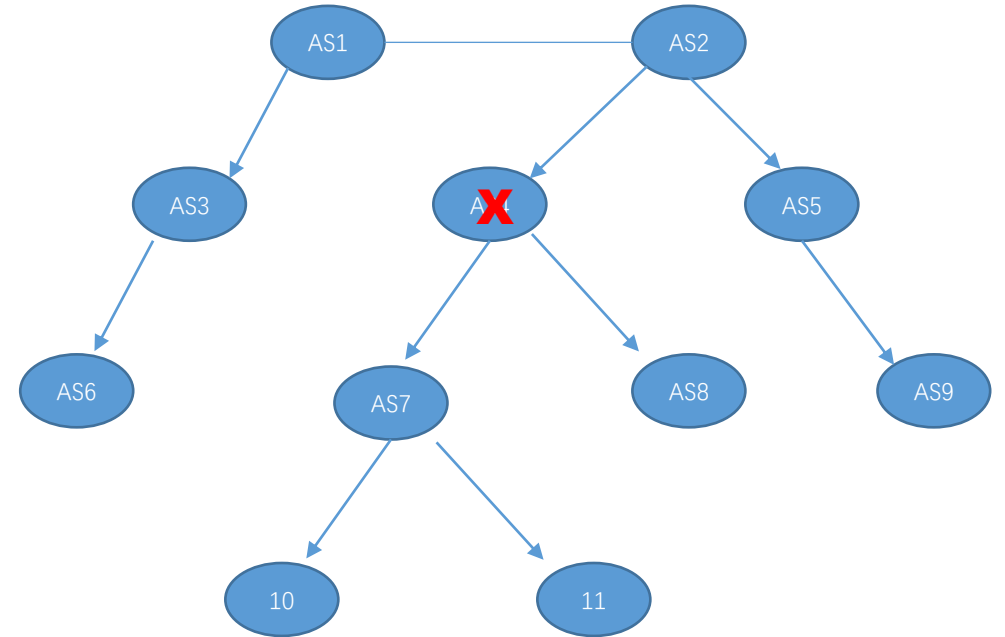
This paper selects the AS topology of **50 countries/regions** for research and ranking, evaluating the topology robustness **from connectivity, user, and domain influence** perspective, clustering the results and get typical region types, and adding optimal links to improve the network resilience.

Experimental results illustrate that the resilience of regional networks can be greatly improved by establishing a few new connections, which demonstrates the effectiveness of the optimization method.

AS Survivability



GOOD



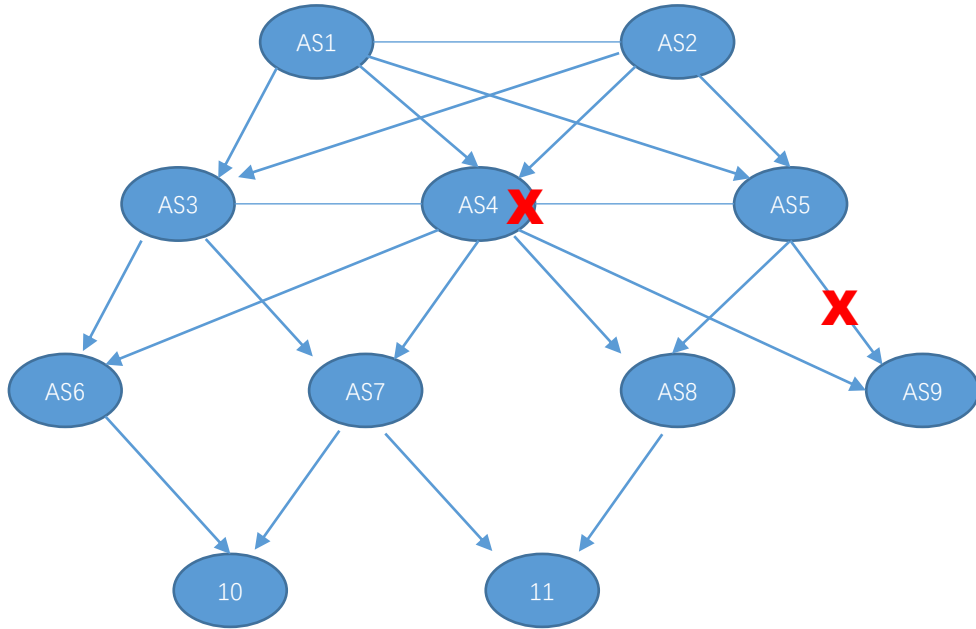
BAD

AS Survivability

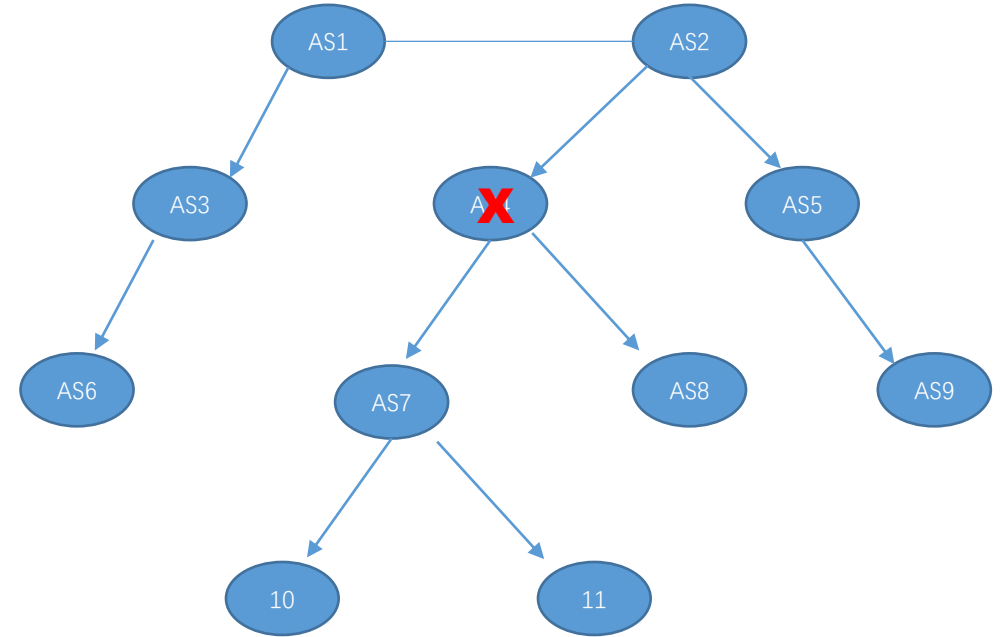
The remaining connections between an AS and other nodes after an failure event occurs is called the survivability of the AS to a failure event. The survivability of AS i to an event x is defined as:

$$e_{ix} = \frac{\sum_{b \in B} r_b}{\sum_{o \in O} r_o}. \quad (1)$$

AS Survivability



When AS4 fail, the survivability of AS 1 is 10/11



When AS4 fail, the survivability of AS 1 is 6/11

Resource Weight

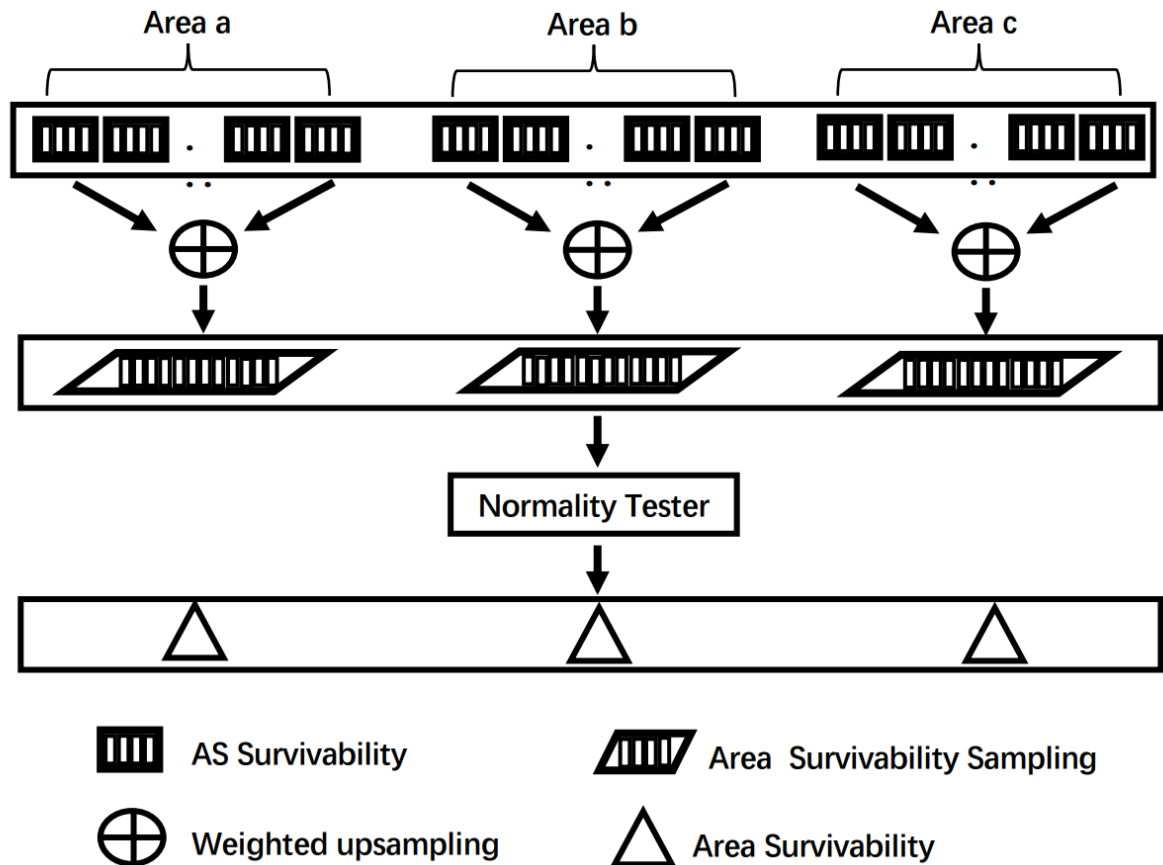
$$e_{ix} = \frac{\sum_{b \in B} r_b}{\sum_{o \in O} r_o}.$$

- From a connectivity perspective.
Each AS has the same weight
- From the perspective of user influence.
 r_i is the user proportion of AS_i . We use the proportion of users of every AS in the whole region as the weight.
- From the perspective of domain name influence.
 r_i is the domain importance measure of AS_i .

[12] APNIC. (2020) Visible asns: Customer populations (est.). [Online]. Available: <https://stats.labs.apnic.net/aspop/>.

[13] J. Naab, P. Sattler, J. Jelten, O. Gasser, and G. Carle, "Prefix top lists: Gaining insights with prefixes from domain-based top lists on dns deployment," in Proceedings of the Internet Measurement Conference, 2019, pp.351–357.

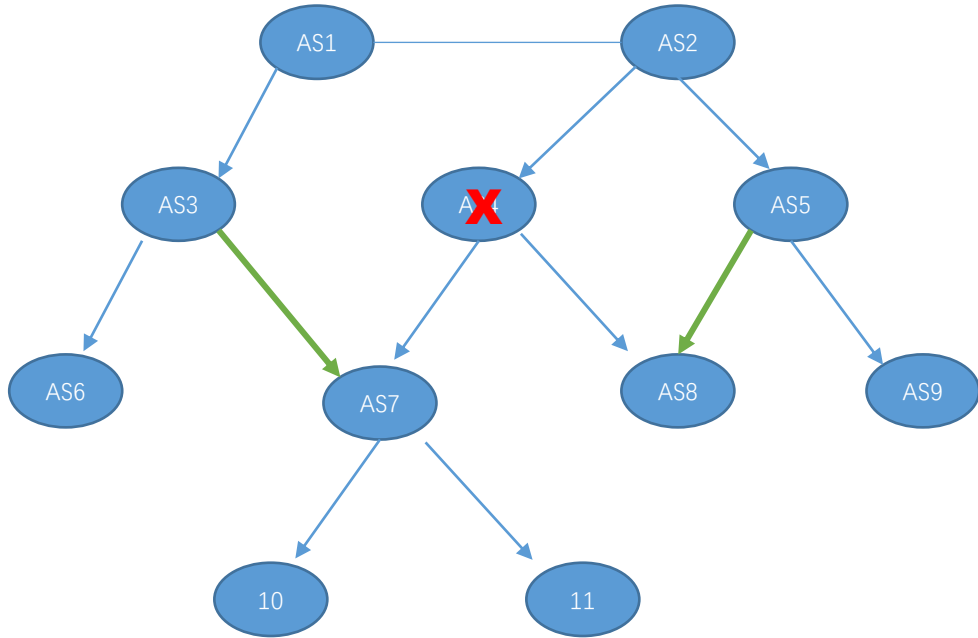
Region Survivability



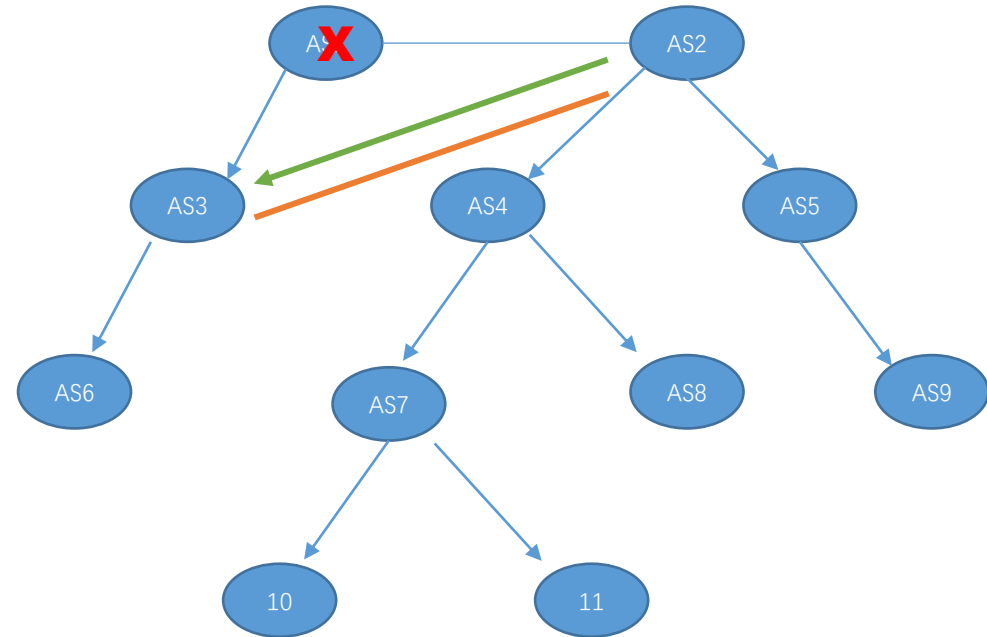
- First, select a set of significant ASes and calculate the survivability sampling for each AS.
- Second, sample from each AS samples by routing influence.
- Finally, for the sampled data of each region, **Kruskal-Wallis test [21]** and **Levene's test [26]** on the resilience samples to rank them at the overall level and the variance level.

Optimization

Factors considered include cost, and Utility
Cost: distance, possible commercial relations



Add P2C link



Add a P2C link,
Or a P2P link

Evaluation

- Data Set: ASRank, Problink, Toposcope, hToposcope (Toposcope+ inferred hidden connections.)
- Weight: Basic/Connectivity, User, Domain
- 50 Regions
- 2 Aspects: Overall, Variance

Evaluation

domain-toposcope-h	1	1	1	1	7	1	1	2	1	1	1	4	5	1	3	10	11	16	8	12	9	19	6	15	18	1	20	22	17	13	24	30	23	31	28	26	27	29	33	21	32	25	14	35	34	36	37	39	40	38
domain-toposcope	1	1	1	1	1	4	7	6	3	1	1	11	8	1	5	12	10	13	9	18	2	20	1	17	19	1	21	23	15	14	29	27	16	33	28	25	24	31	32	26	34	30	22	39	38	36	37	35	41	40
domain-problink	1	1	1	6	1	1	4	1	2	1	1	11	1	1	12	7	5	9	19	18	10	16	3	1	15	17	8	21	30	13	28	33	25	20	31	14	26	24	32	22	36	23	29	27	34	39	35	37	38	40
domain-asRank	1	1	1	1	1	2	1	1	3	1	1	5	1	1	6	9	8	12	7	10	4	19	1	20	14	1	13	15	11	26	17	30	18	27	23	24	21	29	33	22	31	25	32	16	28	35	34	36	38	37
user-toposcope-h	1	1	1	1	5	1	1	1	1	10	4	1	6	12	7	9	2	3	11	13	18	8	20	19	16	15	21	14	17	24	23	22	29	30	27	32	37	33	35	31	28	26	34	36	39	25	38	42	41	40
user-toposcope	1	1	1	1	1	2	1	1	1	3	4	1	6	11	5	10	1	9	7	14	15	8	19	21	16	13	20	12	17	22	25	18	29	28	24	30	32	33	34	31	27	26	36	37	39	23	35	38	41	40
user-problink	1	1	1	1	1	2	1	1	1	1	6	1	3	10	9	13	4	1	7	5	15	11	8	16	19	18	14	21	31	27	22	17	30	35	28	29	25	32	20	12	23	39	40	36	24	34	33	38	26	37
user-asRank	1	1	1	1	1	9	1	1	1	2	1	5	14	3	10	8	4	6	11	12	15	7	13	17	16	19	22	20	18	26	24	23	25	29	28	32	30	33	34	38	27	31	39	21	35	37	36	42	40	41
basic-toposcope-h	1	1	1	1	3	4	2	7	9	8	5	6	12	13	11	10	19	17	14	15	16	18	28	22	20	37	24	21	25	27	23	29	31	26	33	34	35	30	32	44	36	43	41	40	39	42	38	45	47	46
basic-toposcope	1	1	1	1	1	2	3	4	5	8	11	6	7	12	10	9	16	17	14	15	23	13	25	19	18	37	20	24	21	26	28	27	31	22	29	32	34	33	30	43	35	42	40	39	38	41	36	44	46	45
basic-problink	1	1	1	4	1	3	10	13	7	6	9	17	11	2	8	5	14	12	37	20	15	22	34	18	19	27	21	16	24	35	29	25	30	26	32	36	31	33	23	42	41	28	38	43	40	44	39	45	47	46
basic-asRank	1	1	1	1	1	3	7	2	9	5	17	4	8	16	11	6	15	14	10	13	27	18	23	19	20	30	22	21	12	25	26	32	31	24	28	37	34	33	35	42	29	41	38	43	36	40	39	45	46	44
	US	RU	BR	IN	DE	KR	PL	AU	IT	GB	UA	ID	CA	RO	JP	FR	NL	CH	BD	AR	BG	CN	ES	AT	SE	CZ	HK	ZA	TR	NZ	TH	MX	SG	IR	PH	FI	NO	DK	TW	IE	CL	NG	LV	HU	MY	CO	SK	LU	PT	KH

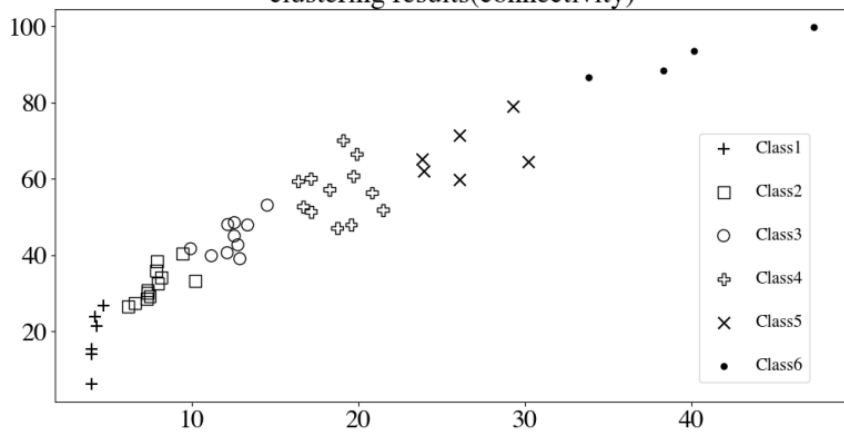
(a) overall level

domain-toposcope-h	1	2	3	11	4	17	21	16	14	26	7	20	35	25	27	10	36	37	5	12	29	23	22	15	13	6	28	18	32	30	9	31	8	33	19	38	24	40	42	34	44	41	39	45	46	47	43	48	50	49
domain-toposcope	1	3	2	4	6	9	5	10	11	7	12	14	18	13	15	8	17	20	39	31	24	16	25	34	29	27	32	19	40	33	30	22	37	26	28	43	38	35	42	21	36	23	41	44	47	45	46	48	50	49
domain-problink	18	13	12	16	3	7	15	4	21	19	2	22	8	17	10	5	14	6	1	27	20	9	32	39	25	28	23	31	24	11	33	34	26	44	46	35	30	29	36	40	38	45	42	41	37	48	43	47	50	49
domain-asRank	1	4	2	3	6	8	5	7	16	20	10	17	11	15	25	12	13	28	18	26	27	14	30	21	9	24	29	38	23	31	33	22	19	34	41	32	36	37	40	39	35	44	47	42	46	43	45	50	49	48
user-toposcope-h	1	3	2	9	6	7	4	13	8	5	15	12	11	16	14	25	10	21	27	20	17	26	19	22	23	34	18	24	29	32	30	35	31	28	38	33	43	36	42	45	37	47	44	39	41	40	46	50	48	49
user-toposcope	1	4	2	5	13	12	7	14	8	3	15	6	10	20	9	18	11	19	27	17	21	26	23	16	24	31	25	22	28	30	32	34	29	33	44	35	45	43	40	42	39	47	46	36	37	41	38	48	49	50
user-problink	2	3	4	1	19	13	9	20	10	11	23	18	7	5	12	26	16	8	24	14	21	15	32	33	31	28	25	6	22	17	29	34	30	36	44	27	41	37	35	47	48	40	42	45	46	43	38	39	50	49
user-asRank	1	2	4	6	9	3	8	10	5	11	12	15	7	20	13	21	18	22	23	19	16	28	17	14	24	30	25	27	26	31	32	34	29	35	37	33	45	40	38	42	44	39	41	36	46	43	48	50	47	49
basic-toposcope-h	1	2	3	4	14	5	7	8	10	18	16	9	17	6	11	21	24	13	12	20	22	25	23	15	28	33	19	30	26	34	27	31	37	29	35	32	36	39	38	43	42	44	41	40	45	46	47	48	49	50
basic-toposcope	1	3	2	7	4	16	14	6	18	5	11	10	8	13	29	34	12	27	17	26	25	37	22	21	38	9	30	31	20	32	15	23	43	41	19	35	42	36	28	39	33	40	24	44	46	45	47	48	49	50
basic-problink	1	5	10	6	2	4	3	21	14	8	18	9	15	22	17	7	23	11	25	19	13	28	16	41	37	29	24	31	33	12	36	20	34	40	35	42	26	30	32	44	43	39	38	45	27	47	48	46	50	49
basic-asRank	1	3	2	4	15	5	10	9	8	11	13	7	17	6	23	24	25	18	14	19	16	21	20	12	22	28	29	33	26	37	27	32	35	30	31	34	36	43	39	40	42	41	46	38	44	45	47	49	48	50
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(b) variance level

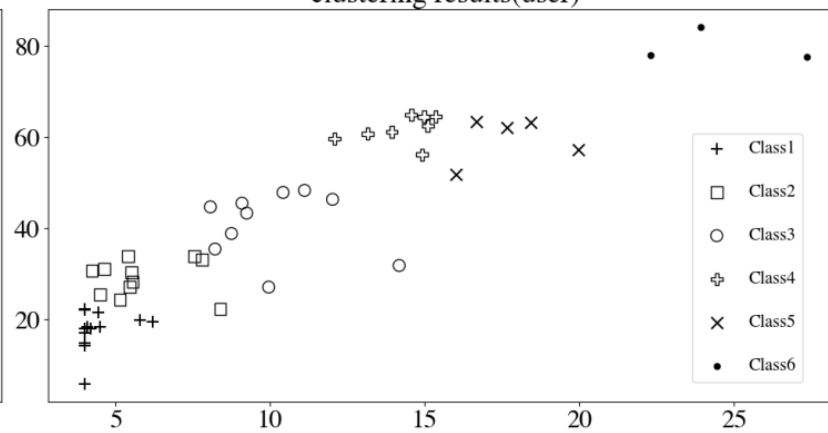
Clustering

clustering results(connectivity)



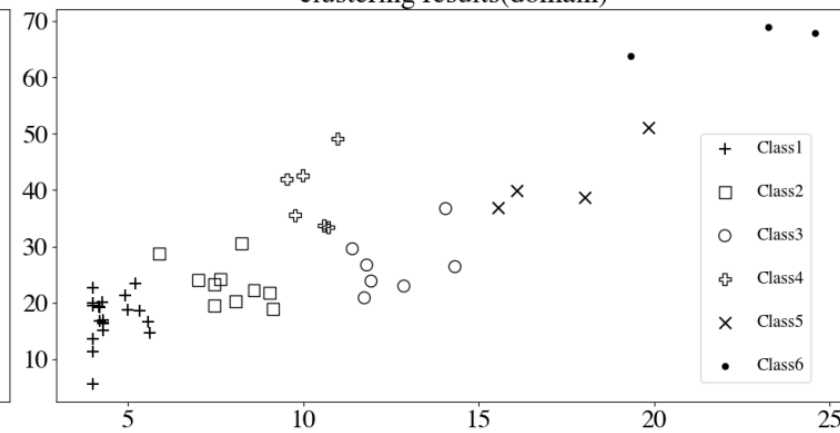
Class1	US	RU	BR	IN	DE	KR						
Class2	PL	AU	FR	IT	ID	GB	CA	JP	RO	UA	AR	CH
Class3	NL	CN	SE	TR	BD	BG	AT	ZA	HK	IR		
Class4	ES	MX	PH	TH	DK	NZ	TW	CL	CZ	FI	NO	SG
Class5	SK	MY	LV	NG	HU	CO						
Class6	IE	LU	KH	PT								

clustering results(user)

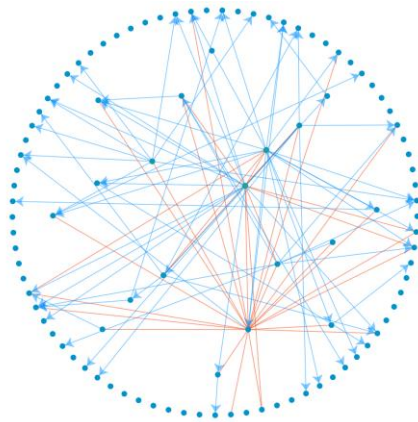


Class1	US	BR	RU	IN	PL	ID	DE	GB	AU	IT	UA	FR	AR
Class2	KR	CA	NL	CN	CH	RO	BD	JP	SE	ES	BG		
Class3	TR	ZA	AT	CZ	MX	HK	IR	TH	NZ	PH			
Class4	CL	SG	FI	CO	TW	IE	NG	NO					
Class5	DK	HU	SK	MY	LV								
Class6	KH	PT	LU										

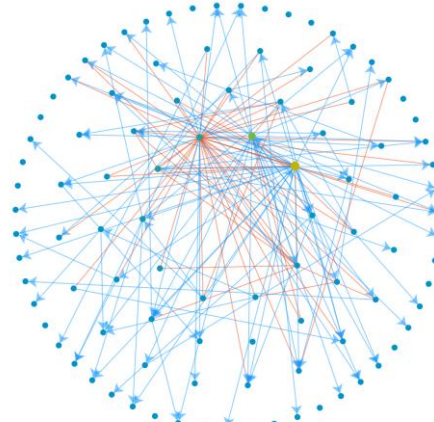
clustering results(domain)



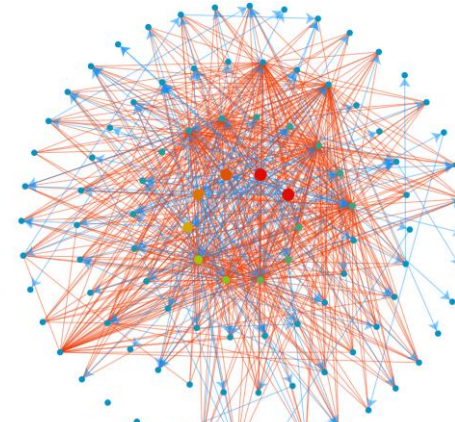
Class1	US	BR	RU	IN	DE	CA	IT	PL	GB	UA	KR	AU	ES	FR	RO	JP	NL	ID	CZ	BG
Class2	AR	CH	BD	SE	AT	HK	ZA	CN	TR	NZ										
Class3	PH	DK	IR	MX	LV	TW	HU													
Class4	FI	NO	TH	SG	IE	NG														
Class5	CL	MY	SK	CO																
Class6	LU	KH	PT																	



TOPO of KH



TOPO of MY



TOPO of AU

Optimization Result

Future Work

- Sample Bias: test with different sample rate
- Infrastructure: Fiber, IXP
- Key node/link
- Expand, submit to journal

Comments/Suggestions

- ??

Thanks!