Multiple Network Visualization with **ManyNets**

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The Cast

- Ben Shneiderman, Catherine Plaisant
- Jen Golbeck
- Awalin Sopan, Miguel Ríos
- Lockheed Martin
- Cody Dunne, John Guerra

About the author

- Madrid, Spain
  - Against bull-fighting
  - Not a soccer fan
  - Best food in the world
- Universidad Autónoma
  - Contacted Ben S. & Catherine for
  - 1-year Fulbright postdoc
  - But back next May :-P

Motivation for ManyNets

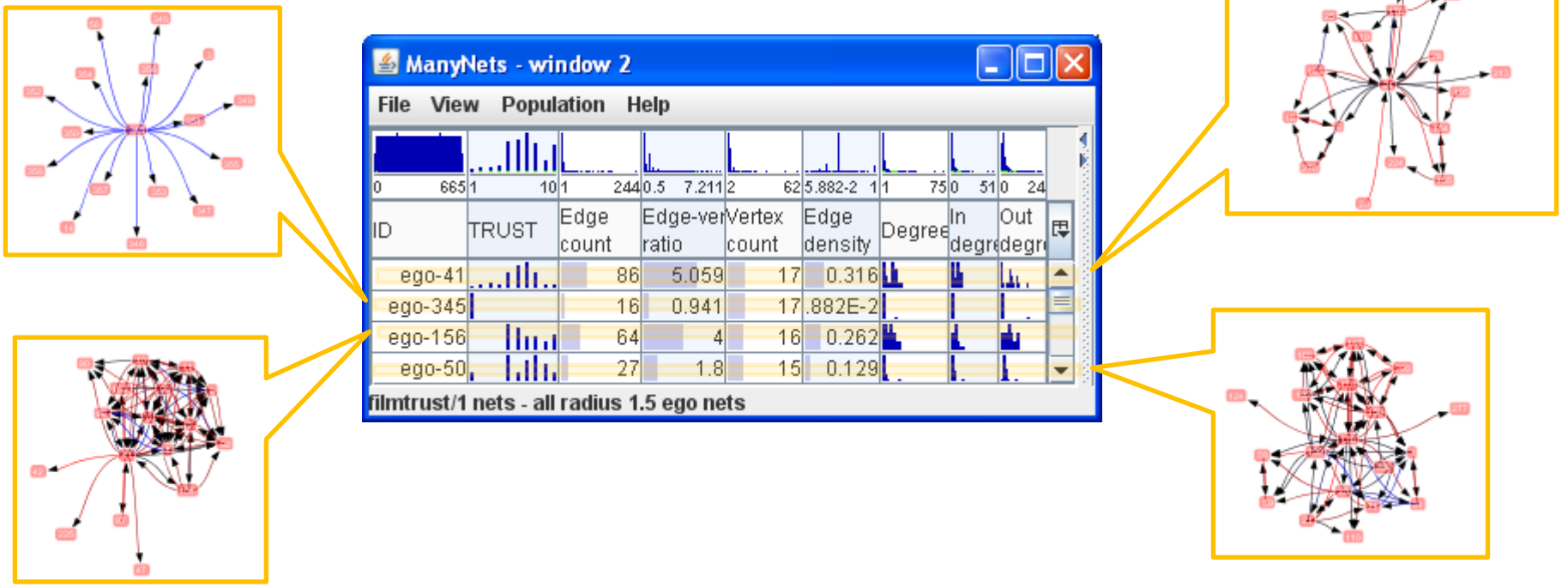
How do you make sense of not *one* network, but *many* – up to thousands?

- What **representation** should we choose, when space is scarce?
- How can you “gain an **overview**” of a large collection of networks?
- In which **scenarios** does this problem arise? When can it be useful to deal with all those networks?
- What sense-making **tasks** would **users** expect to be able to do on these networks?

Representation

- Each network is represented as a row in a table
- Network “attributes” for each network are represented in columns
  - Using miniature histograms when not scalar values
  - User can query cells using tooltips and clicking for details-on-demand
  - Can display networks in SocialAction

(see demo)


ManyNets - window 2
File View Population Help
0 665 1 10 1 244 0.5 7.211 2 62 5.882-2 1 1 75 0 51 0 24
ID TRUST Edge count Edge-ver ratio Vertex count Edge density Degree In degre Out degr
ego-41 86 5.059 17 0.316
ego-345 16 0.941 17 .882E-2
ego-156 64 4 16 0.262
ego-50 27 1.8 15 0.129
filmtrust/1 nets - all radius 1.5 ego nets

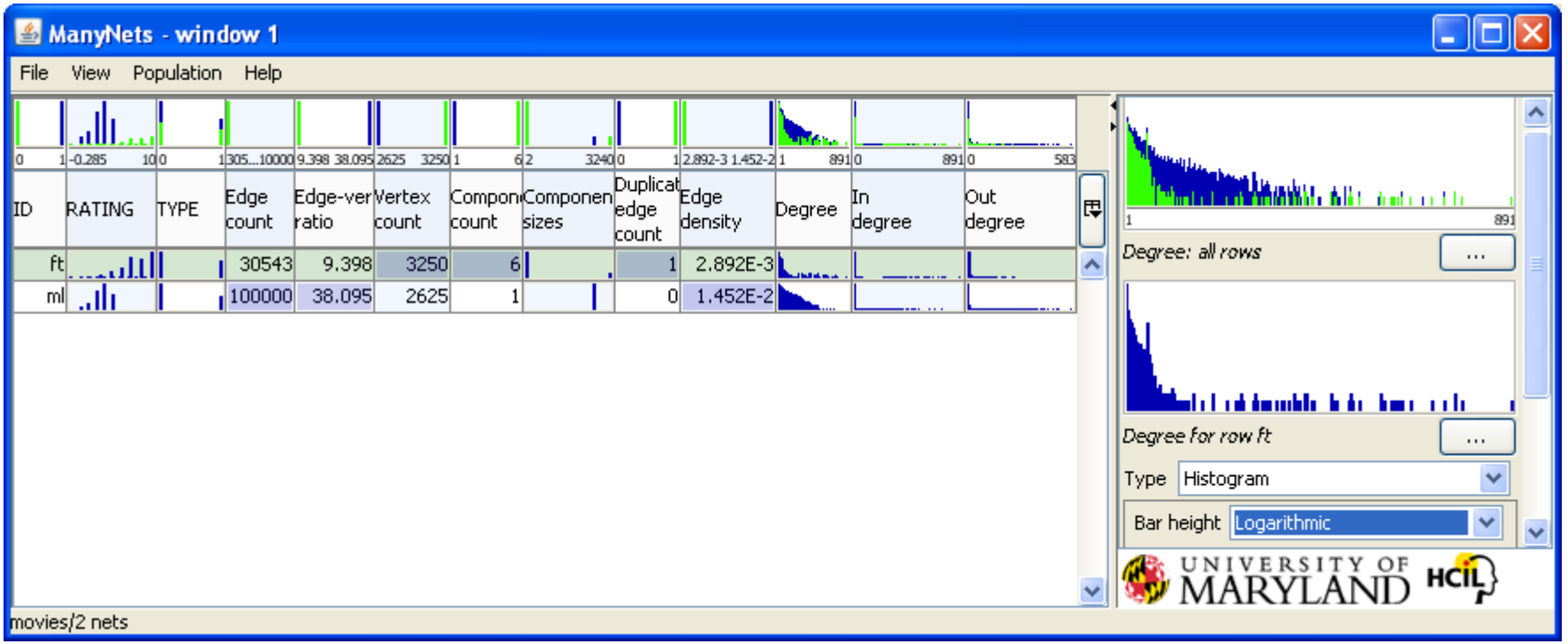
Overview

- Column summaries represent the contents of entire columns
- And highlight contributions of selected rows.
- And can, themselves, be used to highlight rows.

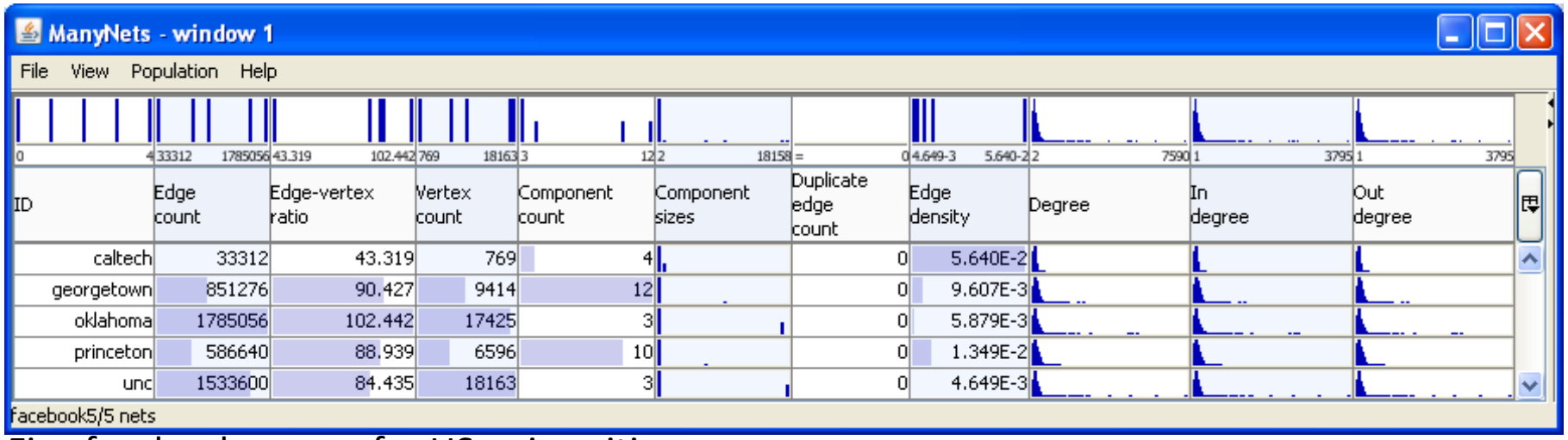
(see demo)

Scenarios – where is this useful?

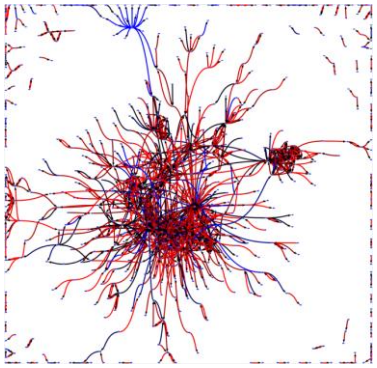
- “Compare different networks to each other”
  - Facebook networks of 5 US universities
  - FilmTrust vs MovieLens
- “Divide and conquer”: large networks are unwieldy
  - By *time*: phone call network sliced into “windows”
  - By *neighborhood*: ego-networks of FilmTrust
  - By *motifs*: all triangles in FilmTrust, to test transitivity of trust.
  - By *clusters*: connected components in FilmTrust.

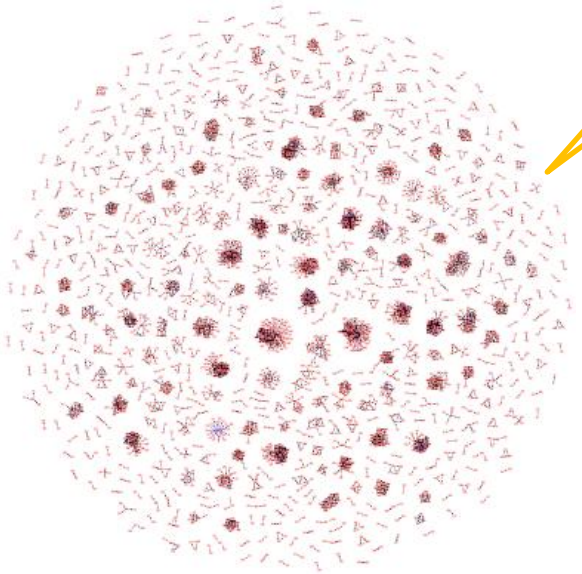


FilmTrust vs MovieLens

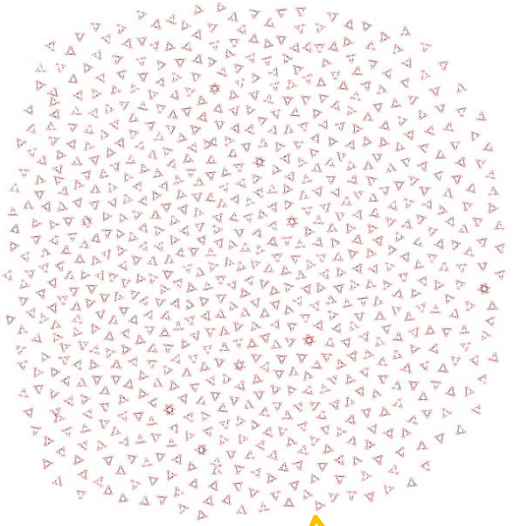


Five facebook groups for US universities

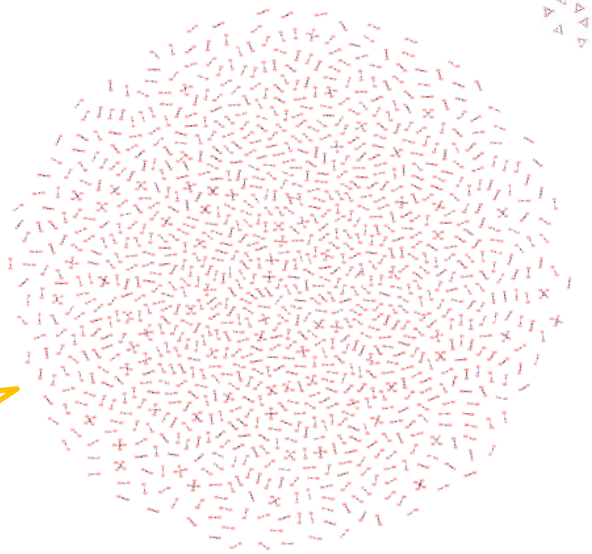




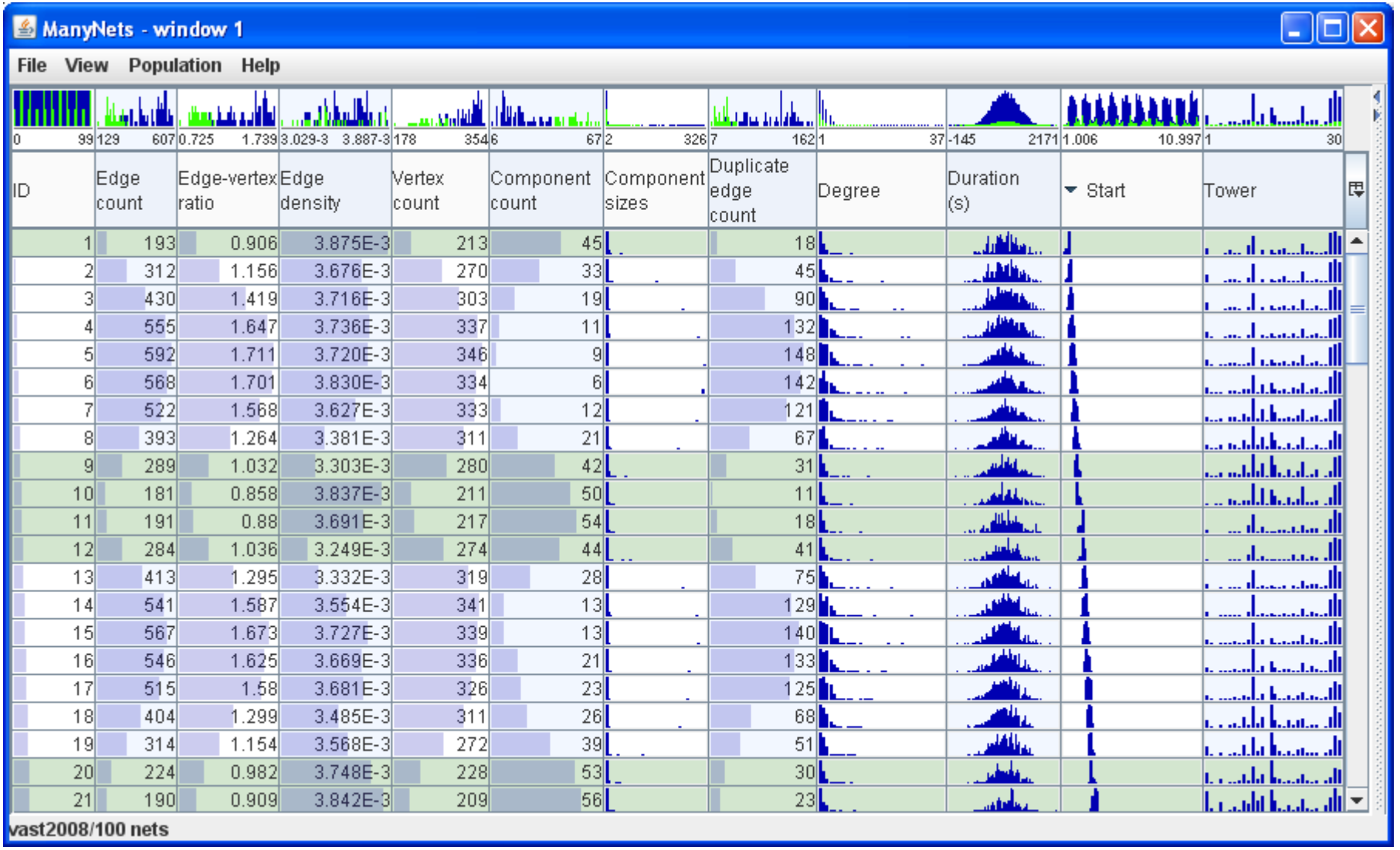
All ego-networks (one per person)



All groups of 3 persons that all know each other (triplets)



All pairs of connected people



Timesliced phone call network (VAST 2008 dataset)

Users

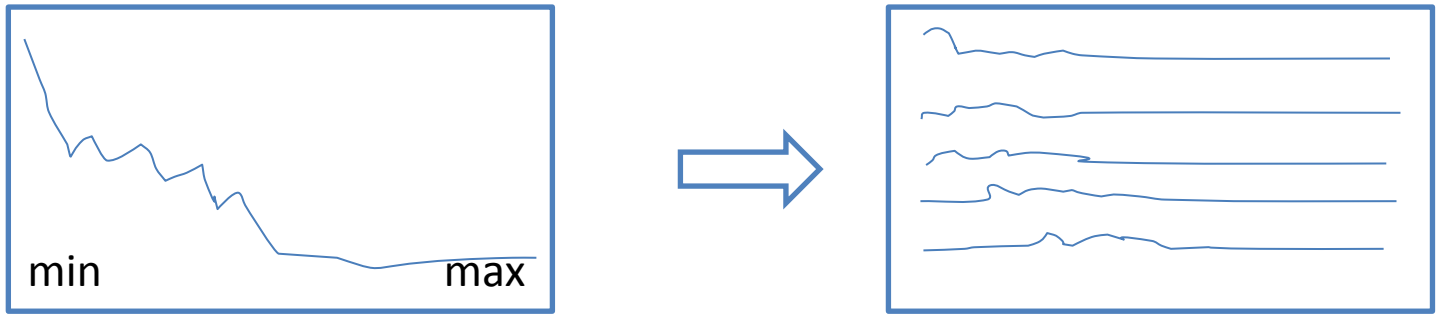
- Tried to train people in 15 min. for CHI usability study – fell back to “discount usability study”
  - Network Analysis is not easy
  - Training video not case-motivated and “hands-on”
  - Multiple interface quirks
- Target uses are **analysts**, willing to invest time in learning the tool.

Tasks

- Find maxima, minima, general **overview** of the distribution of attributes.
- Zoom and filter, and provide **details** for any given entity.
- Work with true **domain data**, without shedding data to fit “network” format.
- Find “**outliers**”.
- Existence, quantity, location of user-defined, domain-relevant “**patterns**.”
- **Compare** several networks, and show **similar** networks, or groups of networks.

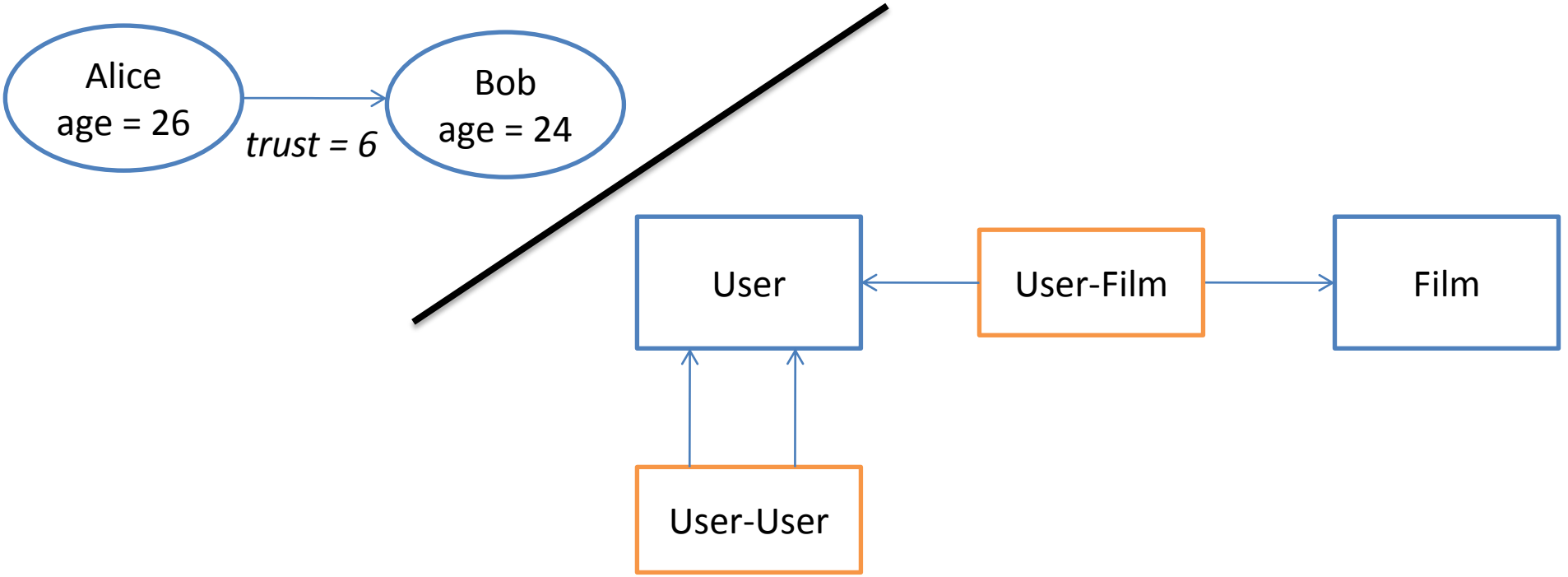
Better overviews

- Beyond histograms: what to use to convey the overall contents of a column.
- Trends, regions, gaps, outliers



Details & Domain Data

- User-defined columns
- Combining different node types – the Entity-Relationship model strikes again



Outliers & Patterns

- “Visual outlier detection”
- Pattern inspection supported via filters, user-expressions, sorting.
- Ad-hoc network pattern matching (but ask us about our ideas on how to implement it)

Similarity

- Computing pairwise similarity
  - Attributes
  - Graph comparison (Jaccard, edit distance)
- Displaying similarity
  - As a histogram
  - As a dendrogram
  - As simple sort order (from sample or using TSP)

Comm Record	profile	post	Mood(I	Mood(I	MBP(Ir	MBP(S	MBJ(TI	MBJ(Fi	MBA(In	MBA(E	MBL(Ju	MBL(P	Treatm the mind)	Treatm the body)	Treatm the mind)	Treatm the body)	Treatm models	Tone(F	Tone(C	Gende	Gende	TSP Order	TSP Jump
0 450	0 216	0 6	0 94	0 94	0 98	0 98	0 81	0 81	0 89	0 89	0 96	0 96	0 28	0 97	0 90	0 59	0 72	0 96	0 96	0 98	0 98	0 450	0 0.496
a1	26496"	s.html"	99	1	68	32	1	99	55	45	68	32	2	0	0	0	98	96	4	56	44	0	0
a2	07282"	s.html"	20	80	83	17	100	0	12	88	84	16	2	81	16	0	1	69	31	47	53	121	836E-2
a3	07951"	s.html"	1	99	0	100	34	66	100	0	83	17	0	18	18	61	3	92	8	83	17	383	0.197
a4	06354"	s.html"	53	47	59	41	42	58	1	99	76	24	1	99	0	0	0	0	100	5	95	448	0.157
a5	27904"	s.html"	87	13	5	95	99	1	78	22	33	67	13	17	3	65	1	8	92	21	79	417	873E-2
a6	02644"	s.html"	76	24	1	99	97	3	73	27	85	15	0	18	65	0	17	88	12	67	33	60	490E-2
a7	90788"	s.html"	2	98	47	53	66	34	98	2	16	84	3	64	31	1	0	90	10	21	79	179	921E-2
a8	02644"	s.html"	24	76	65	35	88	12	88	12	92	8	1	16	20	3	60	0	100	22	78	311	521E-2
a9	41440"	s.html"	93	7	1	99	69	31	56	44	94	6	0	5	92	0	2	89	11	17	83	59	351E-2
a10	36131"	s.html"	3	97	35	65	71	29	79	21	15	85	11	9	18	60	2	60	40	69	31	364	382E-2
a11	75077"	s.html"	6	94	18	82	84	16	30	70	22	78	1	78	17	4	0	94	6	38	62	405	0.113
a12	08823"	s.html"	92	8	42	58	100	0	79	21	99	1	0	6	90	4	0	0	100	40	60	263	544E-2
a13	26496"	s.html"	33	67	81	19	92	8	59	41	37	63	1	15	6	61	17	93	7	43	57	285	531E-2
a14	07361"	s.html"	81	19	97	3	100	0	72	28	1	99	0	8	17	71	4	33	67	68	32	343	891E-2
a15	27904"	s.html"	3	97	37	63	99	1	98	2	23	77	1	5	86	3	6	5	95	81	19	85	215E-2
a16	27904"	s.html"	11	89	93	7	99	1	92	8	8	92	0	85	3	11	1	7	93	88	12	103	229E-3
a17	01136"	s.html"	100	0	100	0	9	91	100	0	57	43	0	0	0	100	0	97	3	100	0	402	0.155
a18	11178"	s.html"	0	100	27	73	100	0	0	100	49	51	0	36	64	0	0	12	88	95	5	217	873E-2
a19	67384"	s.html"	27	73	33	67	100	0	93	7	49	51	0	39	58	0	2	3	97	79	21	86	597E-2
a20	33811"	s.html"	3	97	99	1	96	4	96	4	39	61	83	11	2	4	0	47	53	75	25	367	554E-2
a21	66263"	s.html"	0	100	100	0	100	0	100	0	6	94	0	81	12	0	7	7	93	75	25	101	569E-2
a22	67384"	s.html"	15	85	88	12	100	0	100	0	96	4	2	19	1	0	77	2	98	95	5	328	362E-2
a23	22804"	s.html"	3	97	64	36	63	37	43	57	71	29	0	45	21	0	33	100	0	51	49	211	230E-2
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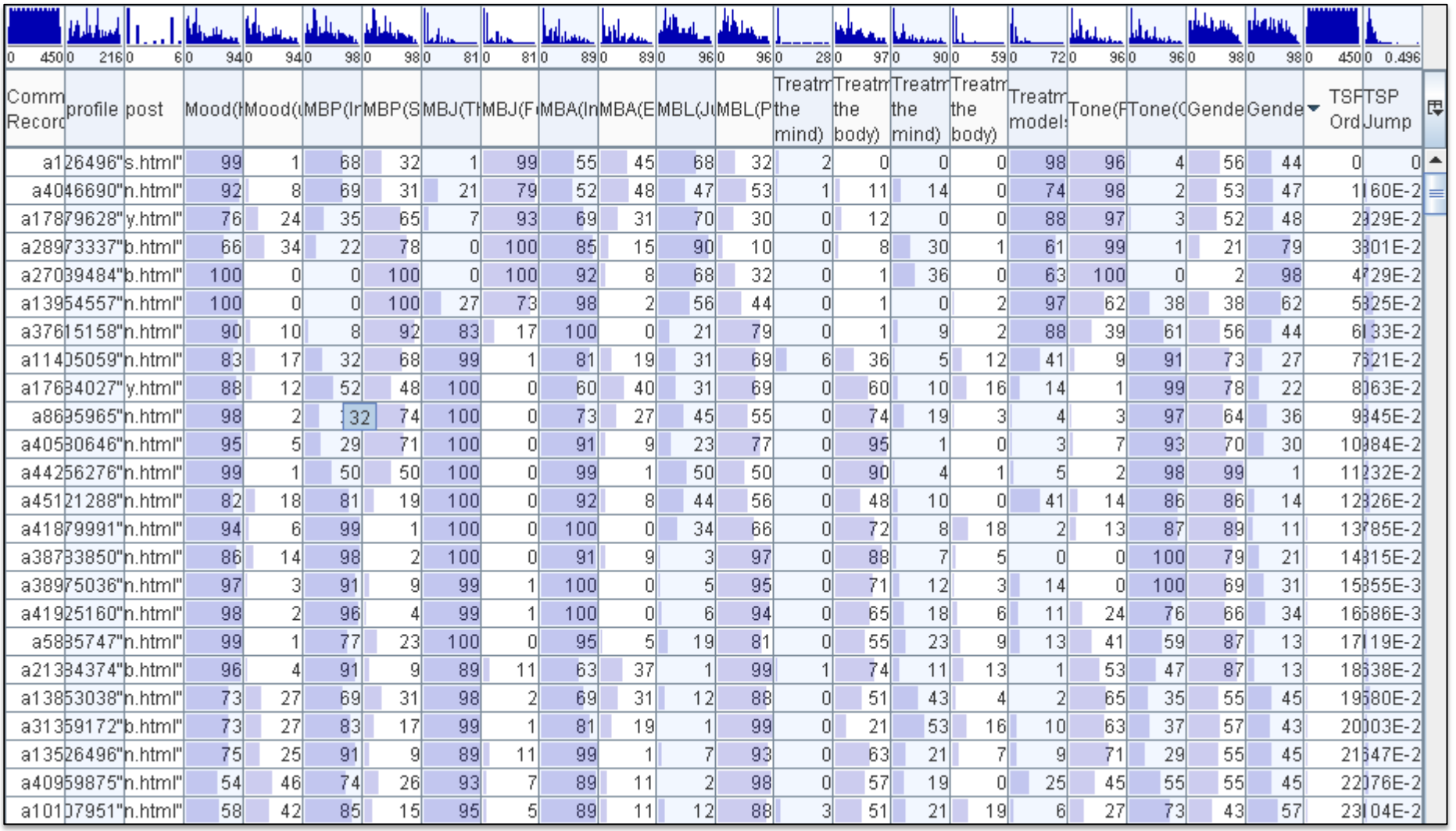

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a12	26496"	s.html"	99	1	68	32	1	99	55	45	68	32	2	0	0	0	98	96	4	56	44	0	0
a40	46690"	n.html"	92	8	69	31	21	79	52	48	47	53	1	11	14	0	74	98	2	53	47	1	60E-2
a178	79628"	y.html"	76	24	35	65	7	93	69	31	70	30	0	12	0	0	88	97	3	52	48	2	29E-2
a289	73337"	b.html"	66	34	22	78	0	100	85	15	90	10	0	8	30	1	61	99	1	21	79	3	01E-2
a270	39484"	b.html"	100	0	0	100	0	100	92	8	68	32	0	1	36	0	63	100	0	2	98	4	29E-2
a139	54557"	n.html"	100	0	0	100	27	73	98	2	56	44	0	1	0	2	97	62	38	38	62	5	25E-2
a376	15158"	n.html"	90	10	8	92	83	17	100	0	21	79	0	1	9	2	88	39	61	56	44	6	33E-2
a114	05059"	n.html"	83	17	32	68	99	1	81	19	31	69	6	36	5	12	41	9	91	73	27	7	21E-2
a176	34027"	y.html"	88	12	52	48	100	0	60	40	31	69	0	60	10	16	14	1	99	78	22	8	63E-2
a86	95965"	n.html"	98	2	32	74	100	0	73	27	45	55	0	74	19	3	4	3	97	64	36	9	45E-2
a405	30646"	n.html"	95	5	29	71	100	0	91	9	23	77	0	95	1	0	3	7	93	70	30	10	84E-2
a442	56276"	n.html"	99	1	50	50	100	0	99	1	50	50	0	90	4	1	5	2	98	99	1	11	32E-2
a451	21288"	n.html"	82	18	81	19	100	0	92	8	44	56	0	48	10	0	41	14	86	86	14	12	26E-2
a418	79991"	n.html"	94	6	99	1	100	0	100	0	34	66	0	72	8	18	2	13	87	89	11	13	85E-2
a387	33850"	n.html"	86	14	98	2	100	0	91	9	3	97	0	88	7	5	0	0	100	79	21	14	15E-2
a389	75036"	n.html"	97	3	91	9	99	1	100	0	5	95	0	71	12	3	14	0	100	69	31	15	55E-3
a419	25160"	n.html"	98	2	96	4	99	1	100	0	6	94	0	65	18	6	11	24	76	66	34	16	86E-3
a58	35747"	n.html"	99	1	77	23	100	0	95	5	19	81	0	55	23	9	13	41	59	87	13	17	19E-2
a213	84374"	b.html"	96	4	91	9	89	11	63	37	1	99	1	74	11	13	1	53	47	87	13	18	38E-2
a138	53038"	n.html"	73	27	69	31	98	2	69	31	12	88	0	51	43	4	2	65	35	55	45	19	80E-2
a313	59172"	b.html"	73	27	83	17	99	1	81	19	1	99	0	21	53	16	10	63	37	57	43	20	03E-2
a135	26496"	n.html"	75	25	91	9	89	11	99	1	7	93	0	63	21	7	9	71	29	55	45	21	47E-2
a409	59875"	n.html"	54	46	74	26	93	7	89	11	2	98	0	57	19	0	25	45	55	55	45	22	76E-2
a101	07951"	n.html"	58	42	85	15	95	5	89	11	12	88	3	51	21	19	6	27	73	43	57	23	04E-2

Recap

How do you make sense of not *one* network, but *many* – up to thousands ?

- **Representation** – a table of network attributes
- **Overview** – column summaries, but plenty of opportunity for improvement.
- **Scenarios** – asides from inter-graph, intra-graph decomposition shows great promise.
- **Users / Tasks –** similarity, outliers, patterns are hard problems. Real data does not come as straightforward networks.

Questions? Comments?

Thanks!