



Information Technologies for Supporting Human Innovation and Creativity: The Evolutionary Path

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So, not a GA talk?

🔷 This is not a talk about

- Genetic algorithms
- Genetic programming
- Estimation of distribution algorithms
- Genetic-based machine learning
- ...

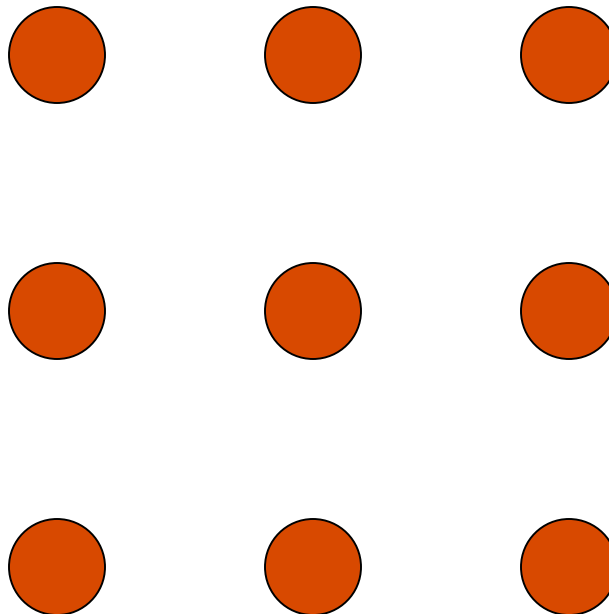
🔷 This is a talk about

- Creativity and innovation support
- The role of genetic algorithms and evolutionary computation
- How fast interaction and visual analytics improve collaboration
- The social aspects of communication in innovation processes



One Innocent Exercises (I/III)

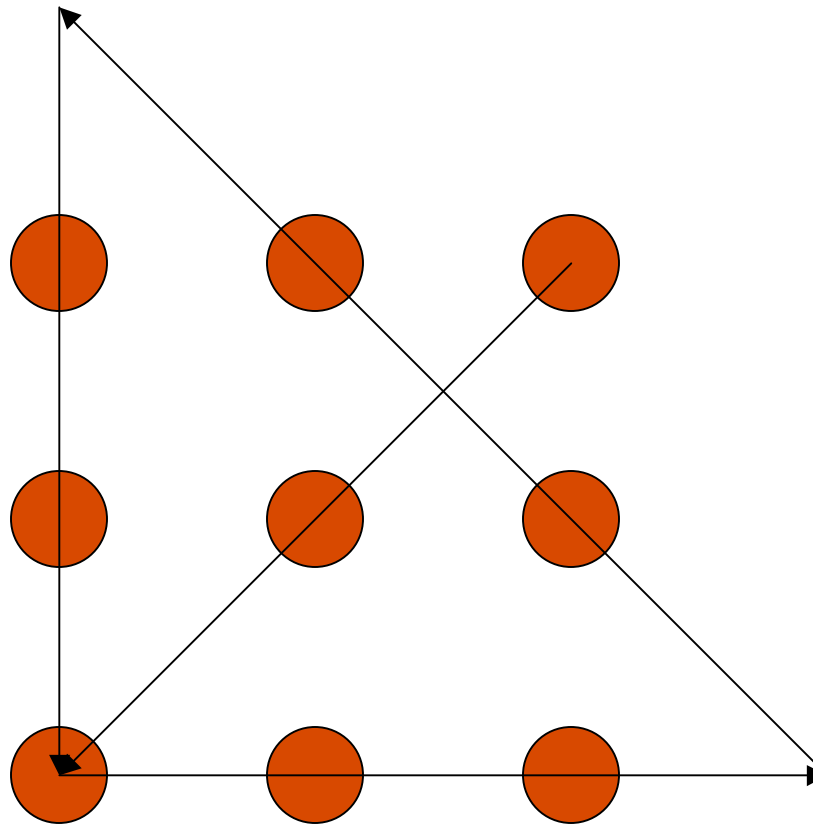
🔲 Using only four strokes, and without lifting the pen, connect all the dots



(Michal Michalko (1994). *Thinkertoys*, Ten Speed Press, 1994)



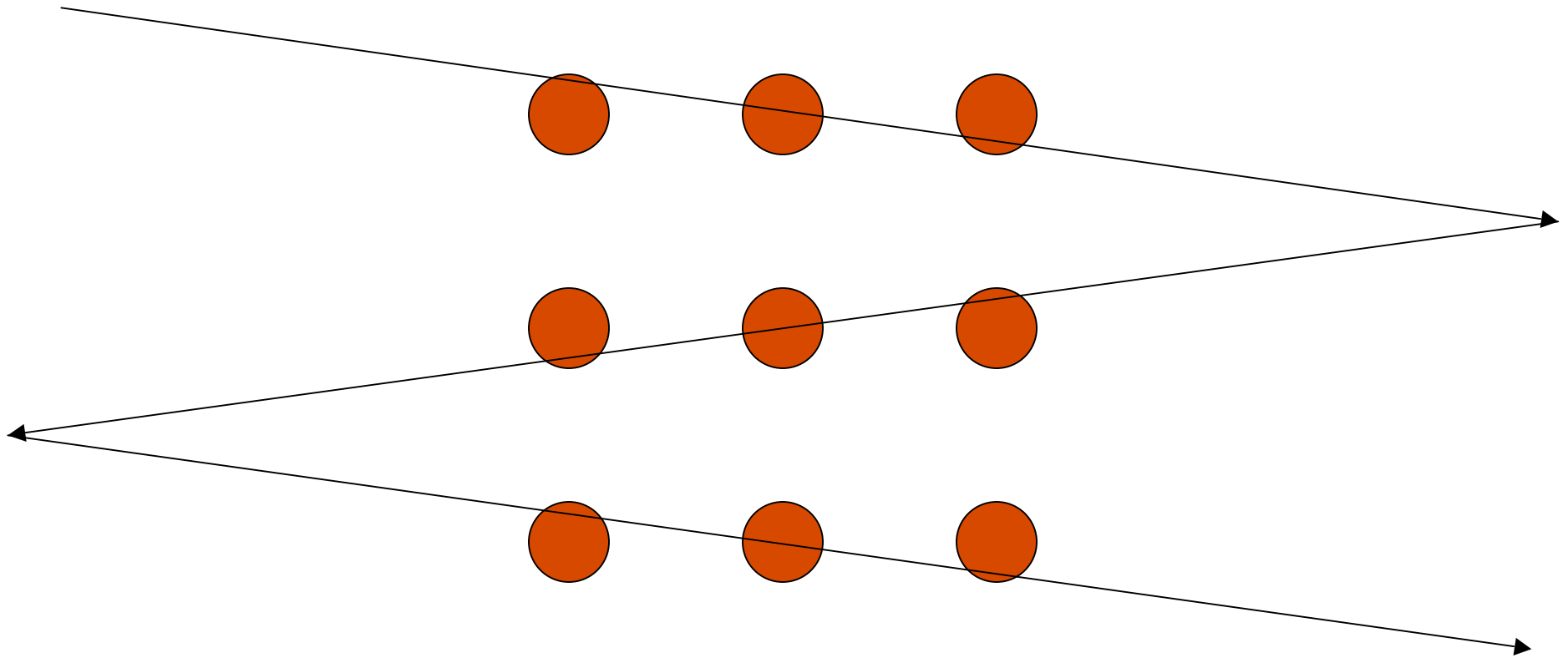
One Innocent Exercises (I/III)



Can you do it again only with 3 strokes?



One Innocent Exercises (I/III)





Why was this exercise tricky?

🎯 Adams, J.L.(1986). *“Conceptual blockbusting: A guide to better ideas”*. Reading, MA:Adisson-Wesley.

🎯 Creativity blocks

- Perceptual
- Emotional
- Cultural/environmental
- Intellectual/expressive
- ...



An Hypothetical Real-World Scenario

➤ Creativity processes are collective ones

- Design groups are becoming inherently multidisciplinary
- Groups are no longer staying on a common location

➤ Computers have become mediators of collaborations

- Email, chat rooms, blogs, wikis...
- A flood of available information
- Different modes of communication

➤ The question:

“Could it be possible to take advantage of computer-mediated communication nature to support human innovation and creativity processes?”

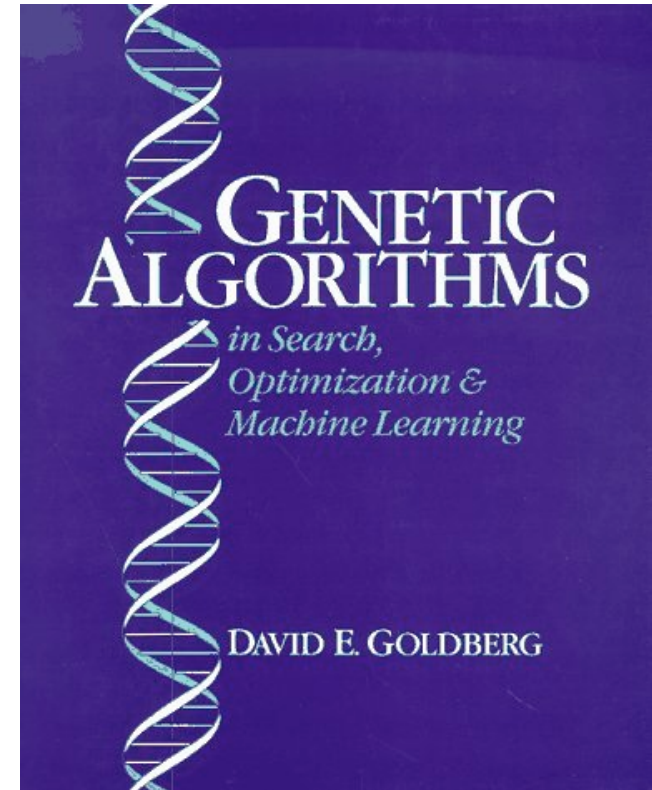


Innovation, Creativity, and GAs?



The Innovation Intuition

- Two reasons:
 1. The innovation intuition
 2. The human-computer quad chart
- The innovation intuition (Goldberg, 1983, 1989, 2002):
 1. Selection + Mutation = *Kaizen*
 2. Selection + Crossover = Crossfertilizing innovation.





Selection + Recombination = Innovation

- Combine *notions* to form *ideas*.
- “It takes two to invent anything. The one makes up combinations; the other chooses, recognizes what he wishes and what is important to him in the mass of the things which the former has imparted to him.” *P. Valéry*





Human-Computer Collaboration

Innovation agent	<i>computational</i>	Standard Genetic Algorithms	Interactive Genetic Algorithms
	<i>human</i>	Computer Aided Design (CAD)	Human Based Genetic Algorithms
		<i>computational</i>	<i>human</i>

Selection agent



3+2 Challenges of Online Innovation

Initial three design challenges:

- Online superficiality.
- Variation in stakeholder articulateness.
- Quantity & heterogeneity of data and analytics sources.

Two more:

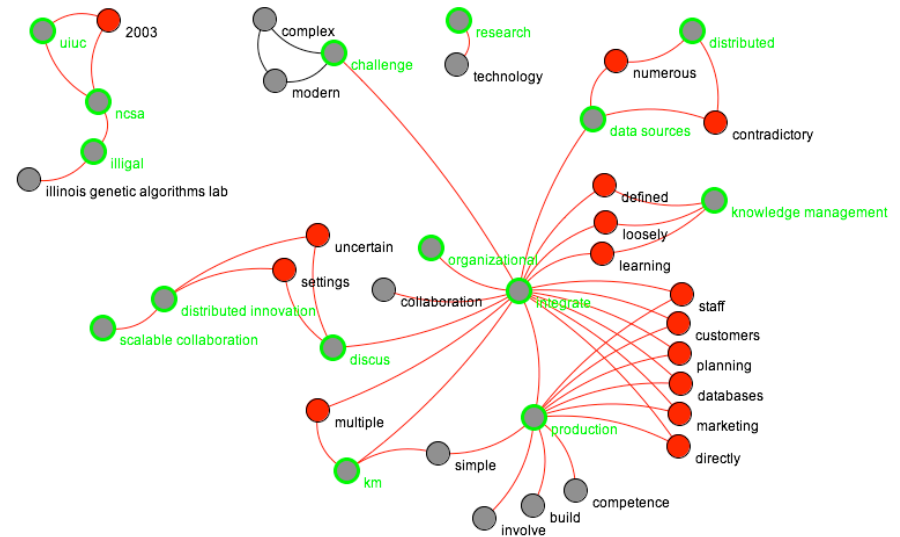
- Inadequacy of fixed structure.
- Importance of the social network of influence.



Online Superficiality

- ❖ Online communication is superficial.
- ❖ Tendency toward write-only world.
- ❖ Many distractions.
- ❖ Difficult to reflect.

Primary solution: Enhance online reflection & innovation through semantic visualization

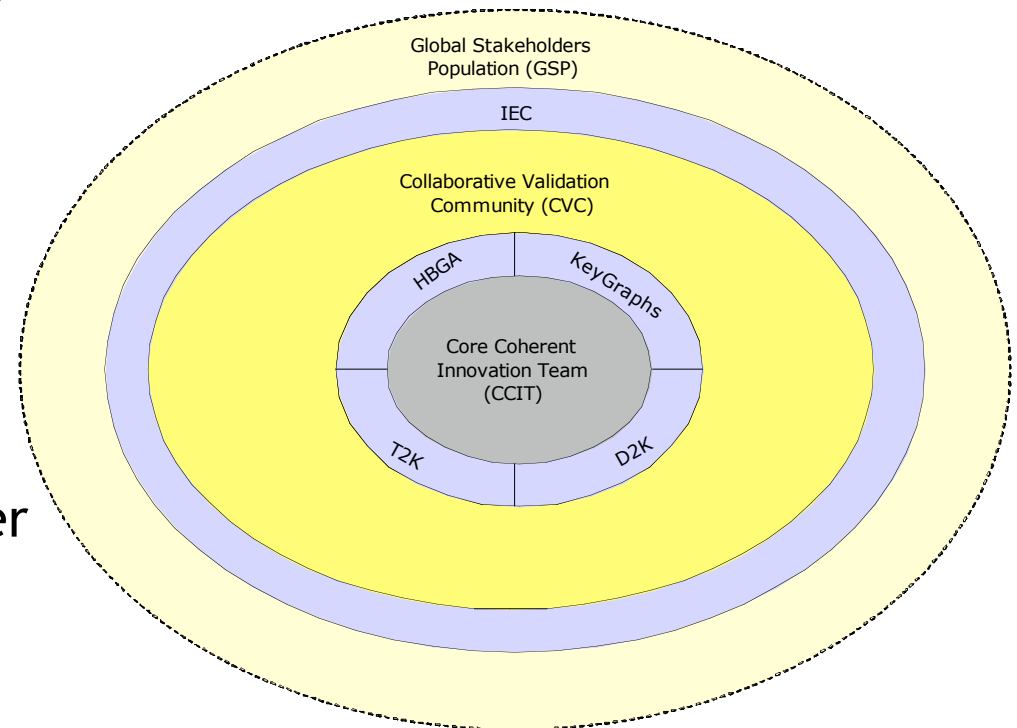




Variation in Articulativeness

- ■
■
 Different stakeholders can express themselves differently.
- ■
■
 2 types:
 - Explainers
 - Evaluators

Primary solution:
 Use full collaboration at center and interactive GA at the boundaries.

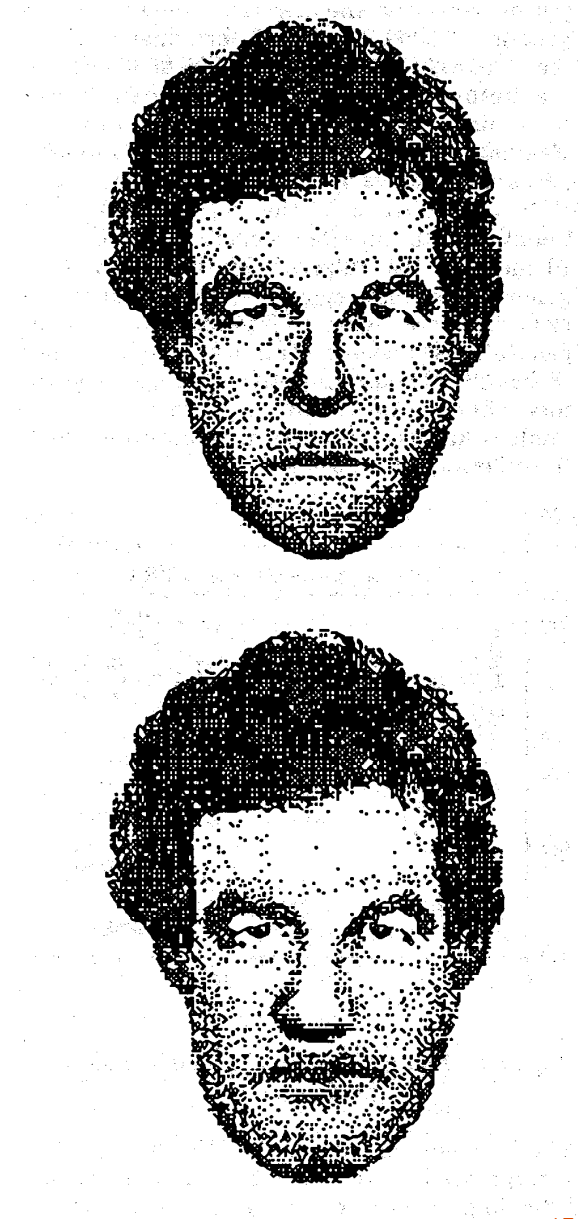




Interactive GAs

- Interactive GA replaces objective function with subjective function from a human.
- Famous example: Faceprints (Caldwell & Johnston, 1991).
- Criminal face reconstruction.
- Used from art to marketing (www.affinnova.com).

Figure : Actual photo of simulated criminal (above). Evolved image from witness using Faceprints (right). (Caldwell & Johnston, 1991)





Quantity & Heterogeneity of Data

- Applications rely on diverse data sources.
- Also need problem-specific analytics.
- Want these at innovation fingertips.

Primary solution:

Build in capable data-text miner and process integrator (D2K) and provide flexible web services interface to problem-specific tools.





Inadequacy of Fixed Structure

- Two versions tried two extremes of organization.
- Amorphous discussion and fixed brainstorming protocol.
- Neither sufficiently flexible for applications
- Non intrusive approach

Primary solution:

Build increasingly flexible administrative controls for space and time topology.



How Do You Envision Then?



The Vision (I/II)

🔗 Computers have become mediators of collaborations

- Email, chat rooms, blogs, wikis...
- A flood of available information
- Different modes of communication

🔗 Let's take advantage of such information

- Logs of conversations
- Archive of documents (email attachments, blogs, personal web pages...)
- Human-computer interactions
- Social aspect of the communication and collaboration



The Vision (II/II)

🔗 Create a system to supports innovation and creativity

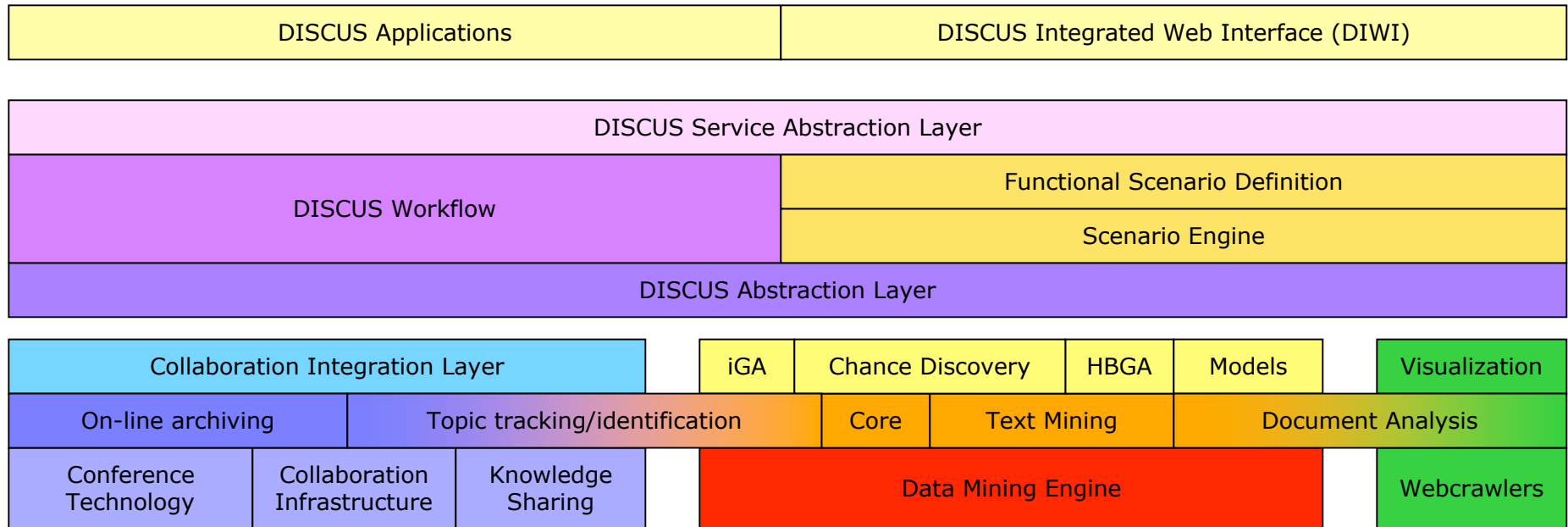
DISCUS: *Distributed Innovation and Scalable
Collaboration in Uncertain Settings*

🔗 The tools available

- Web portals
- Collaboration tools (message boards, chats, blogs...)
- Genetic algorithm (Interactive, Human-based, and Parallel GAs)
- Chance discovery (KeyGraphs and Influence Diffusion Models)
- Data and text mining
- Information retrieval



The Web as a Playground





What About The Pieces?



Relevant, Salient, and Fortuitous Events

🔗 Innovation requires to identify relevant events

🔗 On-line communication:

- tend to be superficial
- take the form of scenarios
- logs of the communication may be available

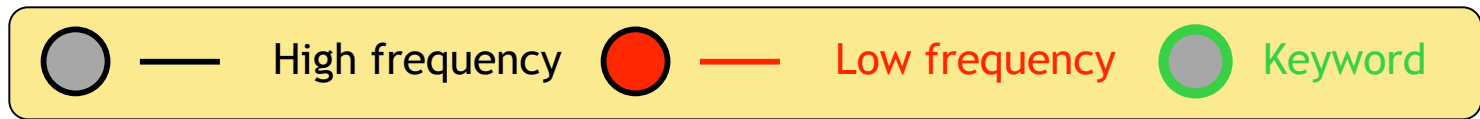
🔗 KeyGraphs are:

- a tool for scenario visualization
- a method for chance identification
- computation embodiments
- a tool for externalization and discussion



What is a KeyGraph?

<http://www-discus.ge.uiuc.edu>





Keygraph & HBGA Box

KeyGraph it! Summarize it! About

DISCUS Communities

DISCUS 3.0: Human-centered enterprise collaboration and innovation Welcome, Noriko.

HOME HELP Search DISCUS Communities...

« Previous Next »

LECTURE 2 QUESTION: WHAT MIND BLOCKS WERE PRESENT IN THE DEFINITION?

30 January 2007. Posted by Xavier.

After reviewing the definitions about creativity and innovation presented in this lecture, can you identify mind blocks underlying such definitions? Feel free to cite other definitions you may have run into.

Posted in [GE-498-ECI](#) | [RSS feed](#) | [Trackback URI](#) | [3 Comments](#) »

Comment by Patrick on 2007-01-30 23:36:10 | [Reply to this comment](#)

For those who explicitly puts down creativity as the production of “artistic work” or even as an “increasingly rare crime” is undermining the fact that creativity is not to be limited by any definition. In the case of “artistic work”, creativity is essential, however, it does not present the whole picture of what creativity has in full. In the case of “increasingly rare crime”, the definition itself is limiting the idea of creativity into something rare and almost extinct. Creativity is about putting imagination into work, and mind blocks such as limiting the definition into problem solving, artistic necessity, new ideas, and even criminal activity are all putting boundaries around the term “creativity”. When creativity is bound by some dictionary definitions, it no longer become a process of freedom and imagination, but prong to established mental mindsets. Thus, mind blocks may not only limit the possibilities of creativity, but also limit one’s ability to be creative.

Comment by clevin3 on 2007-01-31 13:14:20 | [Reply to this comment](#)

I completely agree with the word “play” in the above post. Everyone appears to categorize everything they do. There is work and there is play. The two are seldom integrated, and thus by truly attempting to play while “working” or attempting a

DISCUSSIONS

- » [GE-498-ECI](#)

RECENT ENTRIES

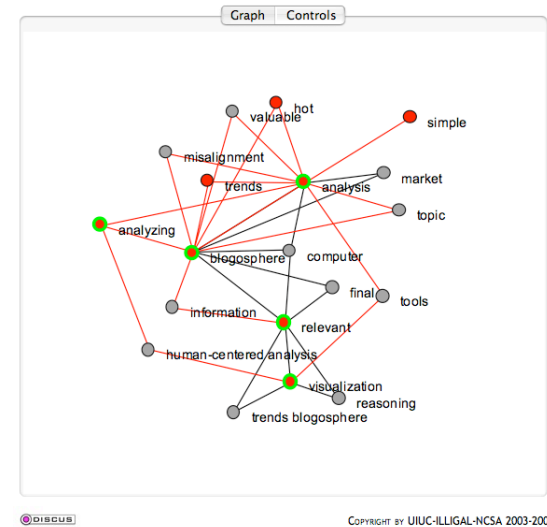
- » Lecture 3 (Step 1): Put all you got on the table
- » Lecture 2 question: What mind blocks were present in the definition?
- » Lecture 1 question: What do tomato sauce and dancing have in common?

FAVORITE LINKS

- » [The DISCUS project](#)

META

- » [Site Admin](#)
- » [Logout](#)





How Can I Compute a KeyGraph?

Document Processing (D')

- Document compactation (stop-word removal and word stemming)
- Phrase construction (most frequent work combinations)

Extraction of high-frequency terms ($N_{hf} \subset D'$)

Extracting links for all $N_{hf} \subset D'$ (top ranking association)

$$key(w) = 1 - \prod_{g \in G} \left[1 - \frac{based(w, g)}{neighbors(g)} \right] \quad based(w, g) = \sum_{s \in D'} |w|_s, |g - w|_s,$$

$$neighbors(w) = \sum_{s \in D'} \sum_{w \in s} |w|_s, |g - w|_s,$$

- Extracting key links among N_{hf} and N_{hf} using the *assoc* metric
- Keyword identify useful bridges among clusters ($N_{hf} \cup N_{hf}$)



But, Aren't We Talking About A Group Activity?



Influence Diffusion Models

🔷 Influence Diffusion Model (IDM)

- Analyze the influence factors in a communication
- Two main influence factors:
 - Turning point messages
 - Role play identification

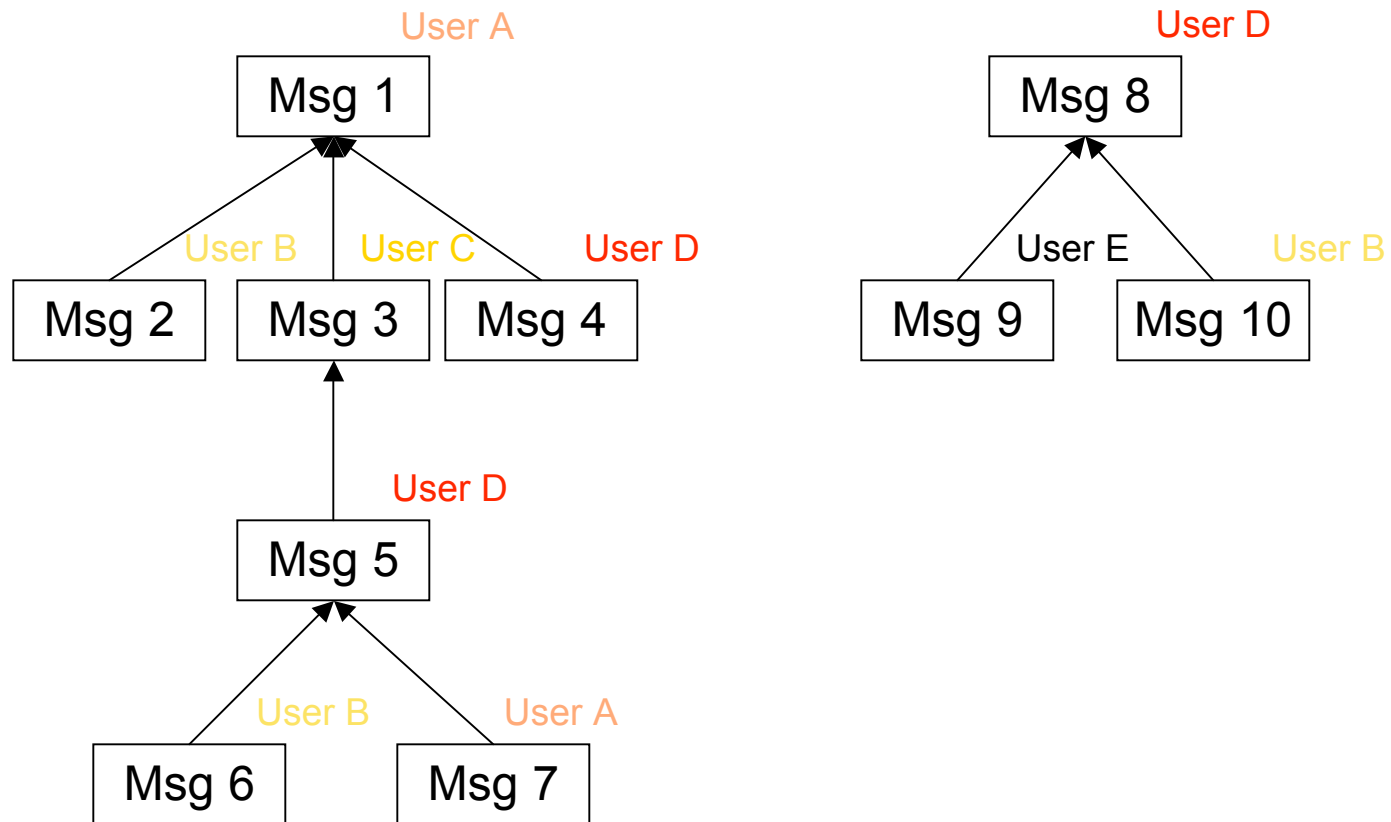
🔷 Help identify communication roles and blocks

- Strong opinion leaders (trend creators)
- Communication facilitators (trend publishers)
- Critical mass for a blossom communication (early adopters)
- Communication dumper (slow adopters)
- Disruptors (rejecters)



Structure on an On-line Communication

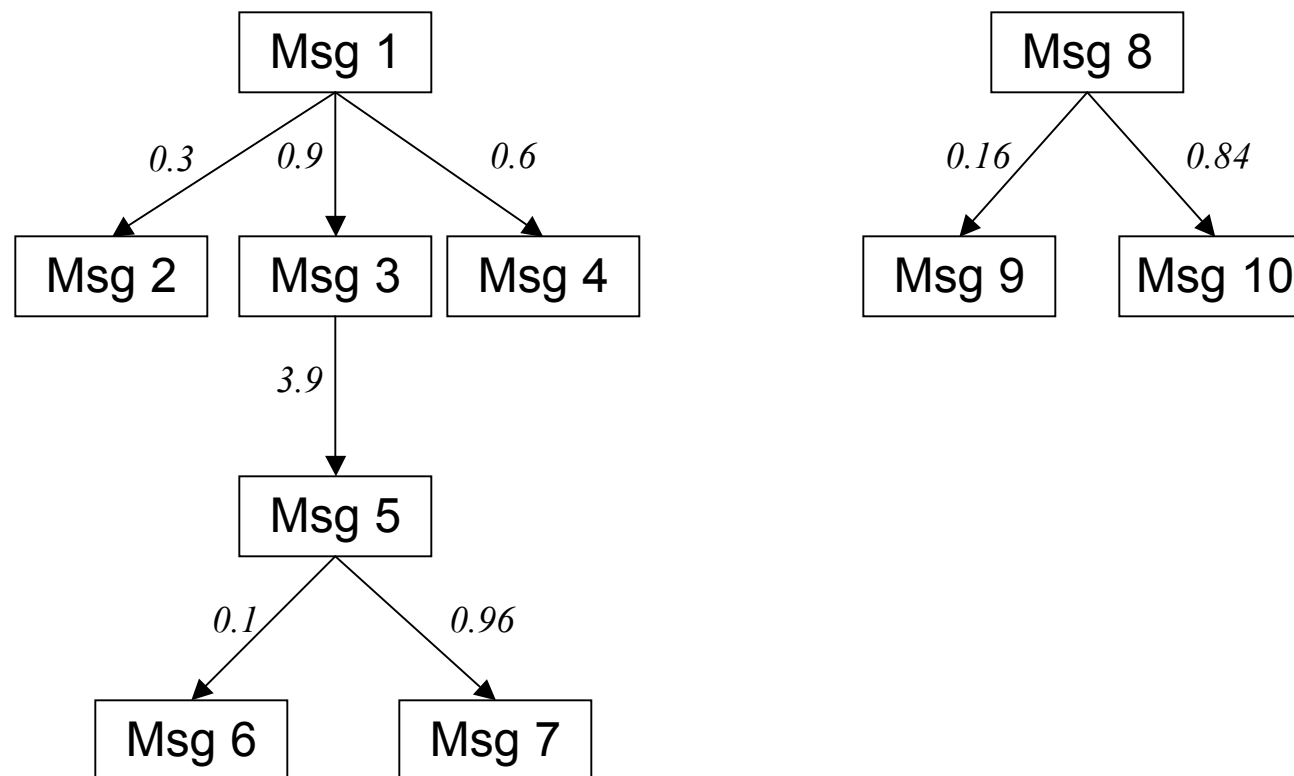
IDM and structured bulletin boards





Influence on an On-line Communication


IDM and structured bulletin boards





A Real Prototype

Resources



[- Knowledge Center Mining](#) - [- Google Search](#) - [- Solution center](#) - [- KeyGraph Analysis](#)

Discussion Board

Houses

| [Start new thread](#) | [Show all bodies](#) | [Hide all bodies](#) |


Pages: < 1 2

+ **Air conditioner** · Portercircle · replies: 11 ☑ May 26, 2004 - 7:21 PM

+ **Transcontinental influence** · xllora · replies: 8 ☑ May 26, 2004 - 7:43 PM

| [Post Reply](#)

In late 18XX and early 19XX there was a strong japanese influence in western culture. For instance, impresionist were fascinated with japanese prints. They even reproduce some of the prints in their pictures. The samne think can be seen in some architectes, such as Frank Lloyd Wrighth. He was greatly influenced by japanese house, and that was



DISCUS

Some of this of space in Japan is one?

ted

29733 bytes
 33530 bytes
 25080 bytes

May 26, 2004 - 7:33 PM

Discussion

- ◆ Houses
- ◆ Resources

User Information

Xavier Llorà (xllora)
DISCUS administrator

[Close window]

Logged Users

Online Members
 My DISCUSsions (14)

Solution Center

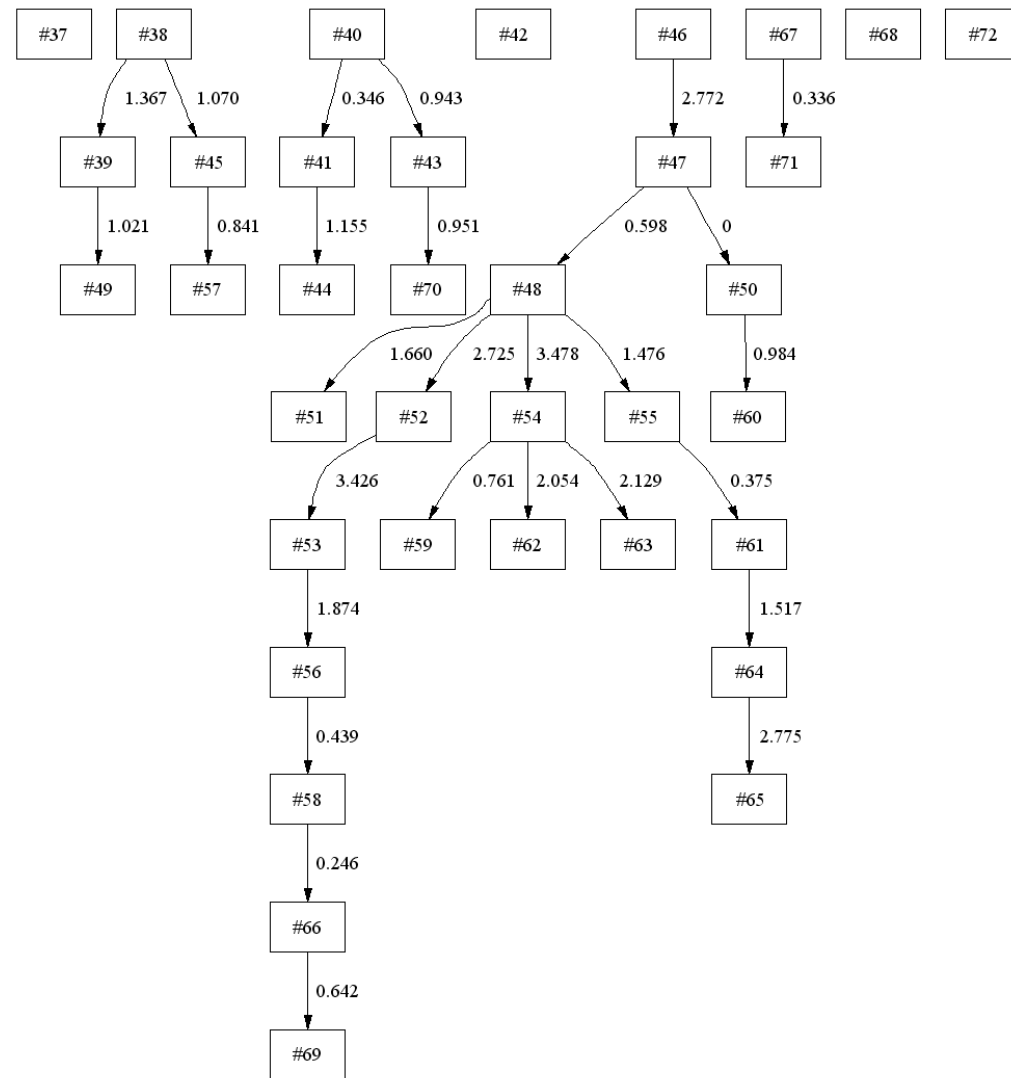
+ **Housing**
 Air conditioning is a must.

DISCUS

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A Real Marketing DISCUSsion





Quantifying Influence on a Real Focus Group

term ranking↓

	IDM rank	inf	hits rank	score
1	phone	67	phone	0.07941
2	cell	50	cell	0.05476
3	peopl	9	peopl	0.01858
4	featur	7	featur	0.01699
5	battery	6	comput	0.01304
6	dissatisfact	5	don	0.01025
7	phonebook	5	call	0.01005
8	call	4	thing	0.00943
9	answer	4	talk	0.00936
10	internet	4	battery	0.00840
11	put	3	gp	0.00761
12	gp	3	number	0.00747
13	camera	3	internet	0.00747
14	devic	3	make	0.00702
15	life	3	feel	0.00675
16	memory	3	devic	0.00661
17	keyboard	3	defin	0.00627
18	player	2	function	0.00611
19	don	2	servic	0.00609
20	song	2	cellphon	0.00595
21	benefit	2	keyboard	0.00579
22	daily	2	ad	0.00571
23	day	2	home	0.00570
24	futur	2	problem	0.00555
25	number	2	technology	0.00537
26	depend	1	lot	0.00524
27	side	1	simply	0.00521
28	walky	1	person	0.00519
29	feel	1	camera	0.00517
30	case	1	free	0.00512

individual ranking¥↓

	IDM rank	inf	hits rank	score
1	Yuichi	63	P060	0.321
2	P060	55	P045	0.294
3	P045	51	P073	0.202
4	P073	40	P078	0.087
5	p046	26	p046	0.068
6	P078	9	Yuichi	0.027

Exclude high frequent terms

individual ranking↓

	IDM rank	inf	hits rank	score
1	P060	32	p046	0.301
2	P045	28	P060	0.265
3	p046	24	P045	0.229
4	P073	17	P078	0.105
5	Yuichi	13	P073	0.095
6	P078	4	Yuichi	0.004

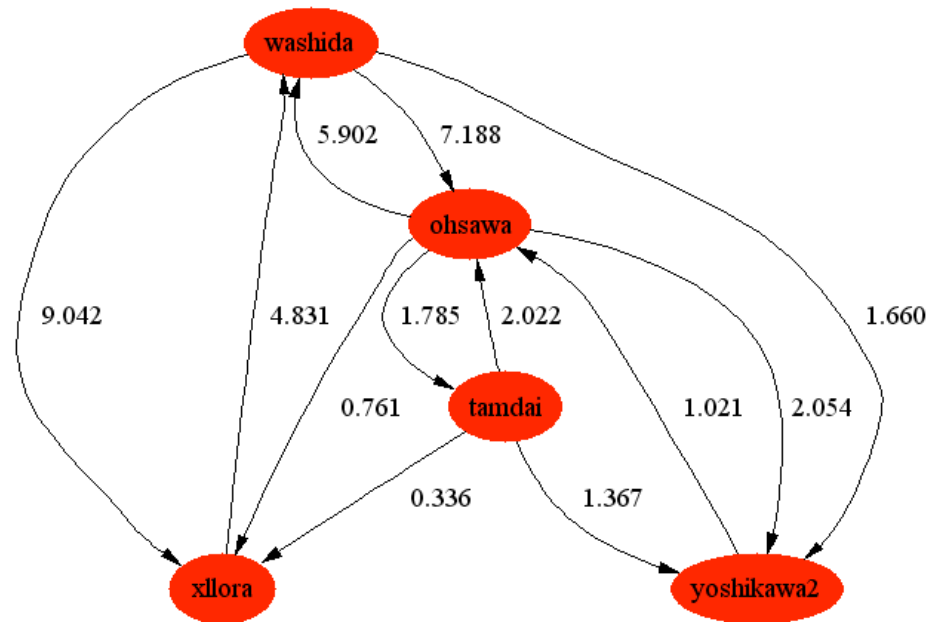


Mining the Network of Influence

- Were focused on semantics to exclusion of the social network.
- Thought that network visualization might be as powerful for reflection as social.

Primary solution:

Incorporate influence diffusion methods.





Putting the Zoom in Zoom-Zoom-Zoom

- Work w/ Hakuholdo, no. 2 Japanese advertising firm.
- DISCUS in use for design of concept car by Mazda.
- Innovation in marketing v. warfighting: Changing consumer vs. changing adversary.





And Where is The GA?



Creativity, Innovation, and Genetic Algorithms?

➤ The Design of Innovation (*Goldberg, 2002*)

➤ *Selection+Mutation=Improvement*

- Mutation makes local changes
- Selection accepts the better ones
- Total Quality Management: continual improvement

➤ *Selection+Recombination=Innovation*

- Combine *notions* to form *ideas*
- The recombined ideas undergo a selection process for acceptance or rejection



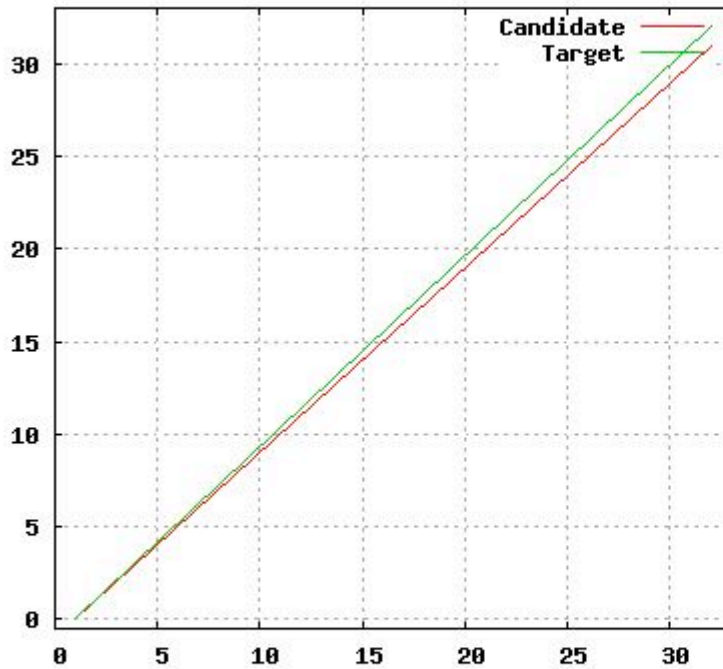
Human-Based Genetic Algorithms

- ▶ A simple collaborative effort (*Kosorukoff & Goldberg, 2002*)
- ▶ A pool of possible future scenarios and chances
- ▶ Two activities: selection and scenario creation
- ▶ Scenarios and chances are generated by participant
 - Free form creation
 - Recombine previous scenarios
 - Guided process supported by chance discovery techniques
- ▶ Group activity
 - One or more groups
 - Sequential or parallel activities
 - Different degrees of connectivity and information exchange

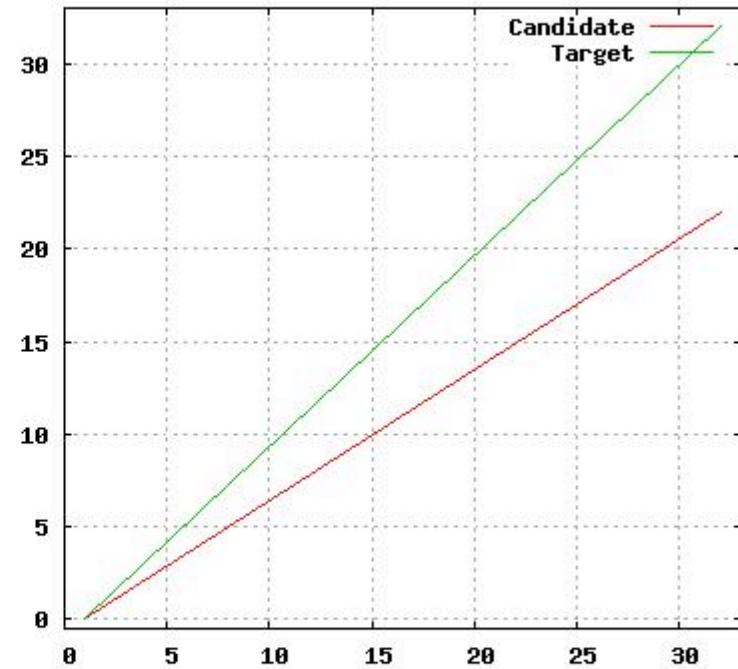


DISCUS, IGA, & Research

Current session status: *Iteration 1. Comparison 16.*



Solution 1



Solution 2

Please, select the best solution:

None

Solution 1

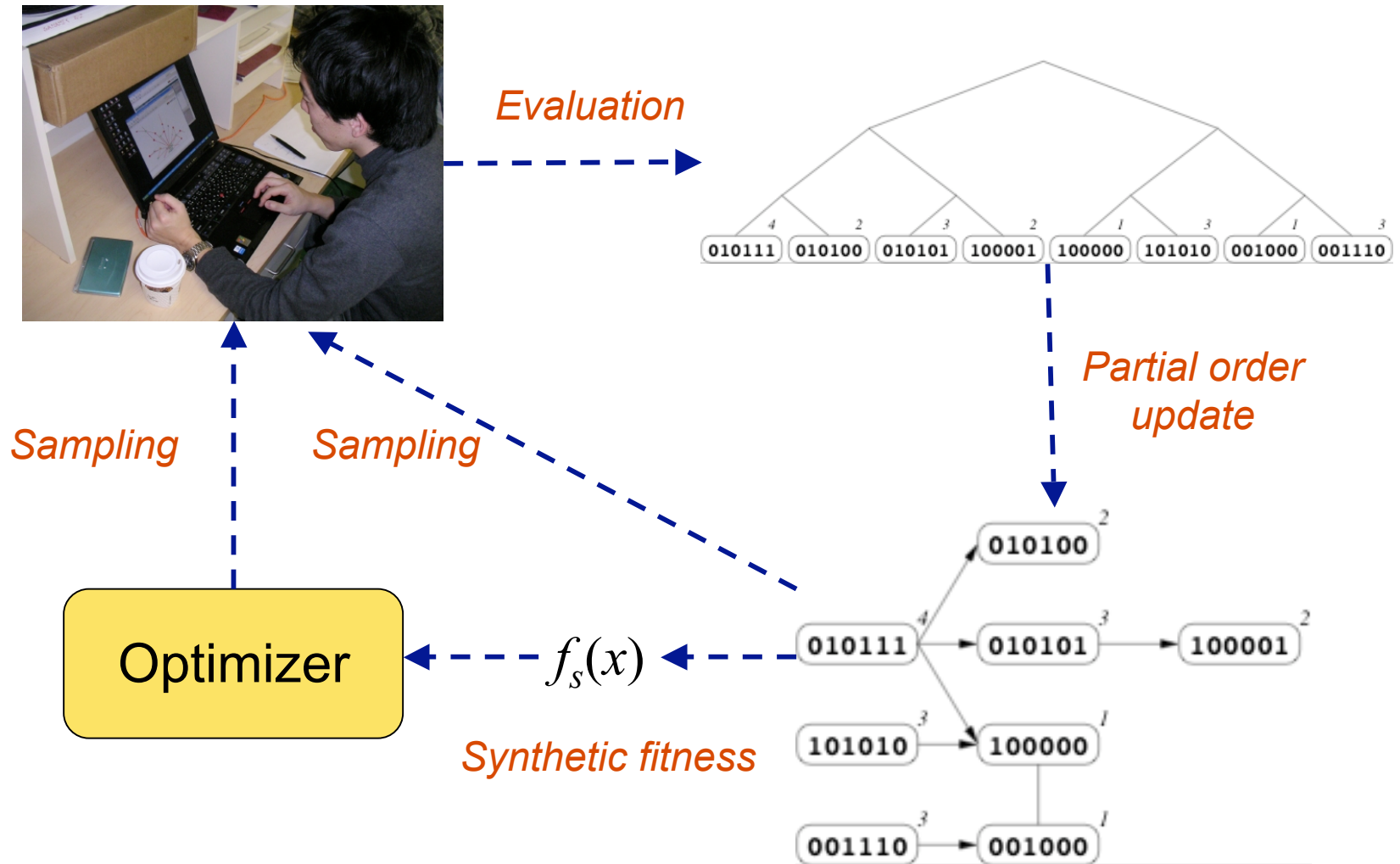
Solution 2

None

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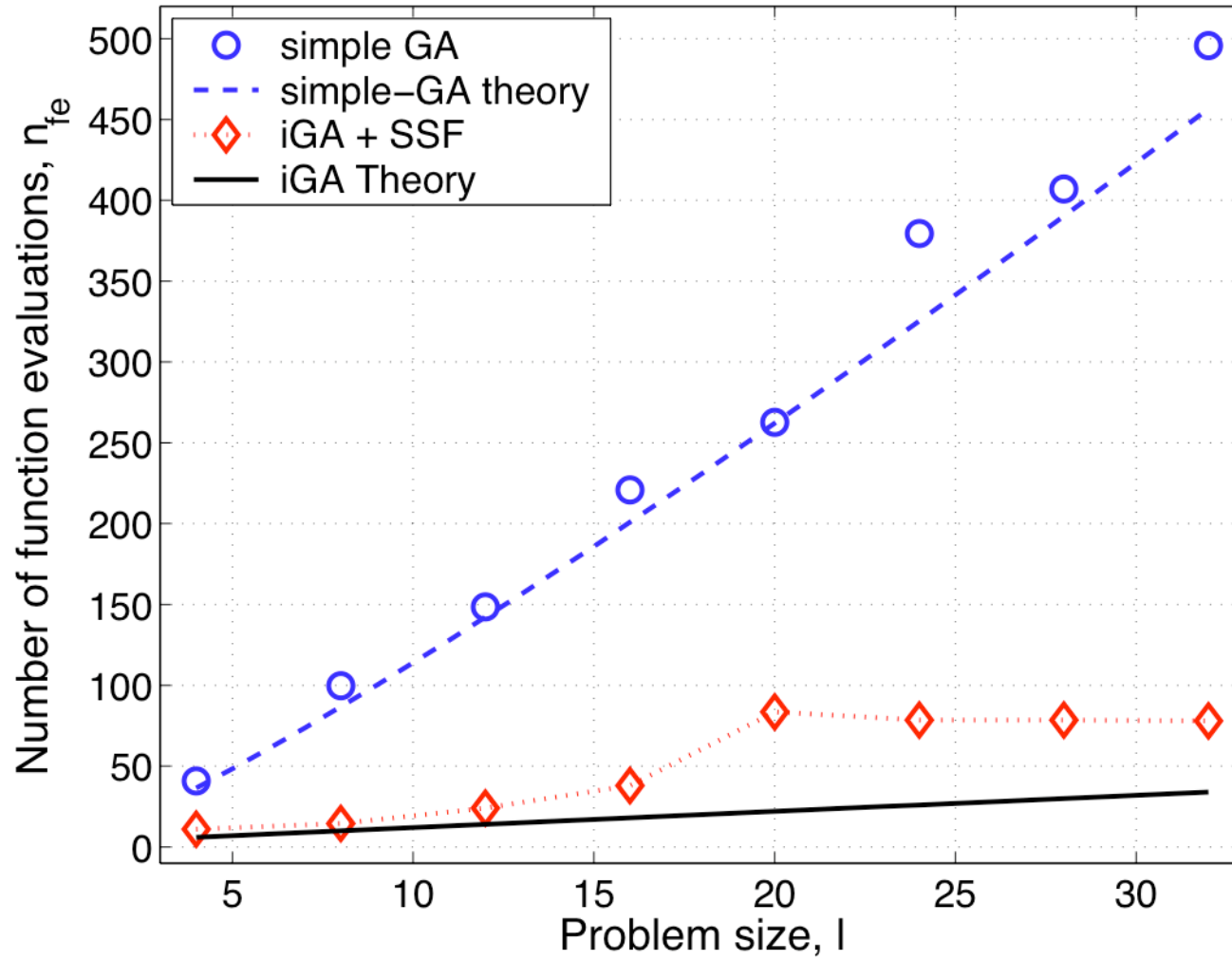


User Subjective Functions





Pilot Experiment





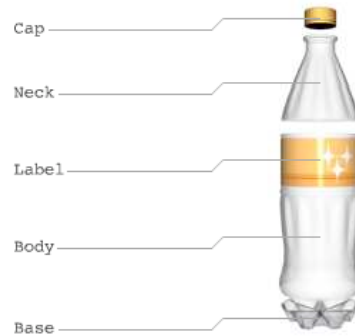
Example I: Affinova IDDEA

- Concept design: Create new product candidates
- Affinova (<http://www.affinova.com/>)

1. Base Concept



2. Featurize



3. Create alternatives



4. Generate alternative, involve customers, and iterate





Example II: The Electronic Sheep

- Proposed by Scott Draves (<http://electricsheep.org/>)
- A form of aesthetic evolution, a concept first realized by Karl Sims
- The goal:
 - Animate and evolve artificial life-forms know as sheep
 - Reference to Philip K. Dirk's novel
- Use screensavers to:
 - Create a distributed rendering farm
 - Collect user votes on favorite sheep
- Popular sheep life longer and generate new sheep
- Search space:
 - The space of parameters of fractal flames, a generalization and refinement of the Iterated Function System (IFS).
 - Each sheep is defined by 240 floating point values to optimize



Example II: The Electronic Sheep

Sheep #1700



Sheep #110345149











Example III: Emotional Prosody

- Cecilia Alm and Xavier Llorà [Alm & Llorà, 2006] (<http://www.i-discus.org>)
- The problem:
 - Text-to-speech (TTS) synthesis (given a text the associated speech is synthesized)
 - The lack of emotion (neutrality) makes the TTS synthesis sound unnatural
- The goal:
 - Adjust the TTS to incorporate emotional prosody
 - Spoken text should sound *sad, angry, happy, etc.*
 - Very useful for story telling or automated audio book generation
- Users can easily discern the emotional prosody, but hard to explain why
- Search space:
 - Several parameters can be tweak to modify the prosody (6 per word)
 - These parameters define the prosody search space



Example III: Emotional Prosody

Sad		Angry	
Strawberry		Strawberry	
Tan-tan-tan		Tan-tan-tan	
Bubhalos		Bubhalos	



Beyond and Above



DISCUS in Combat Coordination: SAINT

- ◆ SAINT: Semantics, Adaptation, and Influence in Networked Teams
- ◆ Funded extension for enhancement of command communication and innovation to US Air Force.
- ◆ Key elements of the proposal:
 - Tighter integration of influence and semantics.
 - Seamless integration of humans and computers.
- ◆ Seeking integration into Air Operations Centers (AOCs).



Toward Seamless H-C Creativity

Building block formation and mapping. Mine key terms and relations and form building blocks or conceptual clusters.

Chromosome formation and interaction. Develop modified vector approaches moving toward Bayesian models of term co-existence.

Building block social evaluation. Use IDM process for social evaluation of building blocks.

Conceptual chromosome fitness evaluation. Build fast, accurate models of human preference to be used in lieu of H evaluation.

Idea generation. Combine subsystems for effective HC creative idea generation.



Building Block on Communication Channels

- Example conducted on one email account
- 450 emails approx.
- Low traffic email box
- No spam

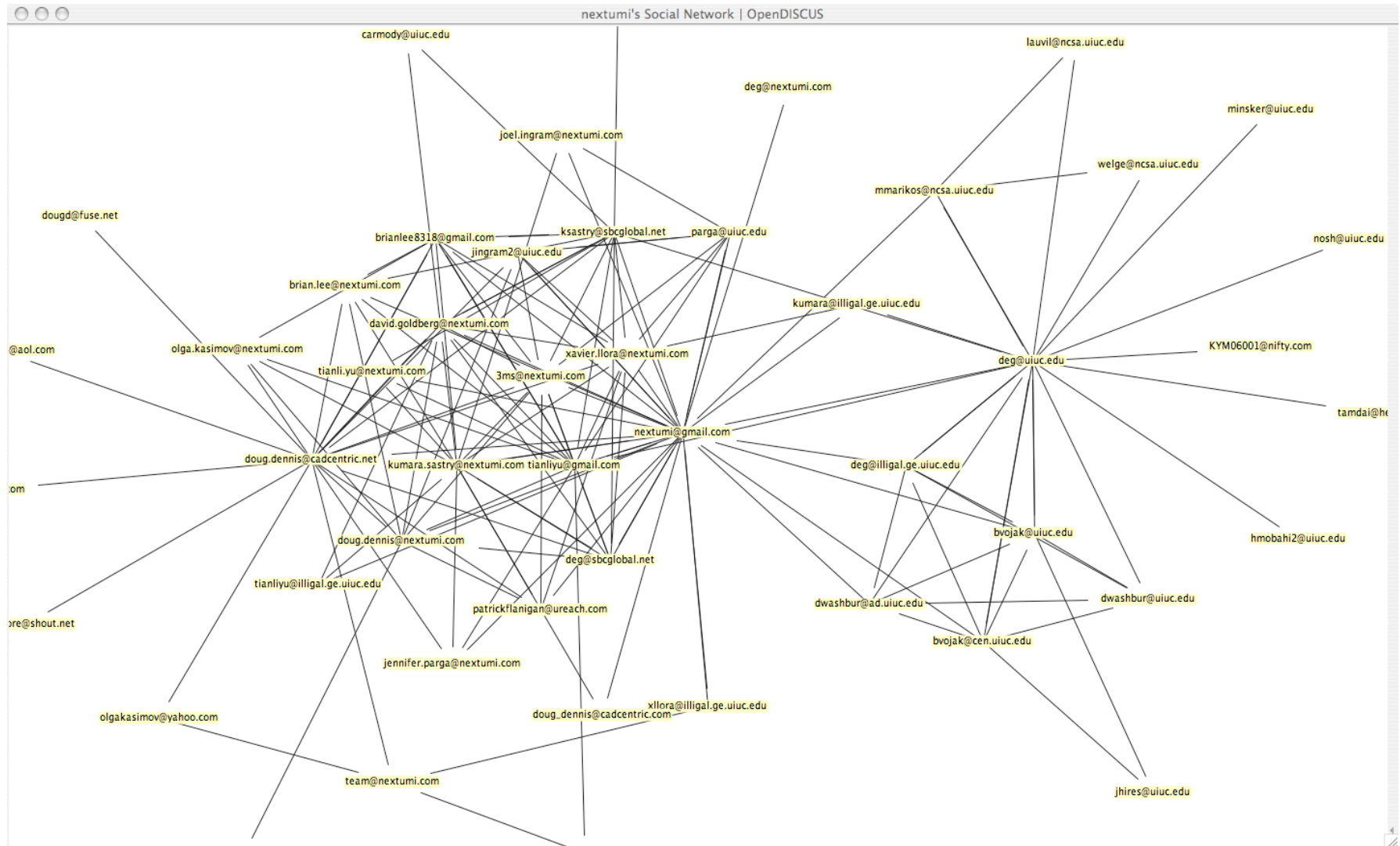


Social Network Analysis

- Email box content extraction and processing
- Following the DISCUS experience we heavily used visualizations
- Visualization of data and analysis results
- A first step involve identifying key players
 - Social network visualization
 - Degree ranking distribution analysis visualization
 - Betweenness/centrality analysis visualization
 - HITS analysis visualization
- IDM vs SN analysis provides a way analysis corporate versus community communication patterns

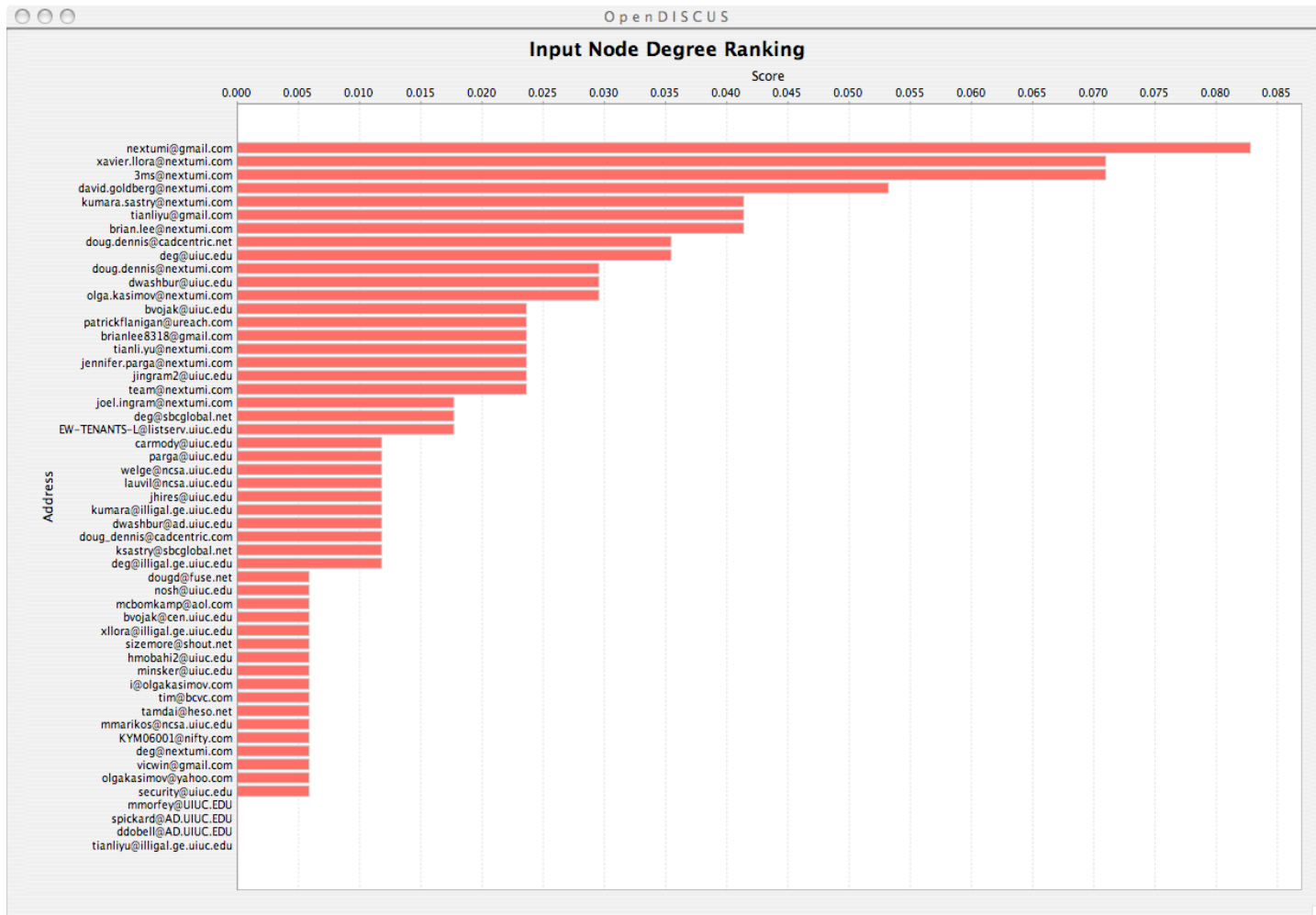


Social Network Visualization



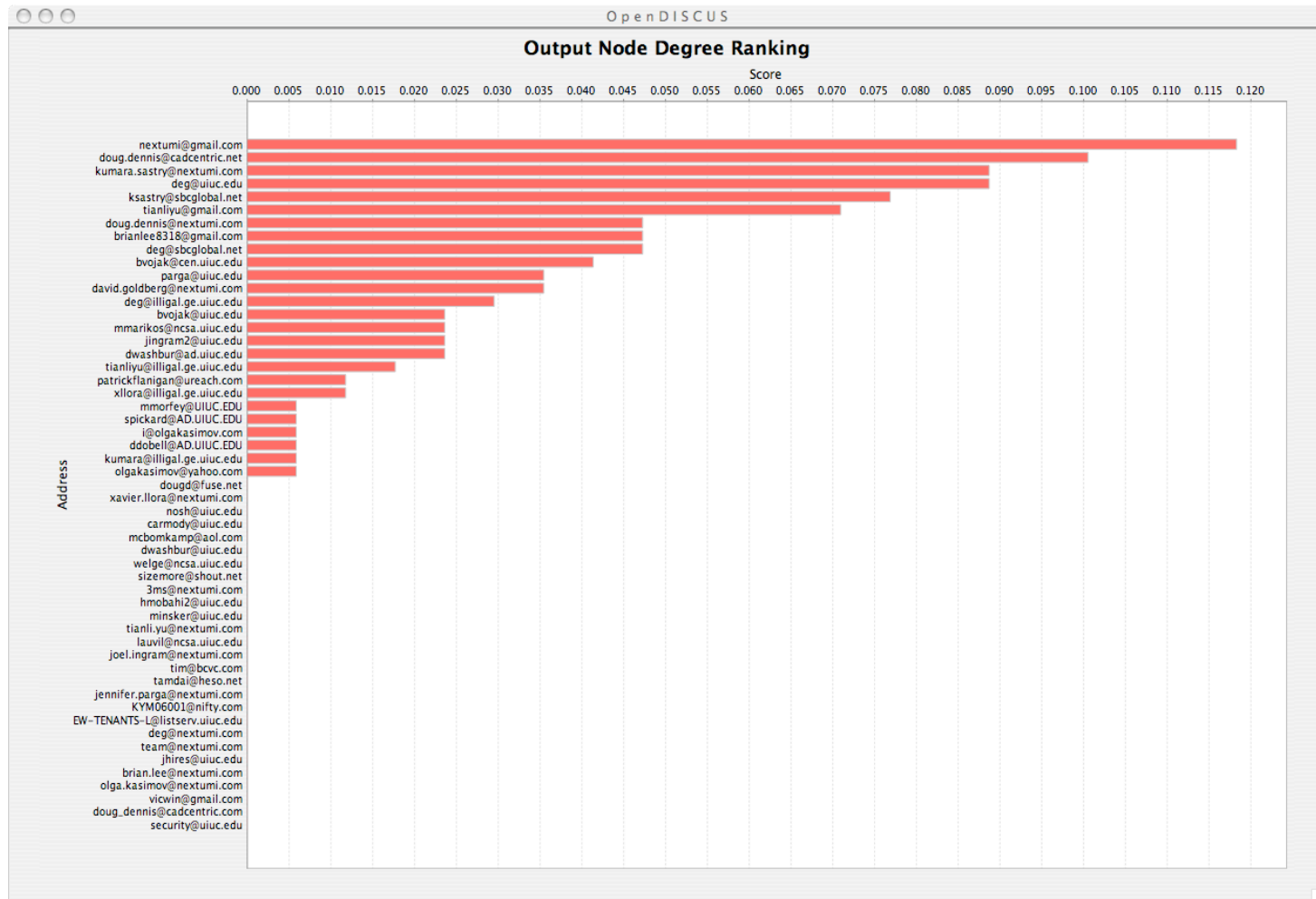


Degree Ranking Distribution (Input)



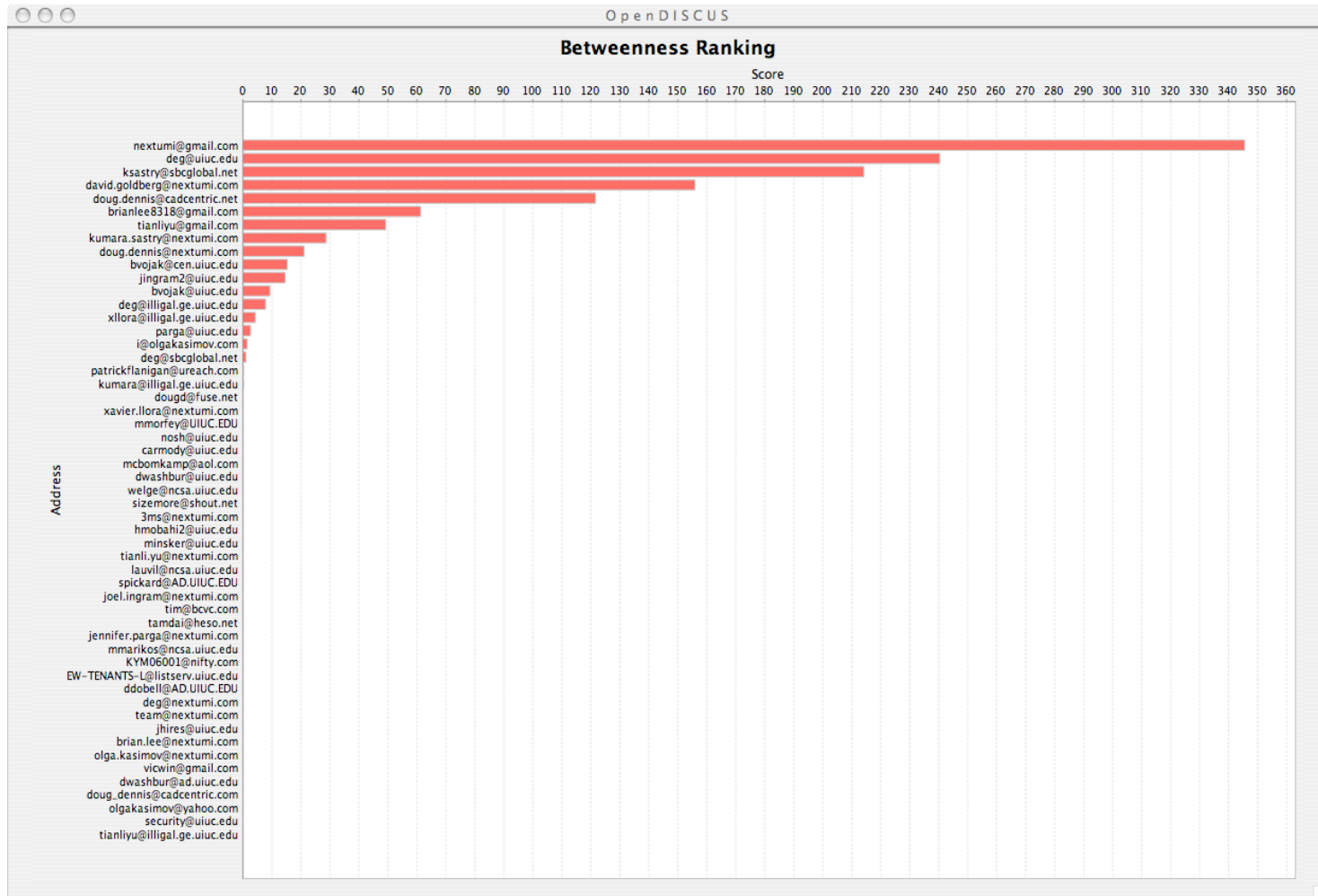


Degree Ranking Distribution (Output)





Betweenness/Centrality





Content Analysis

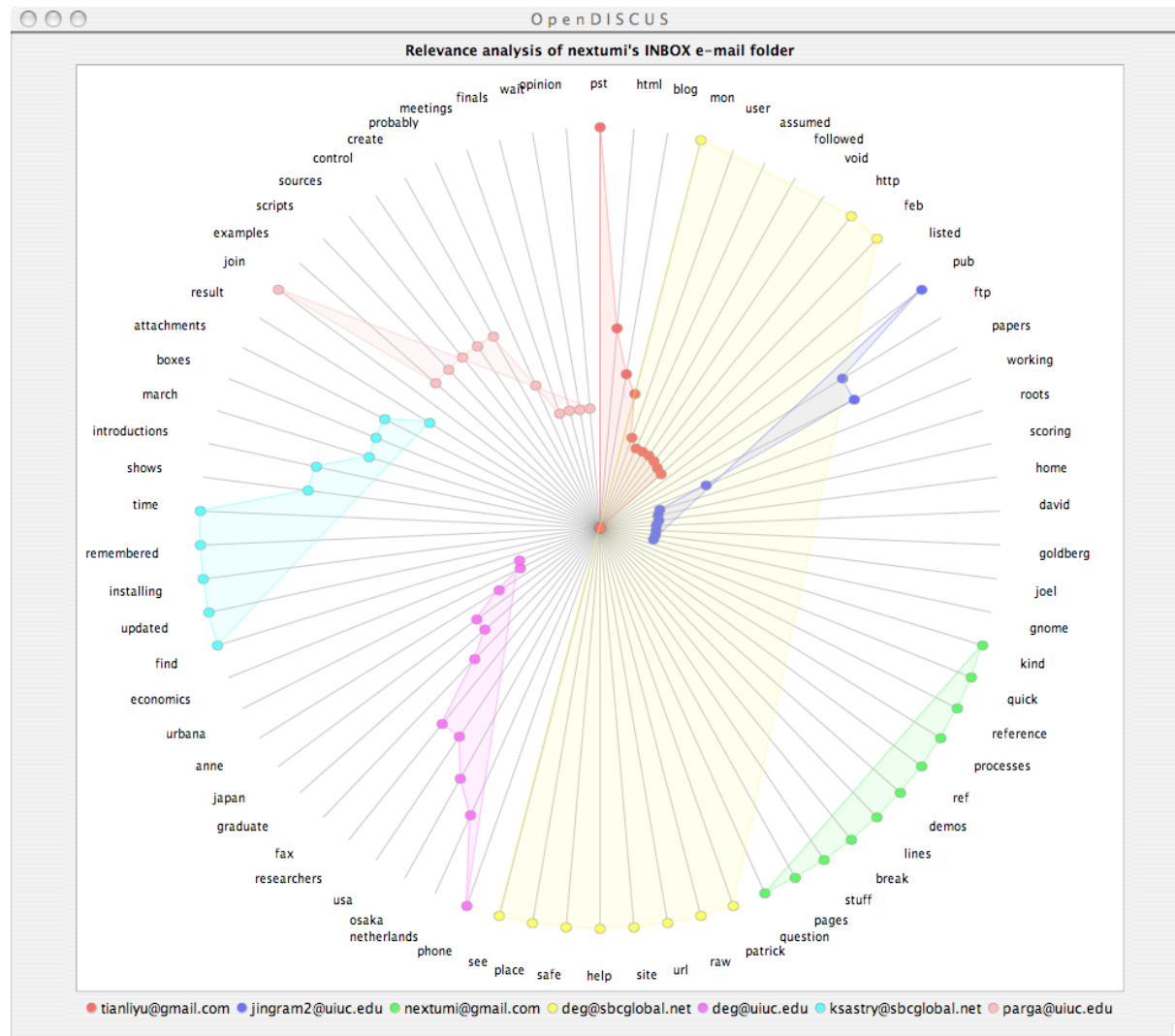
📧 Email box processed content analysis

📊 Visualizations

- Key self/non-self discriminant terms.
 - For a given user, we build a model that distinguishing self from non-self email.
 - It works remarkably well.
 - Terms can be ranked according to their weight.
 - Then all terms are rendered and connected based on weight and grouped by users (useful to identify overlapping and differences among user's topics)
- Communication topics
 - Identification
 - Transition detection

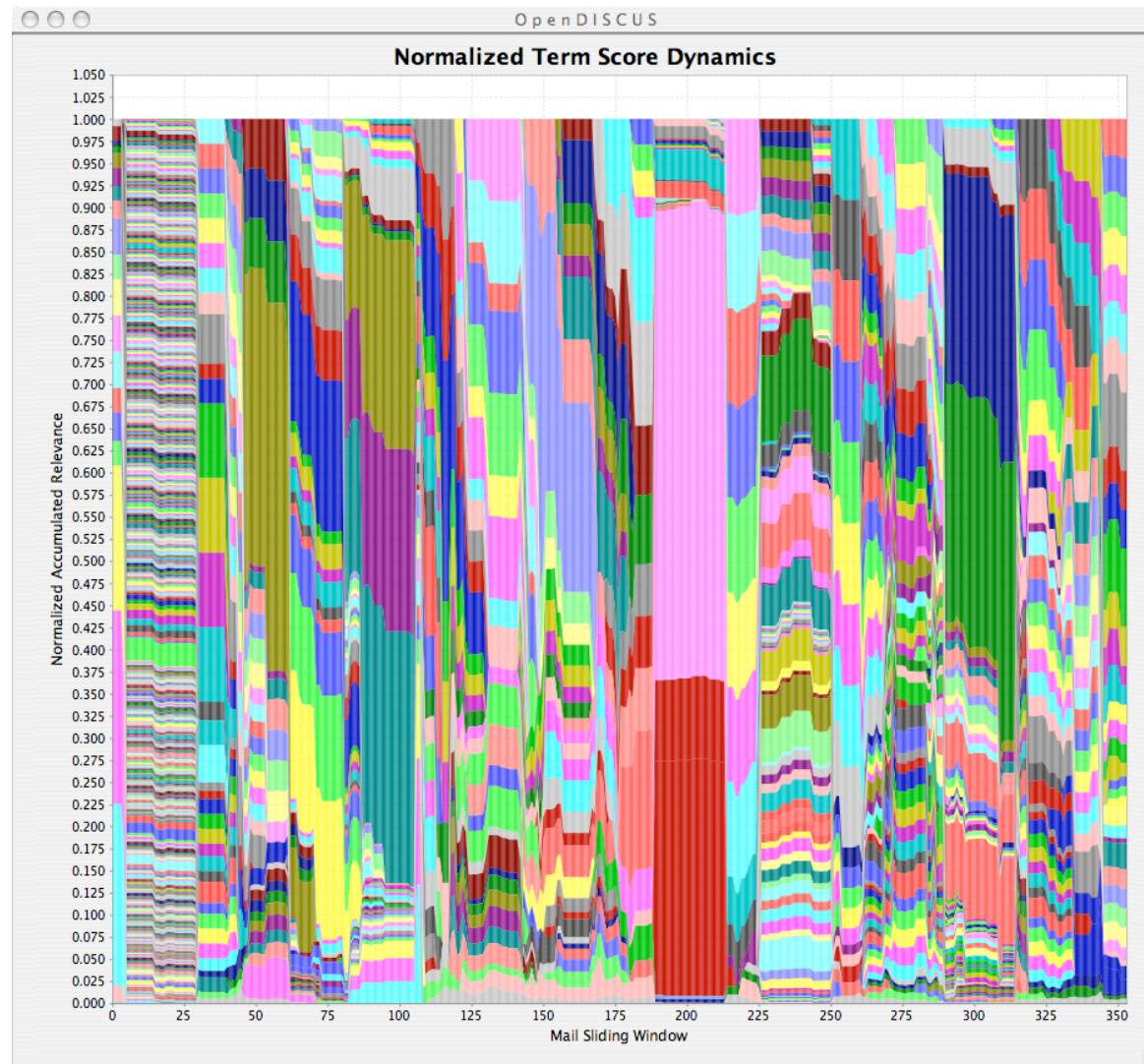


Self/non-self Discriminant Terms





Term Dynamics





The Take Away Message

🔷 The question:

“Could it be possible to take advantage of computer-mediated communication nature to support human innovation and creativity processes?”

🔷 The Answer:

Yes

🔷 The key elements to successfully support innovation and creativity

- Genetic algorithms
- Chance discovery
- Collaboration tools over the net
- Data and text analysis tools
- Visualization techniques



More Information

📍 Contact us

- Xavier Llorà (xllora@illigal.ge.uiuc.edu)
- David E. Goldberg (deg@illigal.ge.uiuc.edu)

📍 Visit

- DISCUS site (<http://www-discus.ge.uiuc.edu/>)
- IlliGAL blog (<http://illigal.blogspot.com/>)
- IlliGAL web site (<http://www-illigal.ge.uiuc.edu/>)
- The LINK aliance (<http://www.ui-link.org/>)

📖 Book:

- Goldberg, D. E. (2002). *The Design of Innovation*. Boston, MA: Kluwer Academic, (<http://www-doi.ge.uiuc.edu/>)