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the Haiti earthquake relief operations from
APAN data sources using lexical link analysis (LLA)

Zhao, Ying; Gallup, Shelley P.; MacKinnon, Douglas J.

17th International Command and Control Research and Technology Symposium
(ICCRTS), Fairfax, VA, June 19-21, 2012.

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Semantic and Social Networks Comparison for the Haiti Earthquake Relief Operations from APAN Data Sources using Lexical Link Analysis (LLA)

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17th ICCRTS, International Command and Control, Research and Technology
Symposium, Fairfax, Virginia, June 19–21, 2012



Research Questions



- How can we discover themes and topics in the discussion forum and sort the importance of the themes?
- How can we discover social and semantic networks of organizations that were involved, compare the two networks to obtain new insights?
 - What were the organizations involved in the *important* themes in the Haiti operation?
 - How do semantic networks offer more potential collaboration when compared to social networks?



HAITI Project

- Data Sources

- ~2600 open source web pages

- Used High Performance Computer (HPC) nodes.
- News feed from 1/13 – 2/23/2010
- Twitter as a starting point
 - SOUTHCOM, USAID and others used Twitter to handle the situations

- US SOUTHERN COMMAND also engaged the HAITI HA/DR Community of Interest (COI) on the All Partners Access Network (APAN) during the Haiti crisis. The APAN data was captured from a MSSQL database. The sources were:

- Official documents and briefings in PDF: ~167 PDF file attachments related to HAITI HA/DR from 1/13/2010 to 5/26/2010
- SITREP: ~150 Situation Report documents
- Forum: ~1173 posts from 1/13/2010 to 6/3/2010
- Blogs: ~3900 blog messages

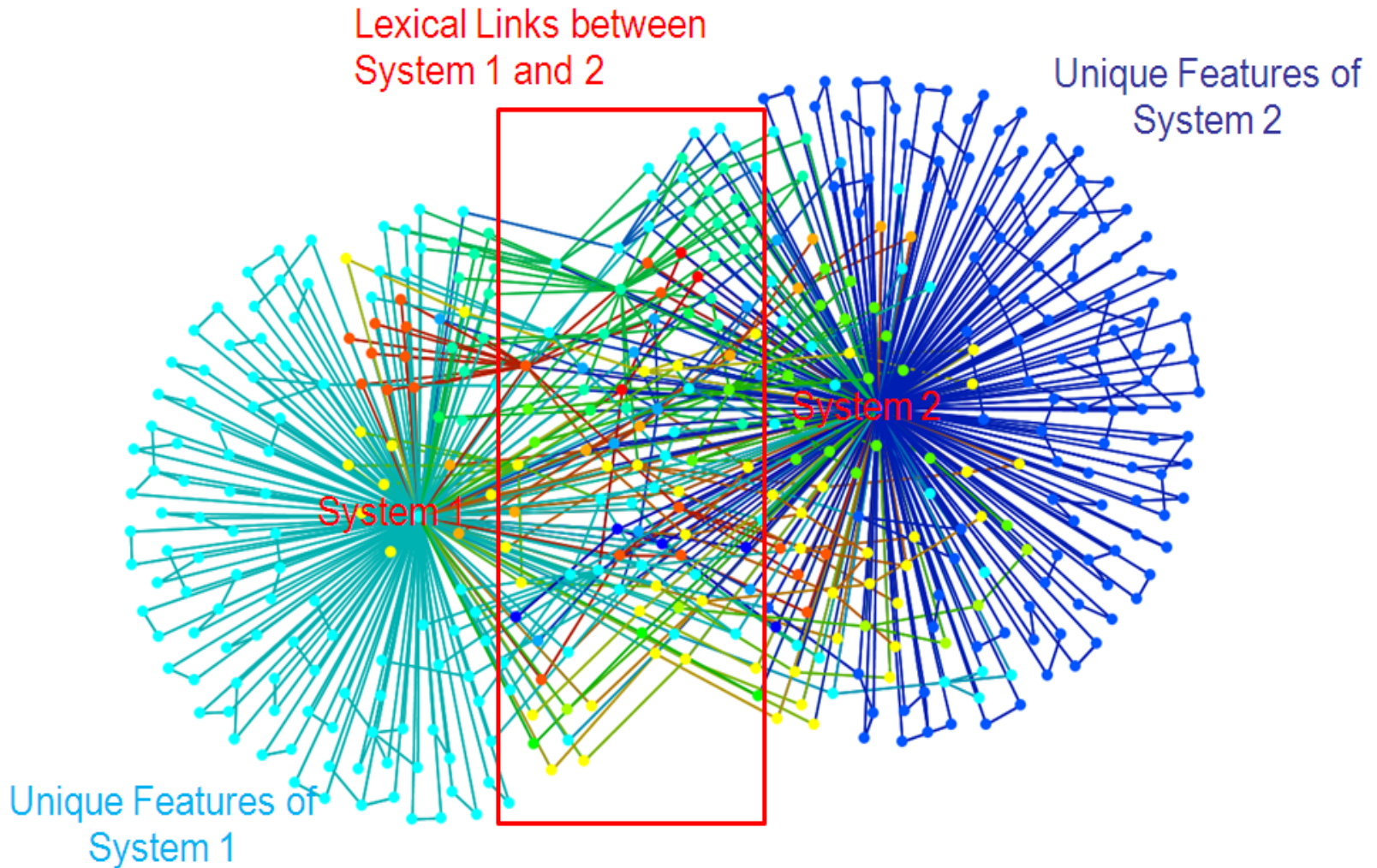


Compare Approaches

- Linguistics based
 - Part-of-speeches (e.g. nouns, verbs): SAP Business Objects/InXight NEE
 - Linguistics rules
- Statistical Co-occurrence
 - Tf*idf (http://en.wikipedia.org/wiki/Tf*idf)
 - Bi-gram, N-gram
- Representation
 - Bag-of-words (BOW), Latent Semantic Analysis (LSA), Latent Dirichlet Allocation (LDA), Support Vector Machines (SVM, accurate on text categorization, cloud/large-scale implementation example like yottamine)
 - Text-as-networks (TAN): Centering Resonance Analysis (CRA), Stanford Lexical Parser (syntactic dependence), AutoMap ,Google PageRank (DAN, Document-as-Networks),



LLA





Why LLA?

Term Evaluation

Once the document is constructed as a network, the next step is to evaluate the nodes to determine the importance of each term. To do this, we employ the concept of *node centrality*. The centrality of a node is a measure of how important it is compared to the other nodes in the network.

There exists a myriad of different node centrality measures. These can roughly be divided into four main categories as illustrated by the figure below.

```
graph LR; NC((Node Centrality)) --- E[Eigenvector]; NC --- D[Degree]; NC --- B[Betweenness]; NC --- C[Closeness]; E --- PR[PageRank]; E --- HITS[HITS]; E --- H[Hubs]; E --- A[Authorities]; D --- ID[In-degree]; D --- OD[Out-degree]; B --- CFB[Current-flow betweenness]; B --- L[Load]; C --- CFC[Current-flow closeness]
```

The simplest category is the degree-based centrality. These define node centrality in terms of the number and strengths of connections between a node and its neighbors.

The eigenvector centralities are also based on the node's neighbours, but is a bit more complex. These measures capture not only the number of neighbors a node has, but also take into account the importance of each neighbour. This group include among others, Google's famous PageRank algorithm.

The groups of closeness and betweenness centrality measures are a bit different, in that they focus more on the overall network structure. Closeness centralities are defined in terms of the lengths of the shortest paths from a node to the rest of the nodes in the network. Betweenness centrality describes whether, and how frequently, a node is part of the shortest paths between pairs of other nodes in the network.

In an attempt to find a node centrality measure well suited for capturing term importance, we experimented with all the measures shown in the figure above. The figure below shows classification accuracies when using representations based on different centrality measures.

- Critical needs
 - Links among documents/categories of information do not usually exist
 - Variety of network centrality measures can be used for term evaluations
- LLA automatically discovers relations among categories of text information to facilitate search, prioritization, prediction and expertise location
 - Generate hyperlinks for intranet documents
- LLA can also focus on **innovations and uniqueness** of the analyzed documents
 - Other ranking techniques which typically sort documents based on the *popularity* or *authority*, are not based on semantics
 - E.g. PageRank by Google



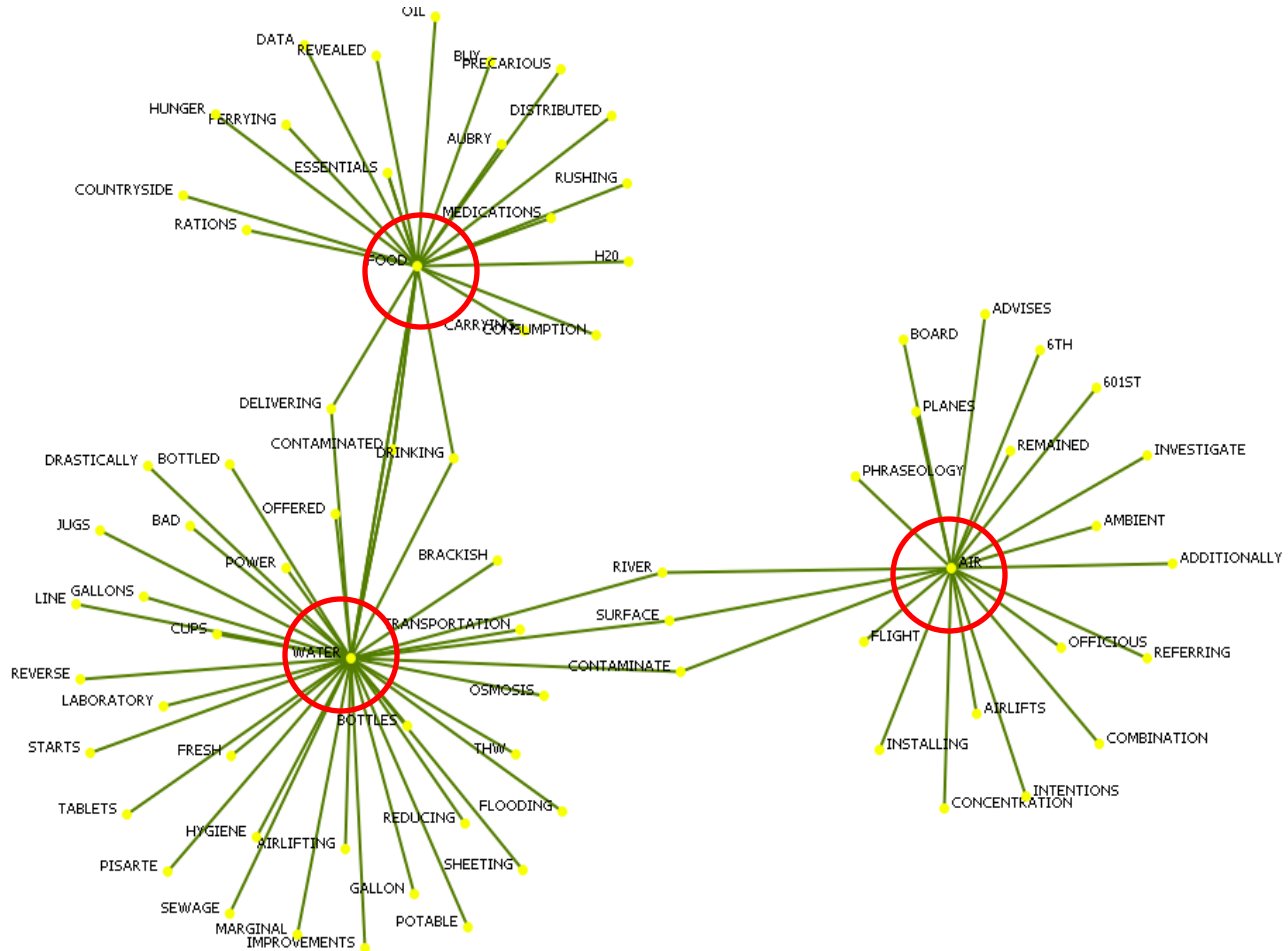
Discovered Themes



Event_Date_Sort	Theme Id	LLA Counts	Theme Keywords
ALL	95	83	WATER,AIR,FOOD
ALL	65	67	PEOPLE,CHILDREN,POST
ALL	6	65	APAN,CONTACT,USER
ALL	people	65	HAITI,OFFICER,PRESIDENT
ALL	64	60	PAP,EMERGENCY,ASSESSMENT,ASSISTANCE
ALL	41	58	INFORMATION,COMMUNITY,REQUESTS
ALL	54	56	MEDICAL,TIME,LIMITED
ALL	29	56	EARTHQUAKE,LEFT,MASSIVE,QUAKE
ALL	46	51	PATIENTS,LONG,CARE
ALL	70	50	RELIEF,FIELD,EFFORT
ALL	73	50	GROUP,SEE,FRENCH
ALL	96	50	DE,POSTED,INITIAL,WORKING
ALL	22	50	COUNTRY,HEALTH,AREAS,CHILE
ALL	place	49	STATE,PORT_AU_PRINCE,CITY
ALL	78	47	BUILDING,HQ,CIVIL,USERS
ALL	86	44	TEAM,COORDINATION,LEAD
ALL	39	42	HOSPITAL,BED,HOUSE
ALL	82	42	SUPPORT,PERSONNEL,CLIENT,UNIT



A "Theme" Defined



A collections of word pairs for the theme associated with keywords "WTER, AIR, FOOD"



Distributions of LLA Counts per Week



Dates	Theme ID	LLA Counts	Theme Keywords
ALL	95	83	WATER,AIR,FOOD
1/20/2010	95	39	WATER,AIR,FOOD
1/13/2010	95	37	WATER,AIR,FOOD
1/27/2010	95	20	WATER,AIR,FOOD
3/10/2010	95	7	WATER,AIR,FOOD
2/10/2010	95	3	WATER,AIR,FOOD
2/17/2010	95	3	WATER,AIR,FOOD
2/24/2010	95	3	WATER,AIR,FOOD
2/3/2010	95	2	WATER,AIR,FOOD
3/3/2010	95	2	WATER,AIR,FOOD
ALL	65	67	PEOPLE,CHILDREN,POST
1/20/2010	65	35	PEOPLE,CHILDREN,POST
1/13/2010	65	19	PEOPLE,CHILDREN,POST
1/27/2010	65	8	PEOPLE,CHILDREN,POST
2/10/2010	65	7	PEOPLE,CHILDREN,POST
3/3/2010	65	4	PEOPLE,CHILDREN,POST
2/24/2010	65	3	PEOPLE,CHILDREN,POST
2/3/2010	65	2	PEOPLE,CHILDREN,POST
2/17/2010	65	1	PEOPLE,CHILDREN,POST
3/10/2010	65	1	PEOPLE,CHILDREN,POST
3/21/2010	65	1	PEOPLE,CHILDREN,POST



Themes sorted for the first week (1/13/2010 to 1/19/2010) and the second week (1/20/2010 to 1/26/2010)

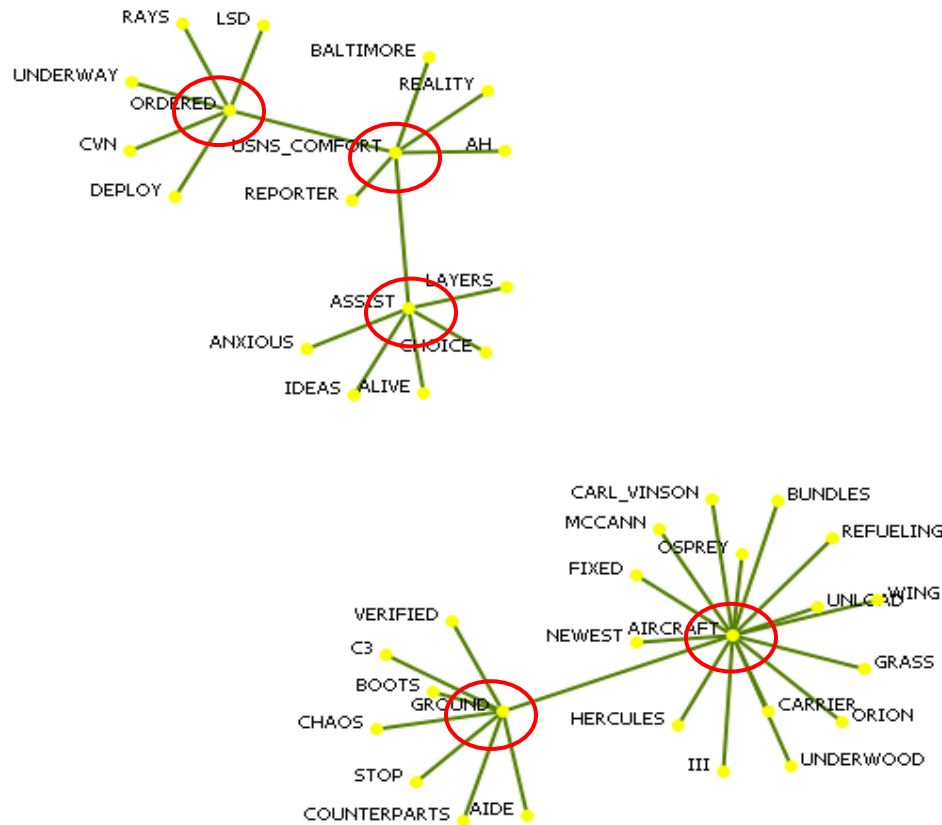
Event_Date_Sort	Theme Id	LLA Counts	Theme Keywords
1/13/2010	ALL	630	
1/13/2010	95	37	WATER,AIR,FOOD
1/13/2010	37	25	HIGH,RATES
1/13/2010	5	22	AIRCRAFT,GROUND,ASSIST,ORDERED,USNS_COMFORT
1/13/2010	6	21	APAN,CONTACT,USER
1/13/2010	82	21	SUPPORT,PERSONNEL,CLIENT,UNIT
1/13/2010	65	19	PEOPLE,CHILDREN,POST
1/13/2010	people	18	HAITI,OFFICER,PRESIDENT
1/13/2010	64	18	PAP,EMERGENCY,ASSESSMENT,ASSISTANCE
1/13/2010	79	18	STAFF,VERSION,BATTLE,LOGS,RECORDS
1/13/2010	69	18	PROVIDE,DEAD,NEEDED
1/13/2010	39	17	HOSPITAL,BED,HOUSE

Event_Date_Sort	Theme Id	LLA Counts	Theme Keywords
1/20/2010	95	39	WATER,AIR,FOOD
1/20/2010	65	35	PEOPLE,CHILDREN,POST
1/20/2010	people	33	HAITI,OFFICER,PRESIDENT
1/20/2010	46	32	PATIENTS,LONG,CARE
1/20/2010	29	26	EARTHQUAKE,LEFT,MASSIVE,QUAKE
1/20/2010	54	25	MEDICAL,TIME,LIMITED
1/20/2010	41	24	INFORMATION,COMMUNITY,REQUESTS
1/20/2010	6	23	APAN,CONTACT,USER
1/20/2010	70	23	RELIEF,FIELD,EFFORT
1/20/2010	72	23	RESPONSE,HELICOPTER,PART

- Important issues were heavily discussed and collaborated in the time of frame of two weeks.
 - The theme “HIGH, RATES” was related to the fact that the US government provided the analysis and information about high fatalities, high risks and high disease rates that might be expected after the event.



Lexical links for the theme associated with keywords “AIRCRAFT, GROUND, ASSIST, ORDERED, USNS_COMFORT”



- Measuring *like-mindedness*. Like-minded organizations do use *many* of the same terminologies in their communications. *like-mindedness* is closer in meaning to *like-wordedness*
- LLA often places the different terminologies such as “CVN” and “Carl_Vinson” in different components of word hubs but grouped together



The overlapping of top ten themes sorted by the LLA counts overall (ALL) and the first and second weeks

	Theme Keywords		Theme Keywords
All	WATER,AIR,FOOD	Week 1	WATER,AIR,FOOD
	PEOPLE,CHILDREN,POST		HIGH,RATES
	APAN,CONTACT,USER		AIRCRAFT,GROUND,ASSIST,ORDERED,USNS_COMFORT
	HAITI,OFFICER,PRESIDENT		APAN,CONTACT,USER
	PAP,EMERGENCY,ASSESSMENT,ASSISTANCE		SUPPORT,PERSONNEL,CLIENT,UNIT
	INFORMATION,COMMUNITY,REQUESTS	Week 2	WATER,AIR,FOOD
	MEDICAL,TIME,LIMITED		PEOPLE,CHILDREN,POST
	EARTHQUAKE,LEFT,MASSIVE,QUAKE		HAITI,OFFICER,PRESIDENT
	PATIENTS,LONG,CARE		PATIENTS,LONG,CARE
	RELIEF,FIELD,EFFORT		EARTHQUAKE,LEFT,MASSIVE,QUAKE

The LLA counts are measures to sort out the main and important topics and themes

- 6 out of 10 top themes (60%) in the top themes overall are also in the top themes of the first two weeks.
- 7 of 10 top themes in the first two weeks are also in the top overall themes



Extracting Social Networks

1	Thread	Level	Time	User	Organization	Content
43	5722	2	1/14/2010	2205	DoD U S Southern	re: attention!!! notice to airmen notam " That is correct. In order to gain aerial access
44	5722	2	1/15/2010	3342	Department of	re: attention!!! notice to airmen notam " I suggest that MTPP be used as a tag for all
45	5729	1	1/14/2010	3645	DoD Air Force	pap ground support I noticed this morning that there was a 60K main deck loader at
46	5736	1	1/14/2010	2205	DoD U S Southern	port-au-prince harbor port damage photos " [] [] [] [] " "
47	5737	1	1/14/2010	2205	DoD U S Southern	rfi on behalf of mlgp haiti " Is there any info on a USCG helo flight inbound from Santo
48	5737	2	1/14/2010	2112	DoD US Southern	rfi on behalf of mlgp haiti " Heather, dont know, but we should send invite using the
49	5737	3	1/14/2010	2205	DoD U S Southern	rfi on behalf of mlgp haiti Yes! Lets do it. can you get them the directions or do you
50	5737	4	1/15/2010	2112	DoD US Southern	rfi on behalf of mlgp haiti " Heather, I dont want to step out of my lane. I think it
51	5741	1	1/14/2010	3645	DoD Air Force	mtpp airfield sitrep Can anyone provide any information regarding the Airfield
52	5741	2	1/15/2010	3342	Department of	mtpp airfield sitrep " I suggest that MTPP be used as a tag for all NOTAMs, blog posts,
53	5741	2	1/14/2010	3545	SSSG	mtpp airfield sitrep " Southern Command Press Release, QUOTE: "airfield has power
54	5741	3	1/15/2010	4038	Telecommunicatio	mtpp airfield sitrep " Both should be used, since Civilian Operators use NOTAMs as
55	5741	4	1/15/2010	3342	Department of	mtpp airfield sitrep.Good point.
56	5743	1	1/14/2010	2406	Integrated ICT	usar activity as of
57	5744	1	1/14/2010	2406	Integrated ICT	logistical activity
58	5745	1	1/14/2010	2406	Integrated ICT	coordination act
59	5746	1	1/14/2010	2406	Integrated ICT	situation activity

List of threads of discussions

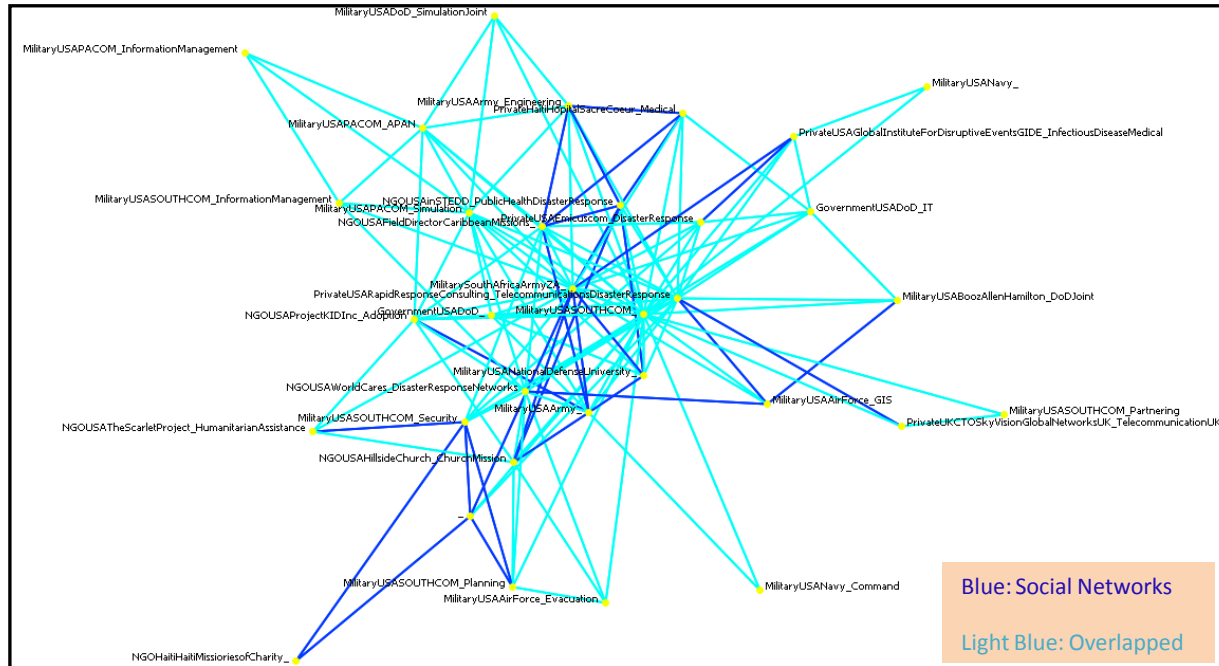
	10022	10023	10033	10100	10113	10393	10406	10432	10473	10484	10491
78 MilitaryUSANORTHCOM_	0	0	0	0	0	0	0	0	0	0	0
79 MilitaryUSANORTHCOM_Joint	0	0	0	0	0	0	0	0	0	0	0
80 MilitaryUSANationalDefenseUniversity_	0	0	0	0	0	0	0	0	0	0	0
81 MilitaryUSANavy_	0	0	0	0	0	0	0	0	0	0	0
82 MilitaryUSANavy_Command	0	0	0	0	0	0	0	0	0	0	0
83 MilitaryUSANavy_InformationManagement	0	0	0	0	0	0	0	0	0	0	0
84 MilitaryUSANavy_Infrastructure	0	0	0	0	0	0	0	0	0	0	0
85 MilitaryUSANavy_Intelligence	0	0	0	0	0	0	0	0	0	0	0
86 MilitaryUSANavy_Joint	0	0	0	0	0	0	0	0	0	0	0
87 MilitaryUSANavy_JointIT	0	0	0	0	0	0	0	0	0	0	0
88 MilitaryUSANavy_LanguageInstitute	0	0	0	0	0	0	0	0	0	0	0
89 MilitaryUSANavy_Planning	0	0	0	0	0	0	0	0	0	0	0
90 MilitaryUSAPACOM_	0	0	0	0	0	0	0	0	0	0	0
91 MilitaryUSAPACOM_APAN	0	0	0	1	0	0	0	0	0	0	0
92 MilitaryUSAPACOM_InformationManagement	1	0	0	0	0	0	0	0	0	0	0
93 MilitaryUSAPACOM_Joint	0	0	0	0	0	0	0	0	0	0	0
94 MilitaryUSAPACOM_Planning	0	0	0	0	0	0	0	0	0	0	0
95 MilitaryUSAPACOM_Simulation	0	0	0	2	0	0	0	0	0	0	2
96 MilitaryUSASOUTHCOM_	0	0	0	0	0	0	1	1	0	0	0
97 MilitaryUSASOUTHCOM_Command	0	0	0	0	0	0	0	0	0	0	0
98 MilitaryUSASOUTHCOM_GIS	0	0	0	0	0	0	0	0	0	0	0
99 MilitaryUSASOUTHCOM_InformationManagement	0	0	0	0	0	0	0	0	0	0	0
100 MilitaryUSASOUTHCOM_Intelligence	0	0	0	0	0	0	0	0	0	0	0
101 MilitaryUSASOUTHCOM_Joint	0	0	0	0	0	0	0	0	0	0	0
102 MilitaryUSASOUTHCOM_ManagementSOUTHCOM	0	0	0	0	0	0	0	0	0	0	0
103 MilitaryUSASOUTHCOM_Partnering	0	0	0	0	0	0	0	0	0	0	0
104 MilitaryUSASOUTHCOM_Planning	0	0	0	0	0	0	0	0	0	0	0
105 MilitaryUSASOUTHCOM_Security	0	0	0	0	0	0	0	0	0	0	0
106 MilitaryUSASOUTHCOM_SpecialOperations	0	0	0	0	0	0	0	0	0	0	0

Threads

Organizations



Social Networks Associated with the Theme “WATER, AIR, DATA”



- Light blue links are social network links that also overlap in the semantic networks - indications of synergy



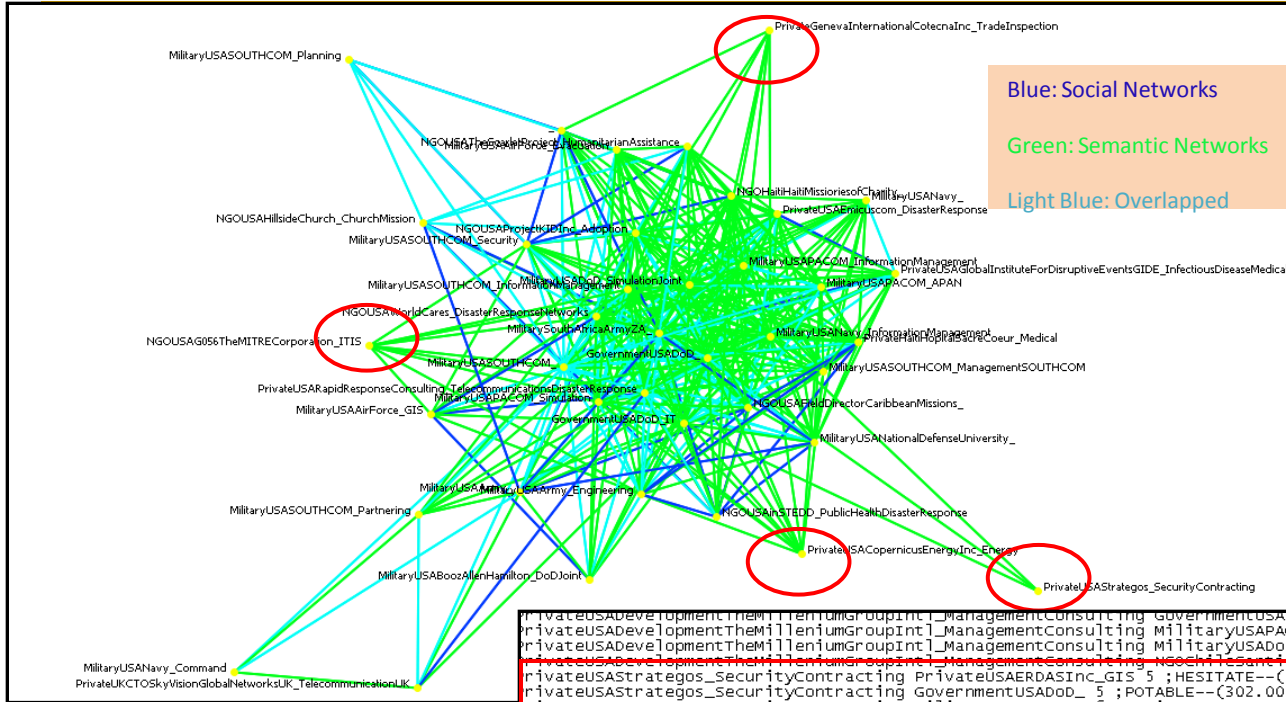
Extract Semantic Networks

```
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PrivateUSACopernicusEnergyInc_Energy MilitaryUSASOUTHCOM_ 5 ;INFORMATION--(189.00)
PrivateUSACopernicusEnergyInc_Energy MilitaryCanadaNationalDefenseCA_ 5 ;INFORMATION--(189.00)
PrivateUSACopernicusEnergyInc_Energy MilitaryUSAPACOM_Simulation 5 ;INFORMATION--COMMUNITY(189.00)
PrivateUSACopernicusEnergyInc_Energy GovernmentUSADoD_ 5 ;SMALL--(208.00)
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PrivateUSACopernicusEnergyInc_Energy PrivateUSAPaxMondial_Reconstruction 5 ;INFORMATION--CONFIDENTIAL(189.00)
MilitaryUSADoD_ITJoint MilitaryUSADoD_InformationSharing 5 ;SUSAN--(68.00)
MilitaryUSADoD_ITJoint MilitaryUSAEuropeanCommand_ 5 ;SUSAN--(68.00)
PrivateUSAEmicuscom_DisasterResponse MilitaryUSASOUTHCOM_Security 5 ;BOBBI--(1.00);JACMEL--(111.00)
PrivateUSAEmicuscom_DisasterResponse MilitaryUSAArmy_Engineering 5 ;BACKGROUND--(189.00)
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PrivateUSAEmicuscom_DisasterResponse GovernmentUSADoD_ 5
;FOOD--DRINKING,CONTAMINATED(302.00);FOOD--WATER(302.00);FOOD--WATER,DRINKING,CONTAMINATED(302.00);FOOD--(302.00)
PrivateUSAEmicuscom_DisasterResponse MilitaryUSASOUTHCOM_ManagementSOUTHCOM 5 ;FOOD--(302.00)
```

- Use shared word hubs



Semantic Networks (Green) Overlaid with the Social Networks for Theme "WATER, AIR, FOOD"



- Red circles show organizations who have semantic links but no current social connections => indicates potential collaborations

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PrivateUSADevelopmentTheMillenniumGroupIntelligenceManagementConsulting GovernmentUSADOD_IT_5 ; FRENCH--CREOLE(198.00); LONG--(200.00); CIVIL--(198.00)
PrivateUSADevelopmentTheMillenniumGroupIntelligenceManagementConsulting MilitaryUSAPACOM_InformationManagement 5 ; LONG--TERM(200.00)
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MilitaryUSASOUTHCOM_SpectiaOperations GovernmentUSADHS_DisasterResponse 5 ; USCG--(78.00)
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Measure Synergy Using Overlapping Connections in the Social networks and Semantic networks



Sorted according to the Synergy Ratio=Overlapped (Light Blue)/Social (Blue and Light Blue)

	Social(Blue and Light Blue)	Overlapped (Light Blue)	Semantic (Green)	Involvement (Red)	Synergy	Top 10 for the First or Second Week
HIGH,RATES	16	16	20	9	100%	Yes
PEOPLE,CHILDREN,POST	140	124	308	26	89%	Yes
APAN,CONTACT,USER	186	160	272	38	86%	Yes
EARTHQUAKE,LEFT,MASSIVE,QUAKE	58	48	184	20	83%	Yes
AIRCRAFT,GROUND,ASSIST,ORDERED,USNS_COMFORT	116	96	102	21	83%	Yes
SUPPORT,PERSONNEL,CLIENT,UNIT	90	74	128	23	82%	Yes
MEDICAL,TIME,LIMITED	116	93	170	26	80%	No
WATER,AIR,FOOD	264	206	511	36	78%	Yes
RELIEF,FIELD,EFFORT	186	142	386	32	76%	No
INFORMATION,COMMUNITY,REQUESTS	234	176	296	35	75%	No
PATIENTS,LONG,CARE	104	74	262	25	71%	Yes
HAITI,OFFICER,PRESIDENT	130	90	298	33	69%	Yes
PAP,EMERGENCY,ASSESSMENT,ASSISTANCE	252	174	312	37	69%	NO

- There are fewer organizations involved in the two weeks than in the overall forum
- “Synergies” seem to go above the average (>80%) for some specific and time-critical themes, for example, “HIGH,RATES”, “PEOPLE,CHILDREN,POST”, “APAN,CONTACT,USER”, “AIRCRAFT,GROUND,ASSIST,ORDERED,USNS_COMFORT”, “SUPPORT,PERSONNEL,CLIENT,UNIT”, and “EARTHQUAKE,LEFT,MASSIVE,QUAKE”
- There are some themes with relatively low synergies overall and on the two weeks, for example, “WATER, AIR, FOOD”, “PATIENTS, LONG, CARE”, “HAITI, OFFICER, PRESIDENT”. This may indicate lack of knowledge or expertise in these areas in general.
- Comparing the two weeks and the average, the synergies among organizations seem correlated with the number of organizations involved in the collaborations: the themes with fewer organizations involved have higher synergies.



Conclusions

- Explored a real-life data set, i.e. APAN forum data in the Haiti interagency operation via Lexical Link Analysis
 - Discovered the themes and sorted them according to the importance and time
 - Extracted social and semantic networks of participating organizations
- Showed the LLA method to examine historic data and improve future operations
 - Identify partners for collaboration or areas of overlap
 - Examined the aspects of the situational awareness of an interagency operation
 - Monitored and visualized organizational behavior
 - Automation allows performing this task easier and more frequent – and in near real-time



DISE



Backup slides



Lexical Link Analysis (LLA)



Summary

- Lexical Analysis (LA wiki, 2009) is a form of text mining
 - Learns
 - Dynamically updates word and context associations with added data
- Link analysis
 - Like network analysis, explores and illustrates associations between objects
- Lexical Link Analysis (LLA)
 - Combines data mining with network analysis
 - Can dynamically identify, assess, and predict trends, patterns and features
- Data mining tools
 - Analyzes structured and unstructured data
 - Confirms previously known patterns, or discovers new patterns
 - Implements innovative visualization and navigation techniques
- Facilitates concept discovery, automated classification, and categorization of unstructured documents

Agent Learning

