A comparison of distributed vs. centralized design

Preliminary results from the study of subway networks and encyclopedias

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Defining the problem

- **Hypothesis:** Systems that are structured or centrally designed are different than those that are unstructured or emerge in an evolutionary fashion

- **Approach:** Observe transportation networks and knowledge networks with network analysis tools for comparison between types of systems

Bottom-line

Structured vs. Unstructured
Planned vs. Evolved

- Information Networks are different:
  - Different path lengths
  - Different depth of information

- Transportation Networks:
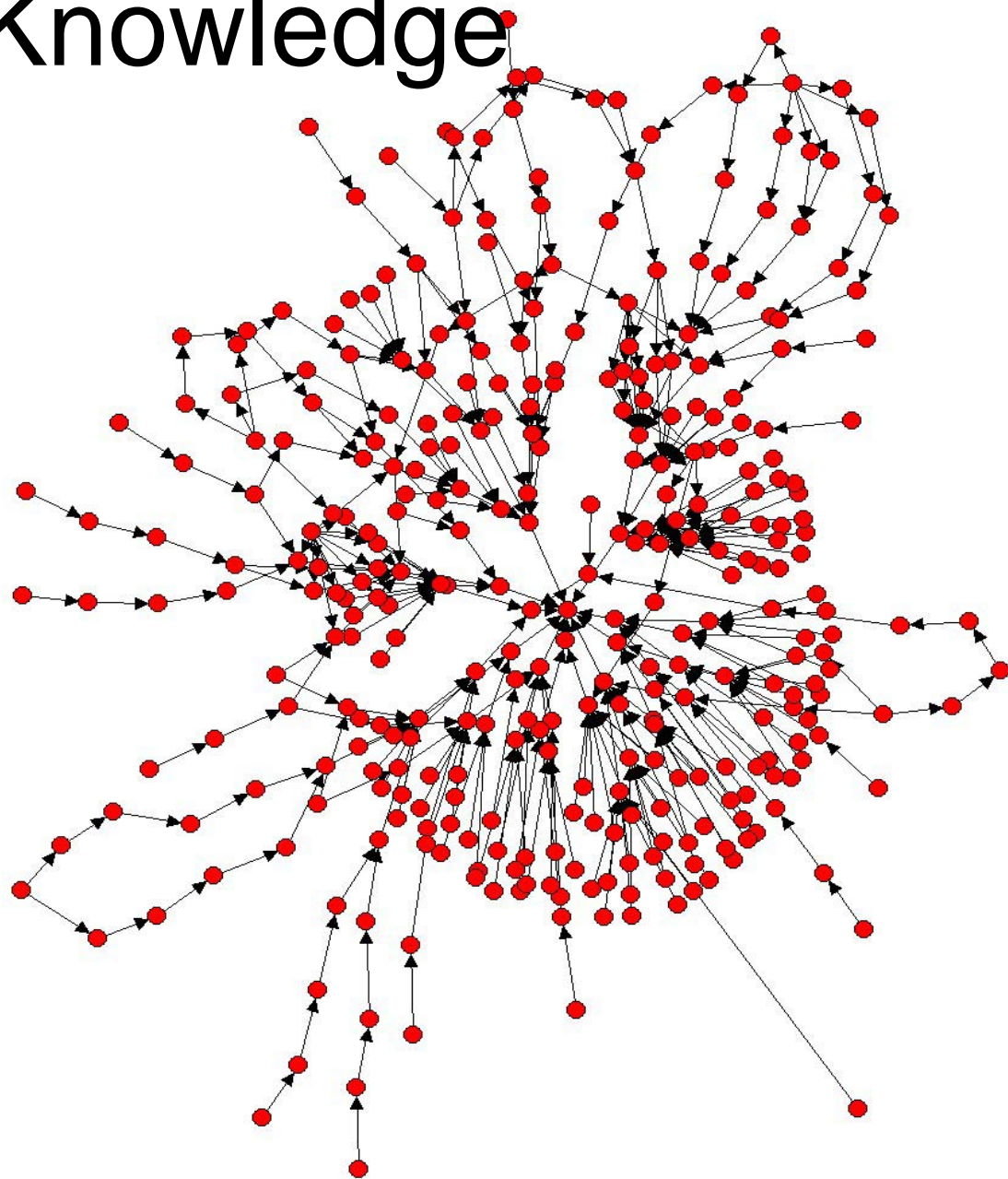 - No common structure among each class

EB Circle of Knowledge

Division_III:Peoples_and_Traditional_Civilizations_of_East__Central__South__and_Southeast_
Division_II:Peoples_and_Civilizations_of_Medieval Division_VI:The_Modern_World_to_1920 Asia

Division_IV:_History_and_the_Humanities

Division_VII:The_World_Since_1920 sion_V:Peoples_and_Civilizations_of_Pre-Columbian_America
Division_I:Peoples_and_Civilizations_of_Ancient_Southwest_Asia__North_Africa__and_Europe
Division_V:_Philosophy

Division_I:_Logic

Division_II:Elements_of_Technology
Division_IV:Peoples_and_Civilizations_of_Sub-Saharan_Africa_to_1885_
Division_VI:_Preservation_of_Knowledge

Division_I:The_Nature_and_Development_of_Technology
Part_Nine:The_History_of_Mankind
Division_II:_Mathematics

Division_I:Religion_in_General
Part_Ten:The_Branches_of_Knowledge
Division_III:_Science

Division_III:Major_Fields_of_Technology
Part_Seven:Technology
Division_II:The_Particular_Arts

Part_Six:Art
Division_I:Art_in_General

Division_II:The_Particular_Religions
Part_Eight:Religion

Division_I:Stages_in_the_Development_of_Human_Life_on_Earth

The_Circle_of_Knowledge

Division_I:Social_Groups:Peoples_and_Cultures
Part_Four:Human_Life
Division_II:The_Human_Organism:Health_and_Disease

Division_V:Law
Part_Five:Human_Society

Division_II:Social_Organization_and_Social_Change
Part_Two:The_Earth
Division_III:Human_Behaviour_and_Experience

Division_IV:The_Earth's_History

Division_IV:Politics_and_Government
Part_One:Matter_and_Energy

Part_Three:Life_on_Earth

Division_III:The_Production__Distribution__and_Utilization_of_Wealth
Division_II:The_Earth's_Envelope:Its_Atmosphere_and_Hydrosphere

Division_VI:Education

Division_III:The_Earth's_Surface_Features

Division_IV:Behavorial_Responses_of_Organisms
Division_II:Energy__Radiation__and_the_States_and_Transformation_of_Matter

Division_V:The_Biosphere:the_World_of_Living_Things
Division_III:The_Structures_and_Functions_of_Organisms

Division_I:Atoms:Atomic_Nuclei_and_Elementary_Particles

Division_II:The_Molecular_Basis_of_Vital_Processes
Division_III:The_Universe:Galaxies__Stars__the_Solar_System
Division_I:The_Nature_and_Diversity_of_Living_Things

EB Circle of Knowledge

- Terms:
  - Adenomyosis
  - Algebra
  - Aluminium
  - Baseball
  - Basketball
  - Beekeeping
  - Brigadier
  - Cellular_automaton
  - Christmas
  - Colonization_of_Africa
  - Color_photography
  - Criminology
  - Design
  - DNA
  - Elisabeth_of_Bavaria
  - Entrepreneur
  - Francisco_Franco
  - Golf
  - Hans_Christian_Andersen
  - History_of_Manchester
  - Ice_cream
  - India
  - Industrial_Revolution
  - James_Chaney
  - Locomotive
  - Massari
  - Meditation
  - Moscow
  - Nobel_Peace_Prize
  - Paris
  - Politics
  - Population
  - Radio
  - Stradivarius
  - World_war_II

Path length comparison between wikipedia and EB

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- En. Wikipedia ■ EBrittanica
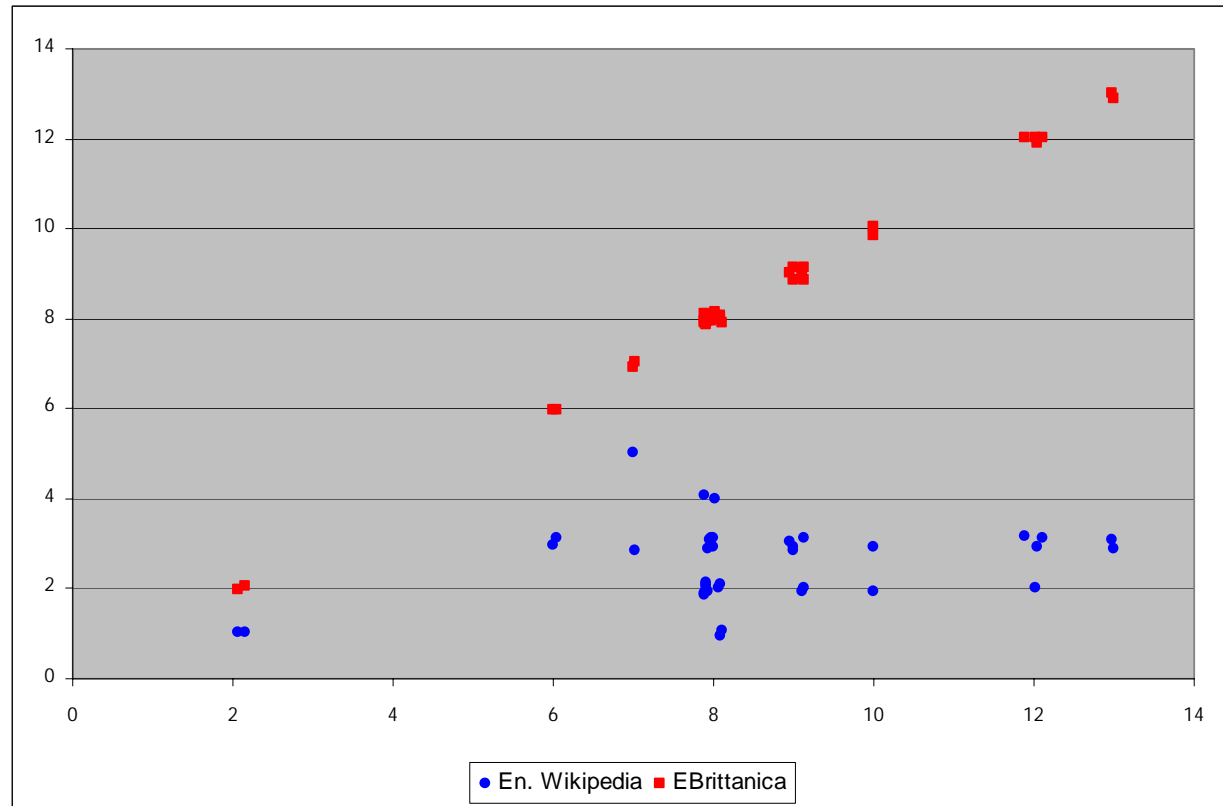
Distance between two terms in wikipedia is shorter than in EB (lies below the diagonal)

Visualizing growth in wikipedia
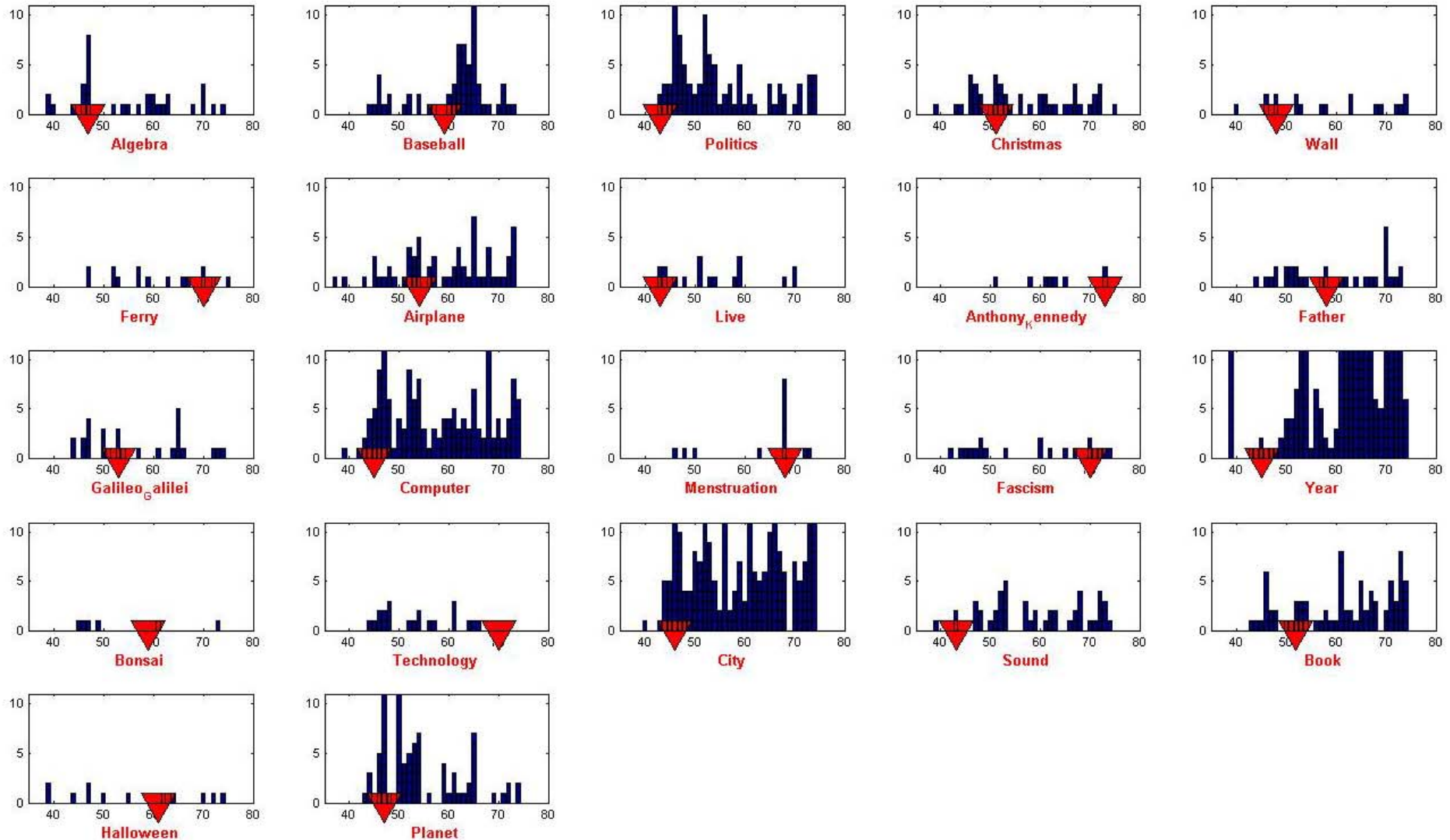
Transportation Systems

Four Transportation Systems

Evolved

Image removed for copyright reasons.
Map of the London subway system.
See: http://de.geocities.com/u_london/london.htm

London

Image removed for copyright reasons.
Map of the Boston subway system.
See: http://urbanrail.net/am/bost/boston.htm

Boston

Planned

Image courtesy of Wikimedia Commons.

Beijing (Planned)

Image removed for copyright reasons.
Map of the Moscow Metro.
See: http://urbanrail.net/eu/mos/moskva.htm

Moscow (Metro+Regional light rail)

Network Representation

- **Nodes:** Station that allow transfers between lines
- **Arcs:** Lines that connect those stations
  - If a line connects two stations, there is an arc
- Allows reuse of Whitney's datasets
- Attempting to do a few systems at full scale -- every station

Basic metrics

Small-worlds???

	n	m	<k>	C1	C2	l	r
London	92	139	3.02	0.222	0.1595	5.394	0.0997
Beijing	29	82	2.83	0.237	0.0667	3.409	-0.1053
Boston	21	44	2.09	0.074	0.0317	3.562	-.3011
Moscow	136	408	3.00	0.080	0.0591	6.037	0.2601

Negative degree correlation
For technical systems???

Centrality

	Degree	Closeness	Betweeness	Eigenvector
London	3.321	19.157	4.882	9.453
Beijing	10.099	30.234	8.922	22.053
Boston	10.476	29.293	13.484	23.693
Moscow	2.222	16.923	3.759	6.231

One planned, one evolved
both have high centrality???

Next Steps

- Add more systems to the subway analysis
  - A few more big ones and some small ones

- Bring in the qualitative data – histories of the systems
  - Are there particular historic patterns that correspond to the numbers presented?

- Complete data analysis

Backups

Implications

- No clear differences between planned and unplanned systems
- Beijing and Boston have negative degree correlation reflecting central hub with spokes topology
- Moscow (when you include light rail) has a radial grid pattern which accounts for the high degree correlation and path length
- Beijing and Boston stand out as much more centralized – i.e. having many path go through a smallish central core than London and Moscow
- High centrality nodes are key transfer point – e.g. King's Cross and North Station

Boston

Image removed for copyright reasons.
Map of the Boston subway system.
 See: http://urbanrail.net/am/bost/boston.htm

London

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Map of the London subway system.
See: http://de.geocities.com/u_london/london.htm

Beijing

Courtesy of the Wikimedia Commons.

Moscow

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