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Talking About Concerns . . .

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What is Modularity?

- Thanks, Mary!
- Thanks, Dick!

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Why Modularity?

- **Software** modularity does not matter
- . . . at all
- Except . . .
  - To the extent it modularizes **work**
- **Work** modularity aids human understanding
- **Work** modularity simplifies coordinating people and teams

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Parnas:

Expected Benefits of Modularity

- Reduce need for coordination
  - “separate groups would work on each module with little need for communication”
- Simplify comprehension
  - “it should be possible to study the system one module at a time”
- These effects lower the cost of change
  - “it should be possible to make drastic changes to one module without a need to change others”

Parnas, D. L. On the Criteria to be Used in Decomposing Systems into Modules. *Communications of the ACM*, 15, 12 (1972), 1053-1058, p. 1054.

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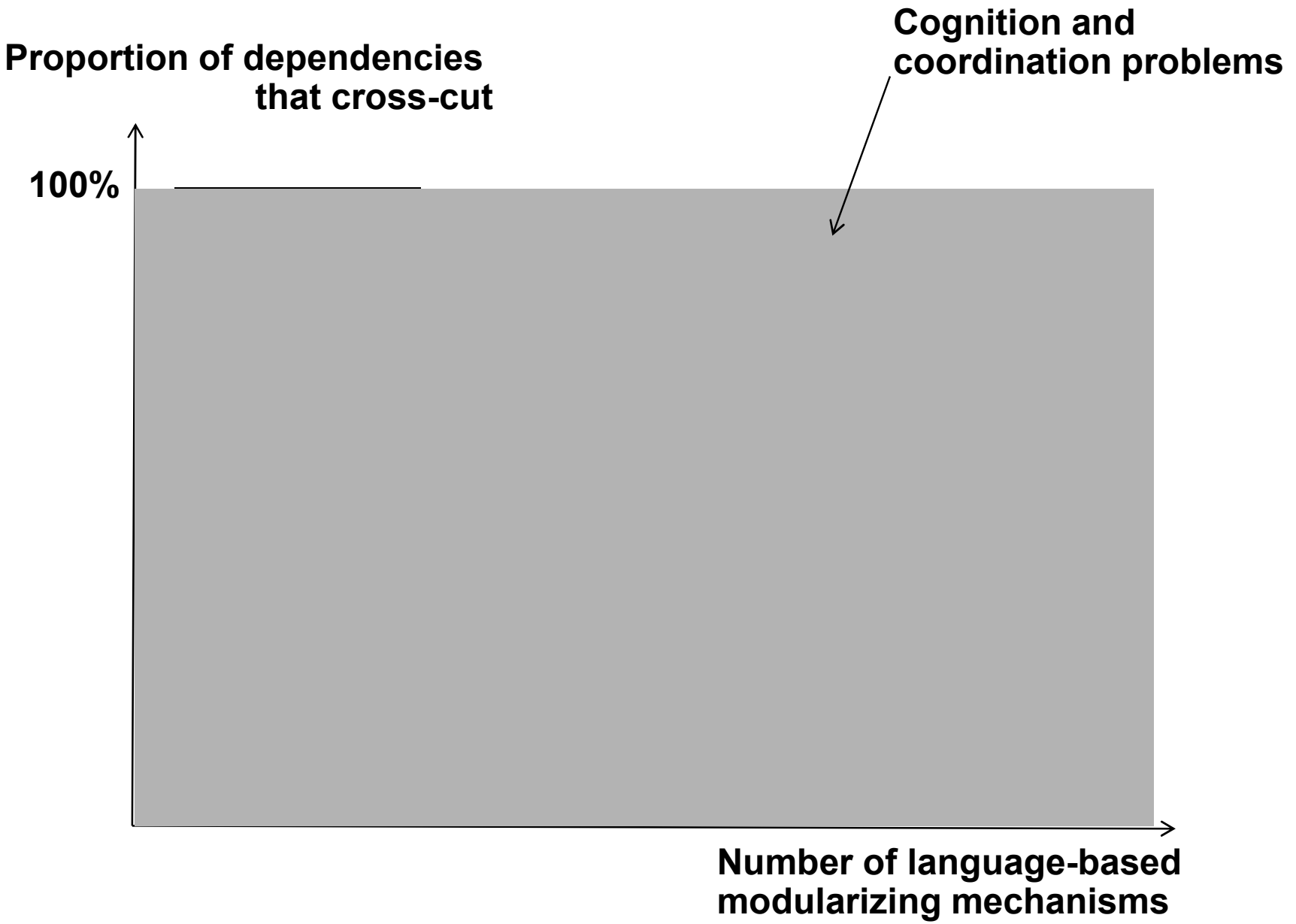
Vision . . .

- “a vivid mental image; ‘he had a vision of his own death’” *
- “an Explanation of Life Founded upon the Writings of Giraldus and upon Certain Doctrines Attributed to Kusta Ben Luka” *
- “a thought, concept, or object formed by the imagination” **
- “direct mystical awareness of the supernatural“ **

*wordnetweb.princeton.edu/perl/webwn
**Merriam-Webster Dictionary



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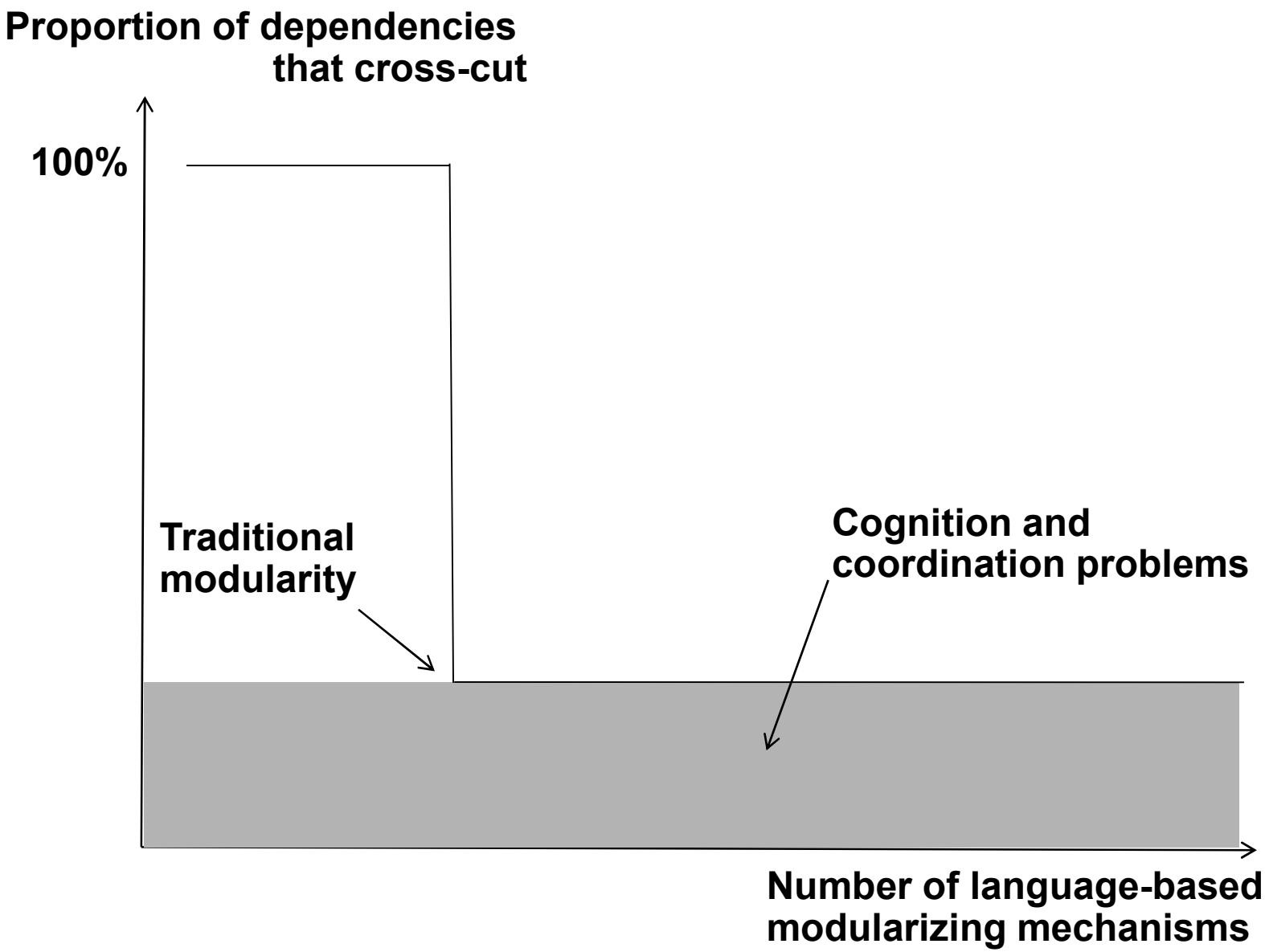

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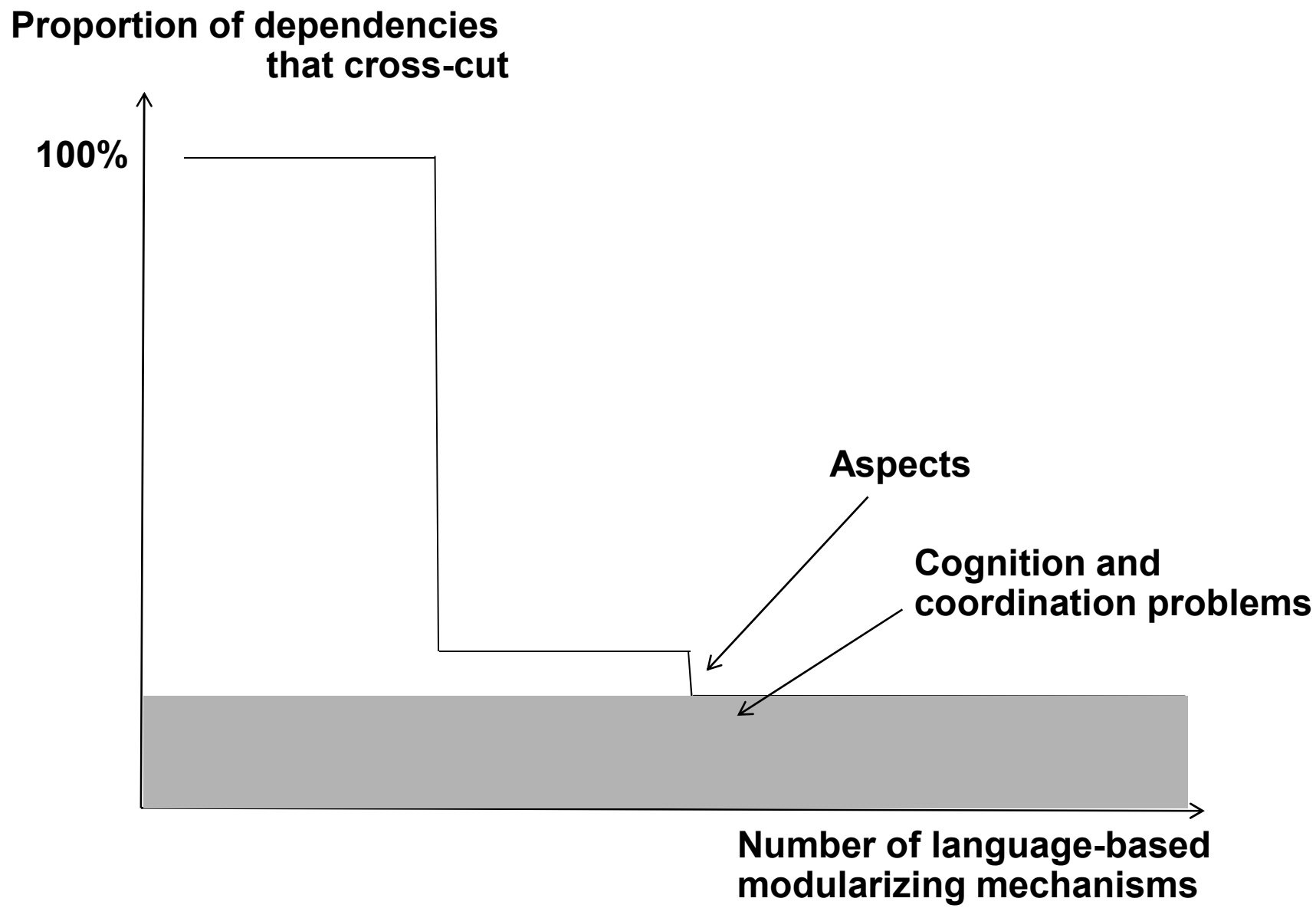

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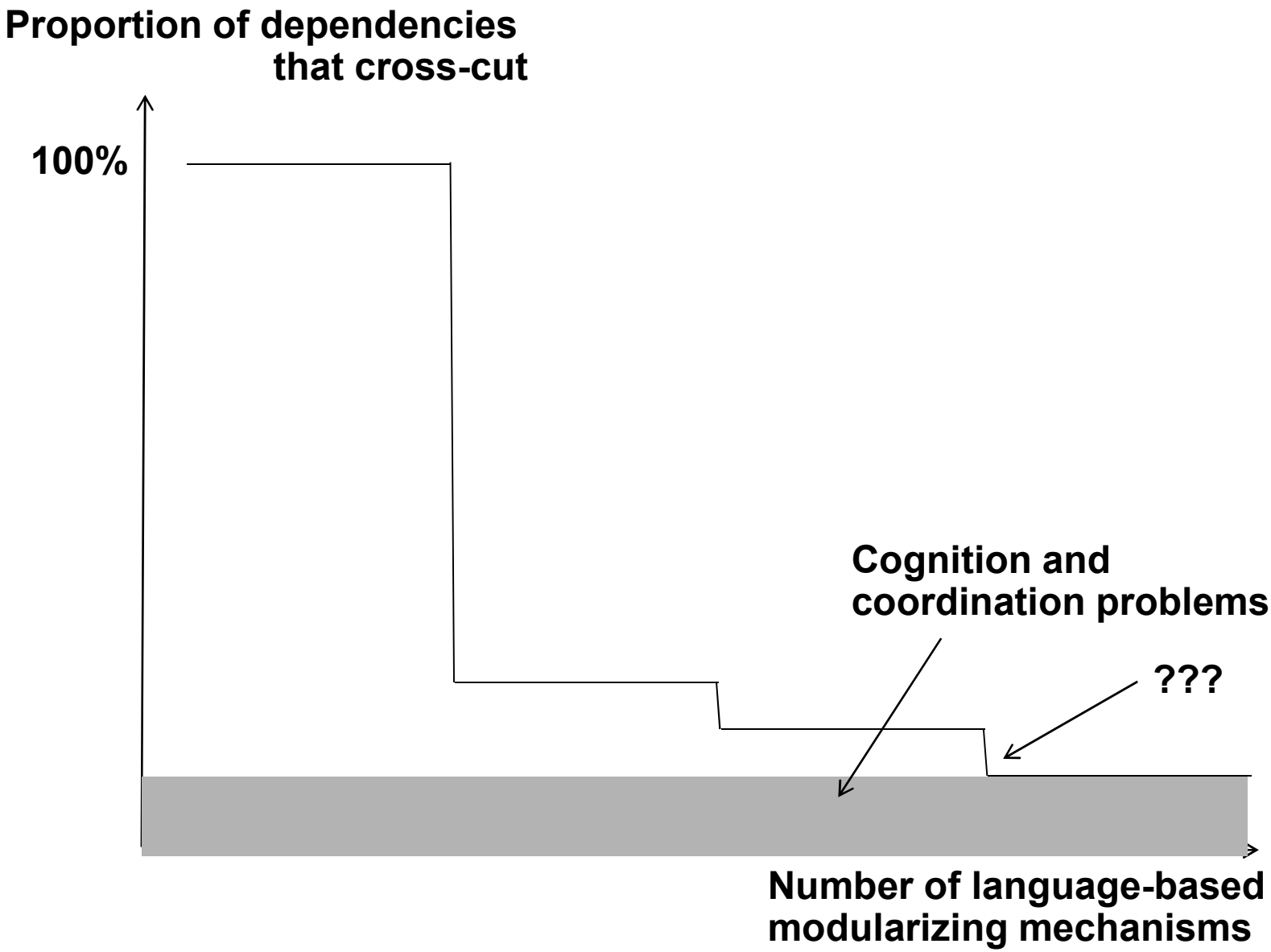

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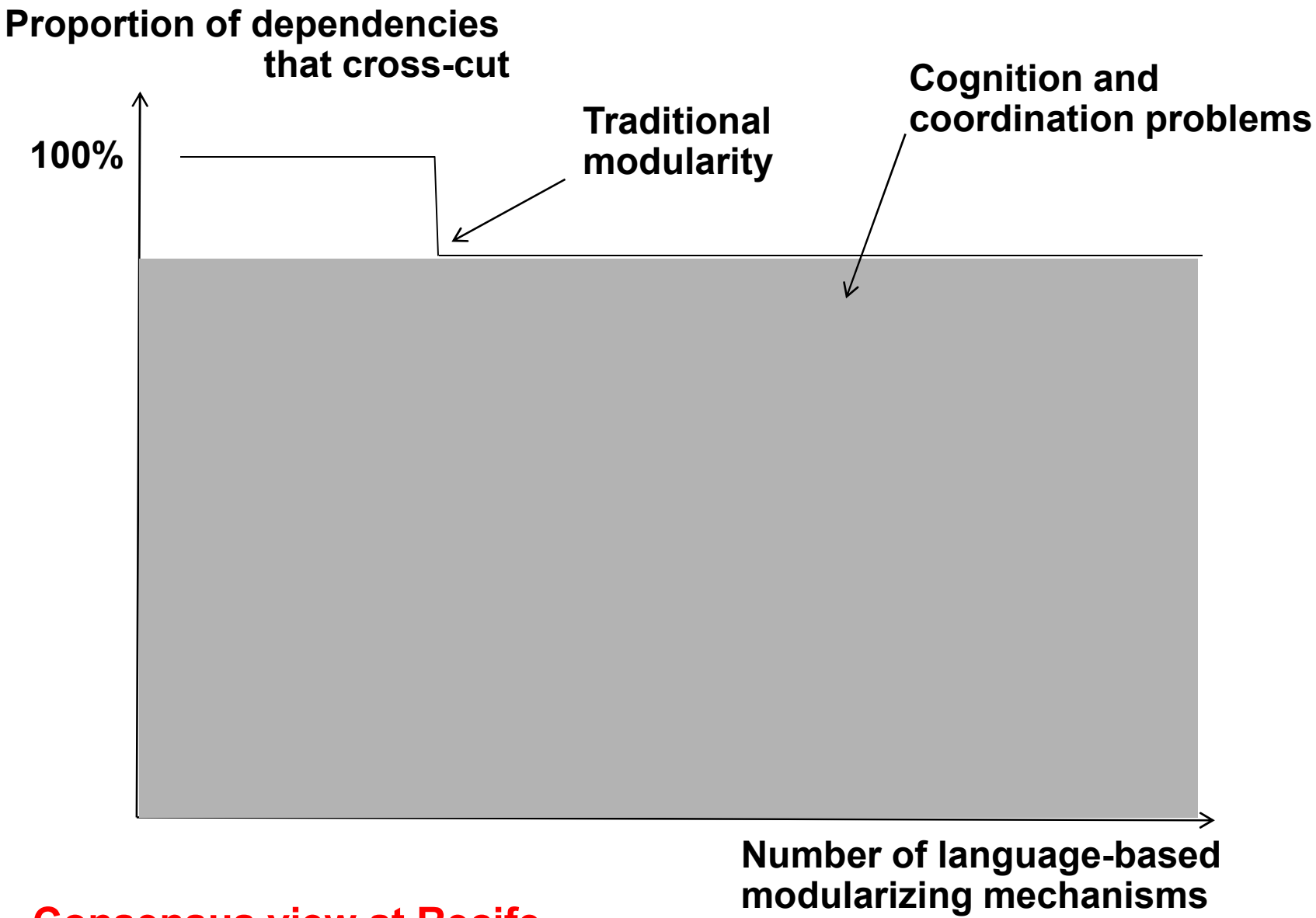

Consensus view at Recife

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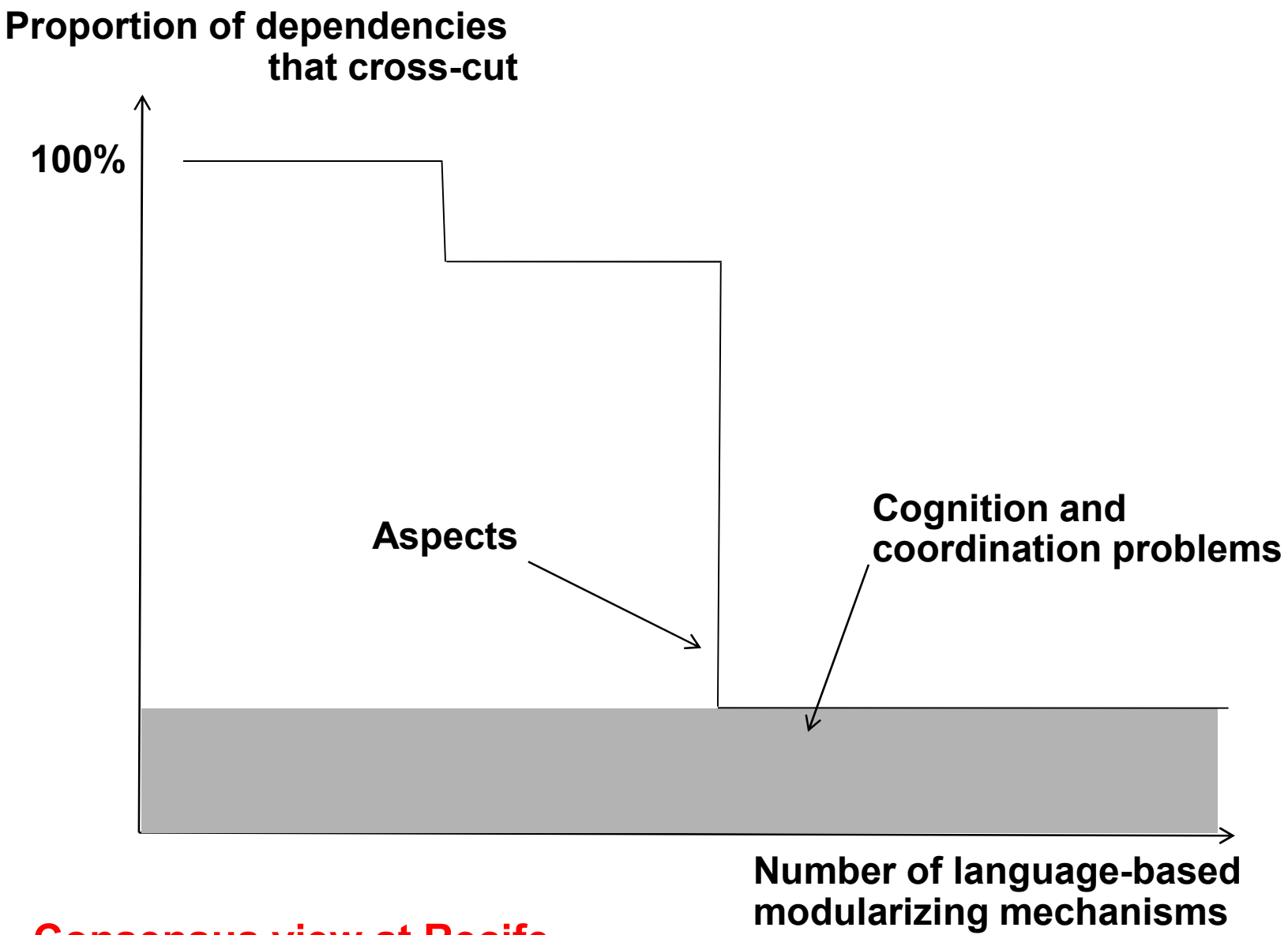

Consensus view at Recife

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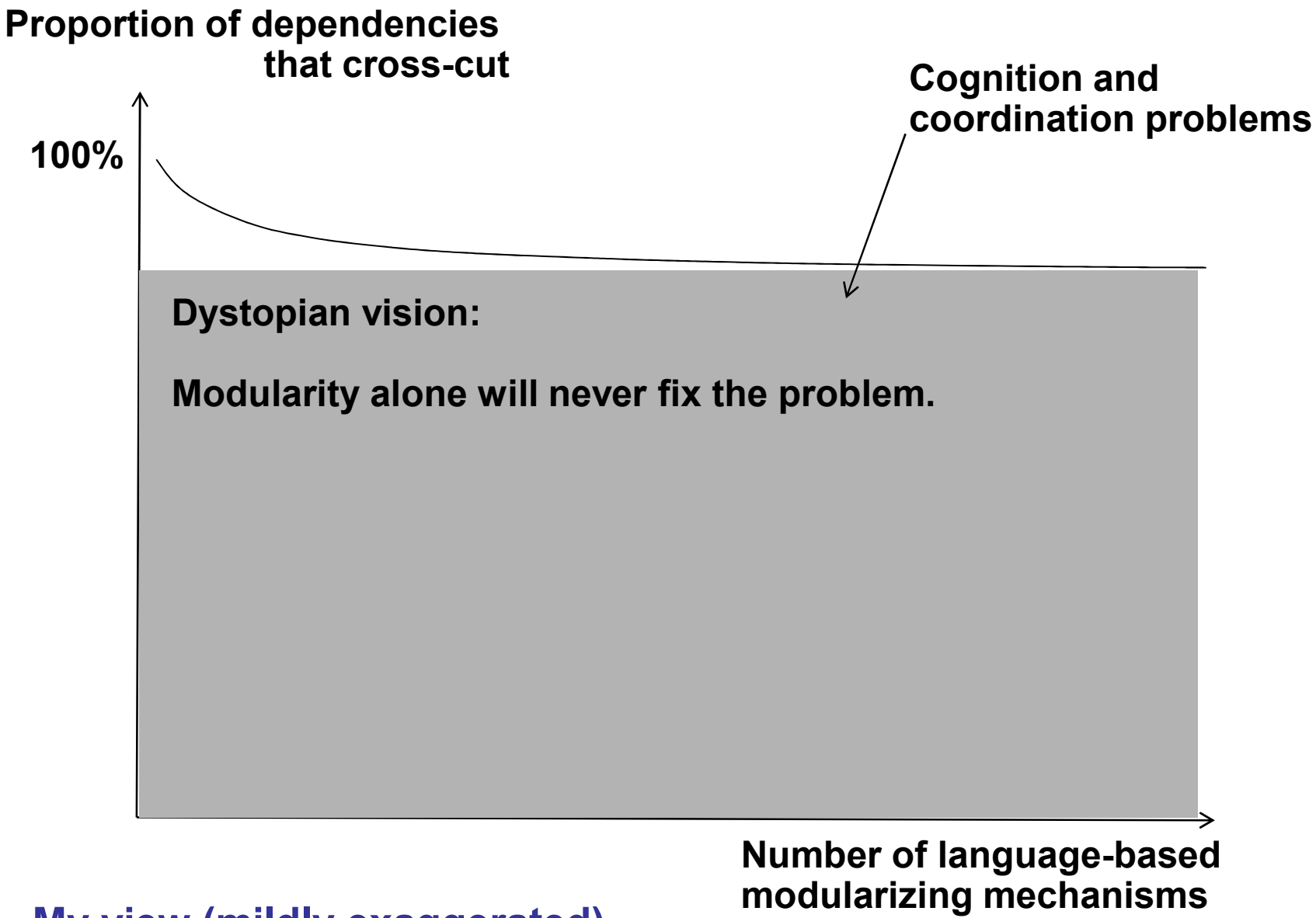

My view (mildly exaggerated)

Approaching the Gray Area . . .

- Organizational design, work assignment, and tools set up to bring the right dependencies to the attention of the right people so they can act appropriately

Two Examples . . .

- Organizational design and work assignment
  - Lessons from feature-driven development
- Using information from the environment
  - Learning from human activity

Feature-Driven Development

- Unit of functionality in end-user terms
- Feature is the unit of development managed by a project
- Features tend to cut across traditional software entities
- Work often overseen by “feature manager”
- Developers associated with component, assigned to work on particular features

The Study

- Setting
  - Software for automotive navigation system
  - 1195 features
  - 32 months of activity
  - 179 engineers in 13 teams
  - 1.5 M LOC, 6789 source files, 107 architectural components
  - Organization had 5 years of prior experience with feature-driven development
- Architects prepare feature development specification

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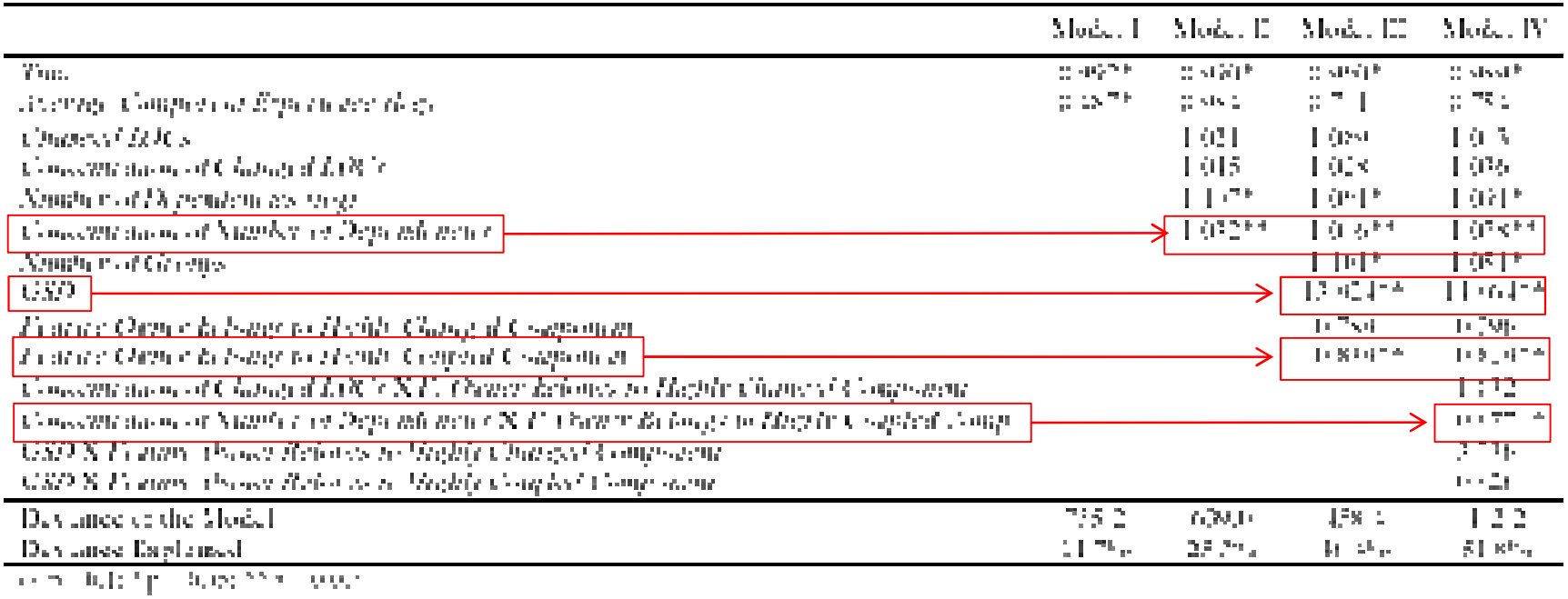
What Causes Integration Failure?



Odds Ratios from Regression Assessing Factors Driving Feature Integration Failures

From Cataldo, M. & Herbsleb, J.D. (2011). Factors Leading to Integration Failures in Global Feature-Oriented Development: An Empirical Analysis. *Proceedings, International Conference on Software Engineering* (to appear).

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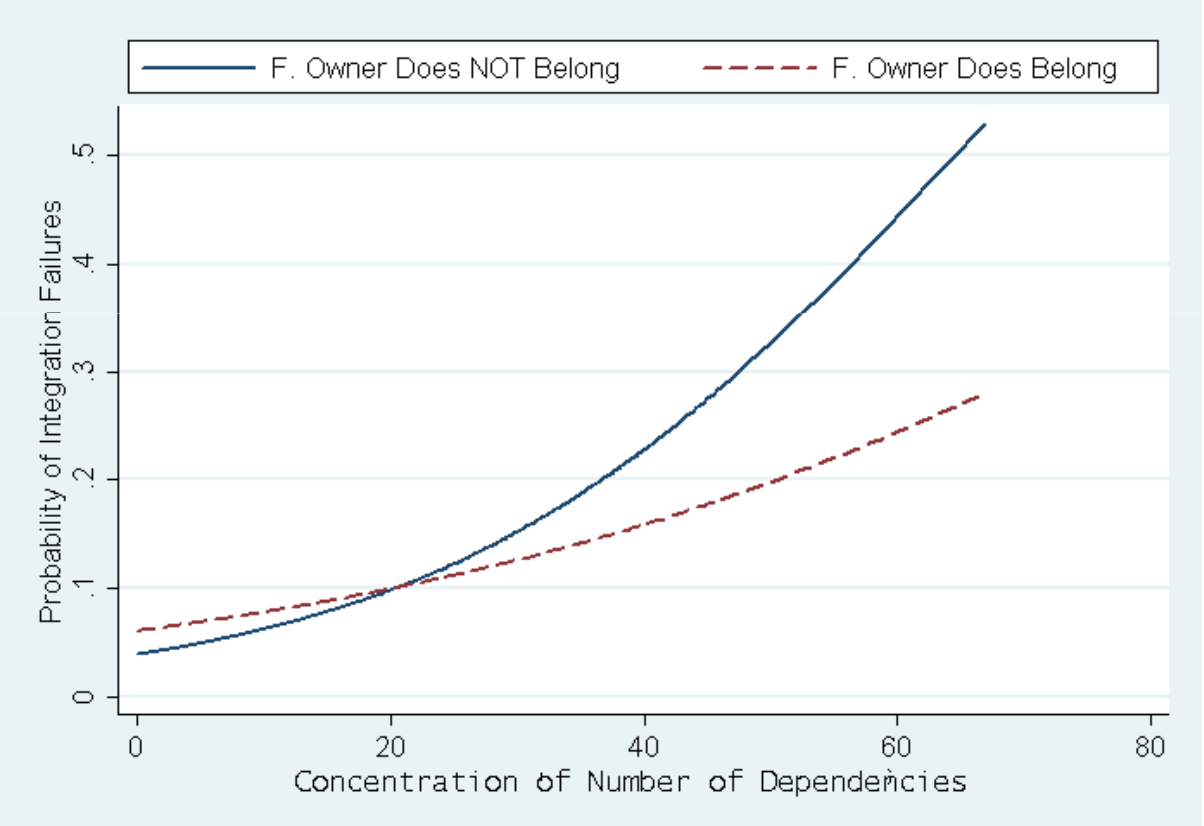
Ownership Matters!



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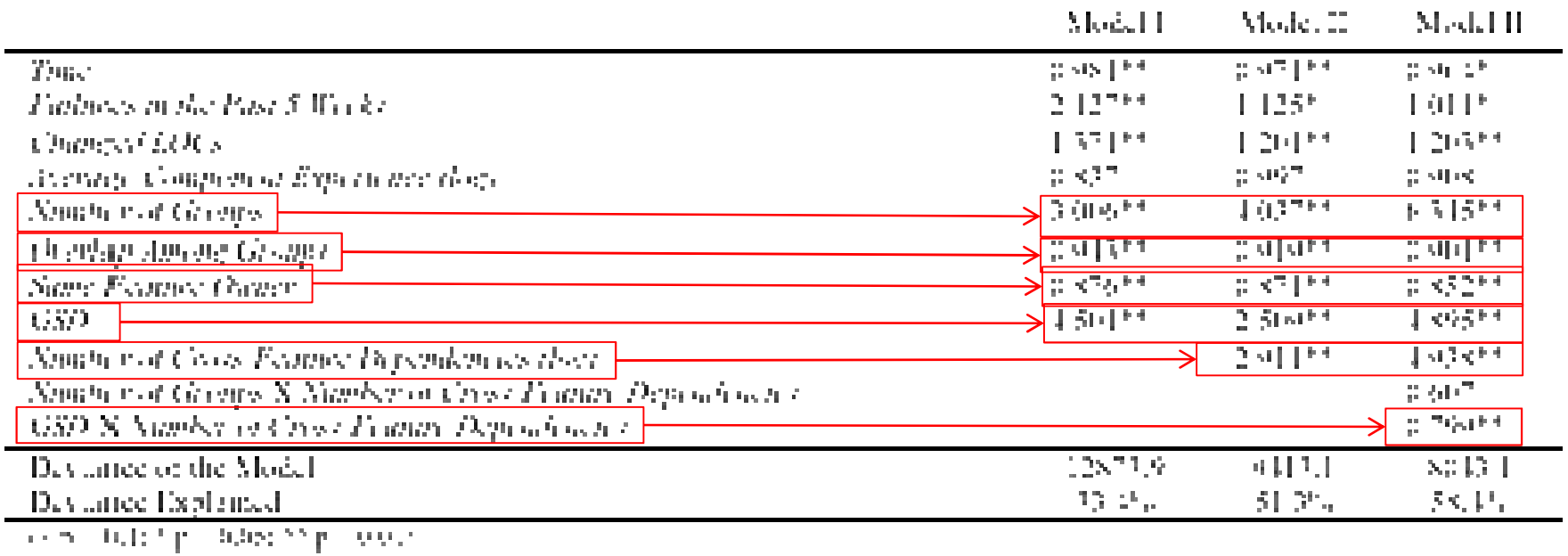
Destructive Feature Interaction



Odds Ratios from Regression Assessing the Impact of Cross-Feature Interactions on Integration Failures

From Cataldo, M. & Herbsleb, J.D. (2011). Factors Leading to Integration Failures in Global Feature-Oriented Development: An Empirical Analysis. *Proceedings, International Conference on Software Engineering* (to appear).

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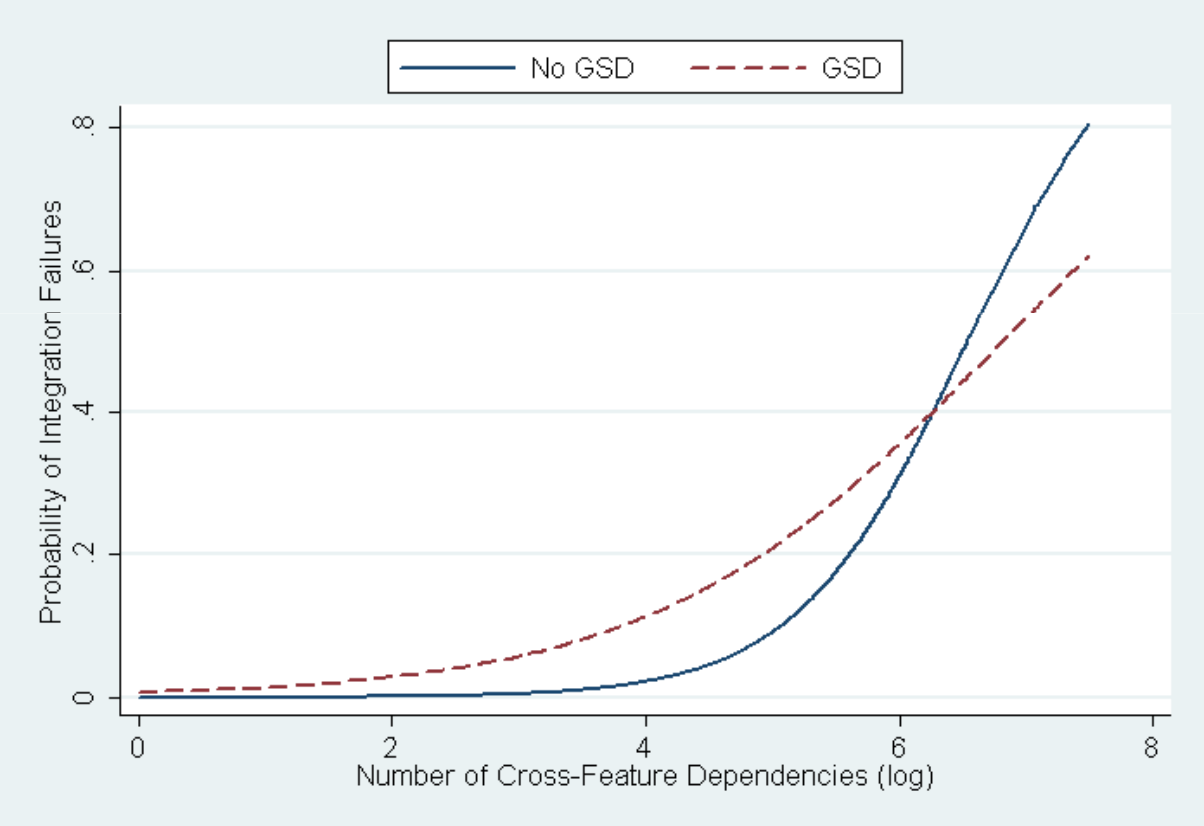
Co-location Doesn't Scale



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Broader Lessons

- Organizational arrangements matter!
- Effects can be quite large
- Effects often are not commonsensical

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Inferring Dependencies from Traces of Human Activity

- Prior work
  - Use files changed together as measure of dependencies
  - Can generate a measure of coordination requirements
  - Validated in a number of settings
- Can we generalize from “files changed together” to “entities discussed together”?

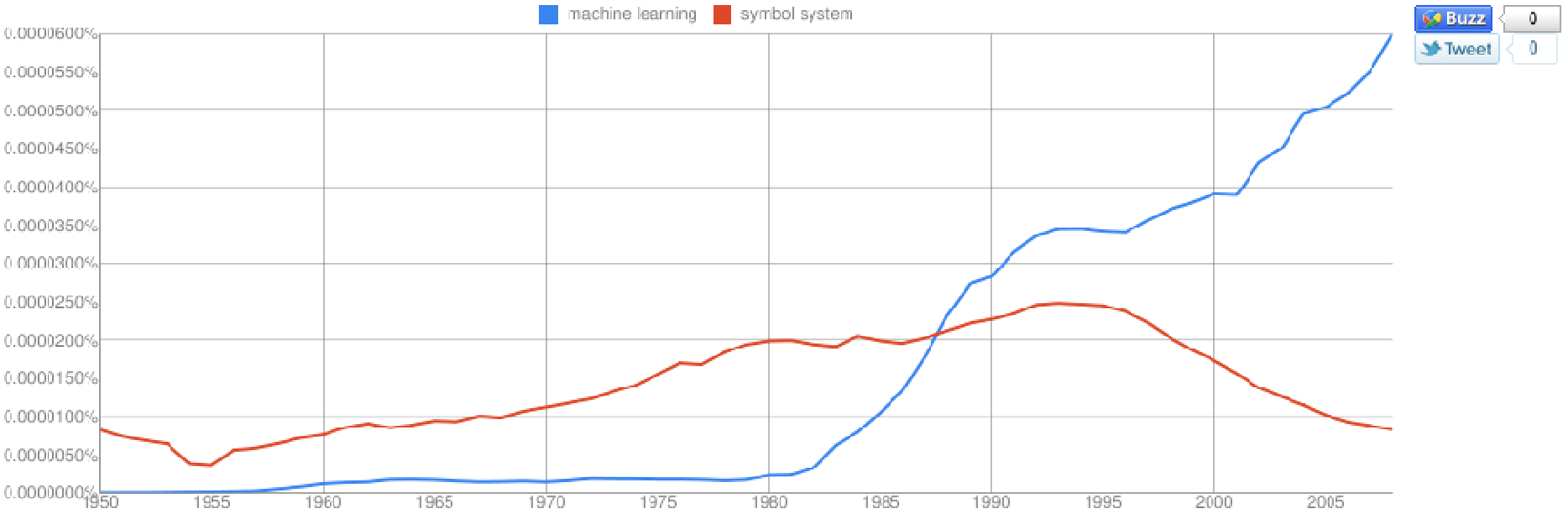
A Brief Digression/Analogy

Google labs Books Ngram Viewer

Graph these **case-sensitive** comma-separated phrases: machine learning,symbol system

between 1950 and 2008 from the corpus English with smoothing of 3.

Search lots of books



Search in Google Books:

1950 - 1987	1988 - 2003	2004 - 2005	2006 - 2007	2008	machine learning
1950 - 1961	1962 - 1992	1993 - 1995	1996 - 1999	2000 - 2008	symbol system

Run your own experiment! Raw data is available for download here.

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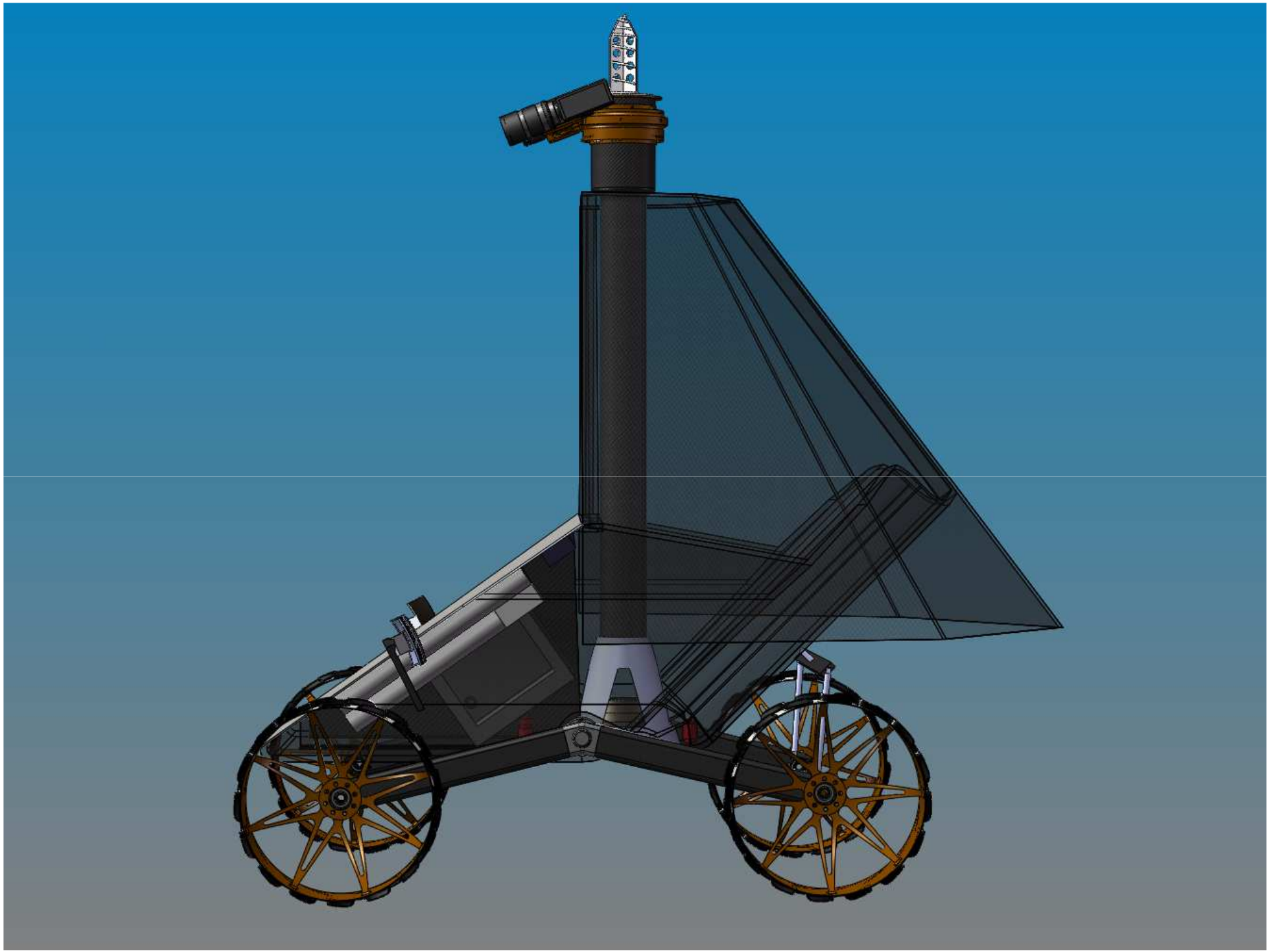
Text Analysis: Field Robotics

- Project
  - Lunar X Prize competition



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Text Analysis: Field Robotics

- Project
  - Lunar X Prize competition
- No automatically collected version or change data
- Constantly shifting component boundaries and interfaces
- Can we use text analysis to derive dependencies?

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Steps

- Collected data
  - 25 all-hands meetings
  - About 10,000 words each
- Developed code book
  - 6 field robotics articles

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Code Book

Component:	Brief description:
Communications	Communications external to the robot, for control or mission, including operator interface.
External Relations	Acquiring external resources (incl. funding, parts, & purchasing), publicity, investor & media relations.
Internal Relations	Project/program management, HR, task assignments, training, collaboration tools, clarifying norms & expectations.
Mobility Effectors / Actuators	Effectors and actuators that propel the entire robot: e.g. tracks, wheels, shocks, & motors with associated firmware.
Mission Specific Effectors / Actuators	All other motors, gears, & moving parts that don't move the robot as a whole, e. g. camera mast rotation motor.
Perception software / computing	Software, and any dedicated hardware, for: terrain mapping, environmental modeling, and/or object detection. Camera/lens zoom, shutter, and focus control software.
Planning software / computing	Mission task planning, including the overall mission plan and computing resources for semi-autonomous execution.
Power	Includes batteries, solar cells, switches, power cables & controls.
Sensors	Camera; thermal, ultrasonic, tactile, radar/sonar range sensors; Inertial Measurement Unit, GPS, & any wiring or processing going from sensors to controls.
Shared / general computing	Includes general purpose processors / onboard computers (e. g. avionics box). Abbreviated "gpp."
Structure	Chassis, fasteners (e.g. Frangibolt, weld joints), radiator, payload, paints, reflectors.

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Steps

- Collected data
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- Developed code book
  - 6 field robotics articles
- Manual coding of decision discussions
  - Tested inter-rater reliability
    - QAP correlations .80

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Text Pre-Processing

Step	Description
1	Removed contractions (e. g. changing "what's" to "what is").
2	Applied a Krovetz (dictionary-based) stemmer to covert terms into morphemes
3	Removed common English terms (e. g. 'the'), replacing them with placeholders ('xxx').
4	Removed punctuation.
5	Turned meaningful bigrams into unigrams (e.g. 'solar cells' became 'solar_cells').

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Steps

- Collected data
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- Developed code book
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- Manual coding of decision discussions
  - Tested inter-rater reliability
    - QAP correlations .80
- Created thesaurus

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Link Identification

- Co-occurrence of terms
- Human coding: same decision
- Selected sliding window size
  - Size 15 had best agreement with hand coding
  - Threshold established
- QAP correlations comparable to human-human agreement (~.8)
- Sets of links based on topics

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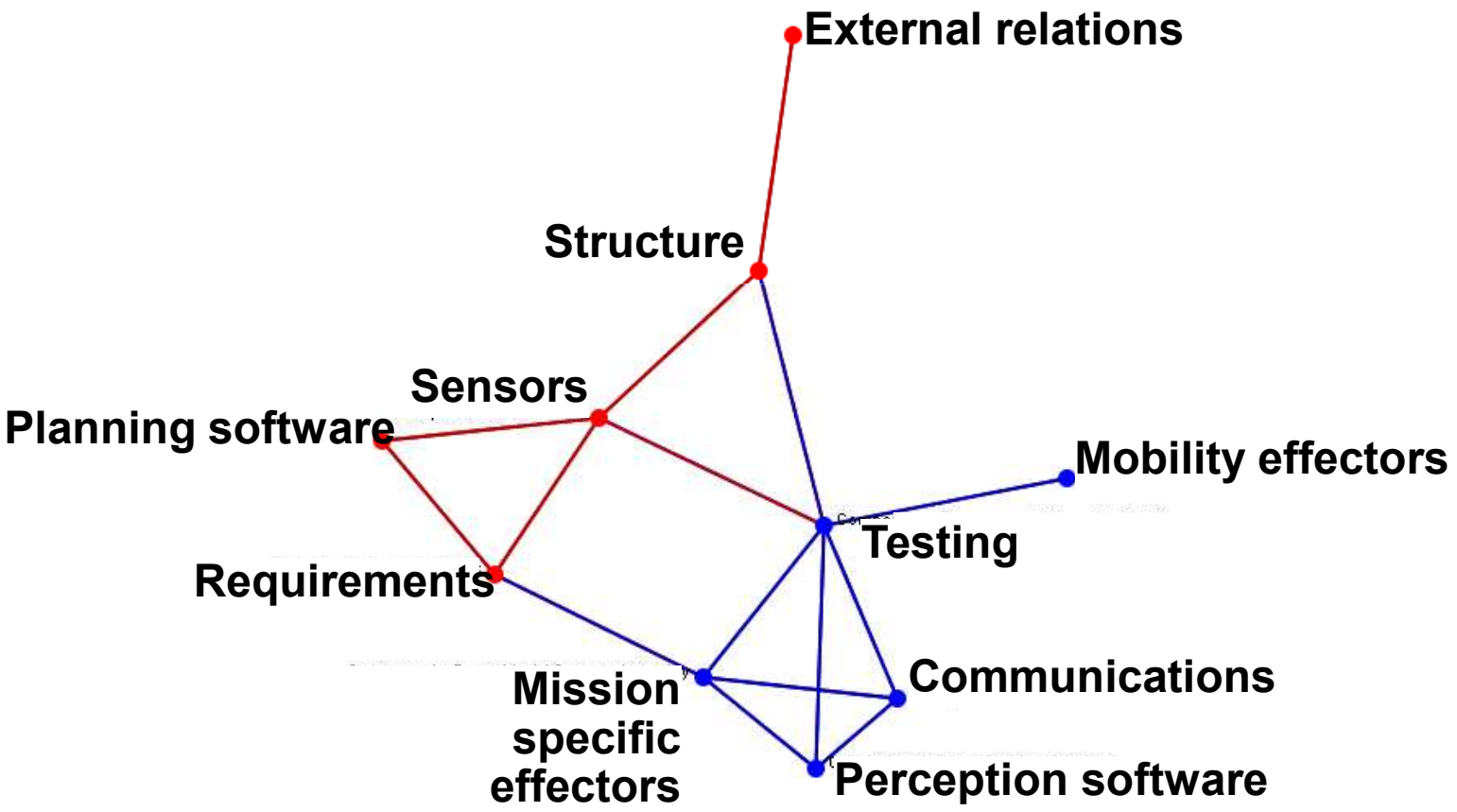
Optics



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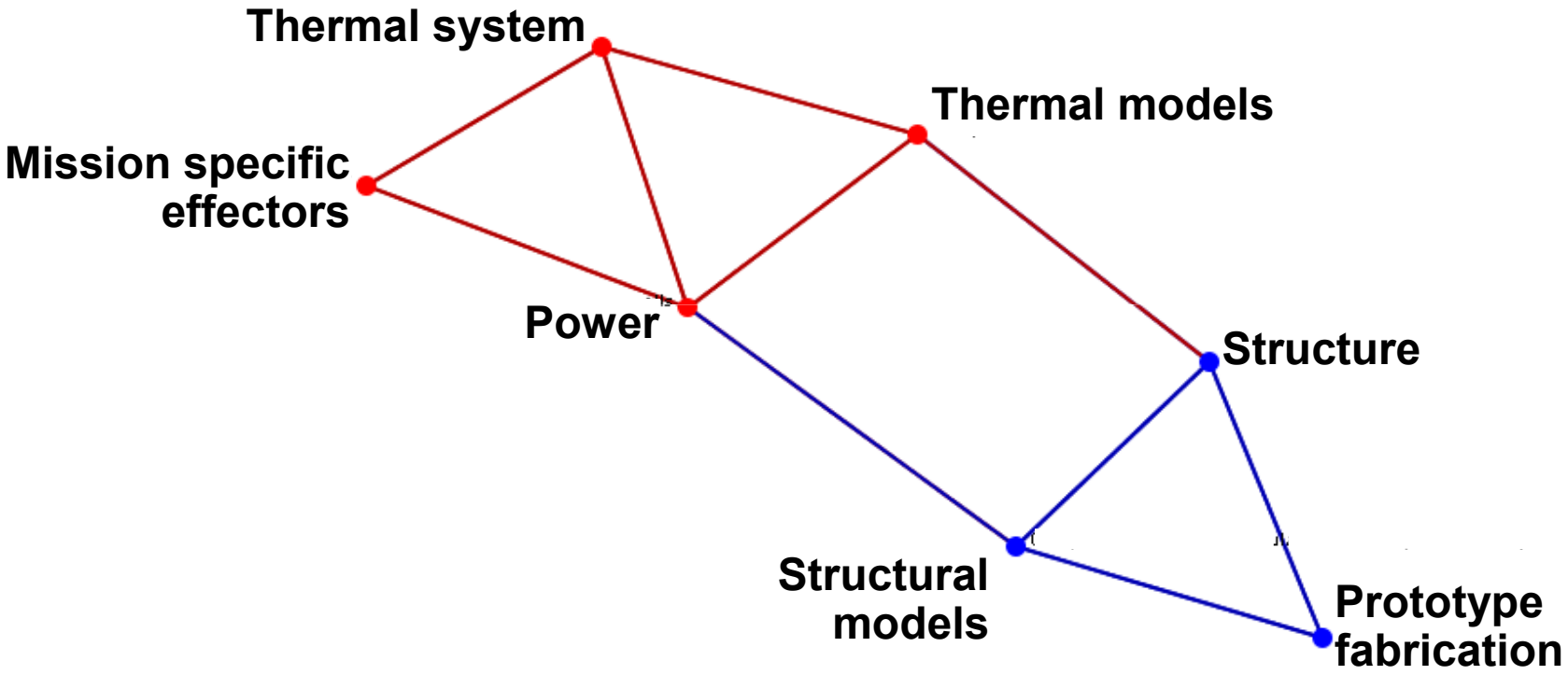
Thermal



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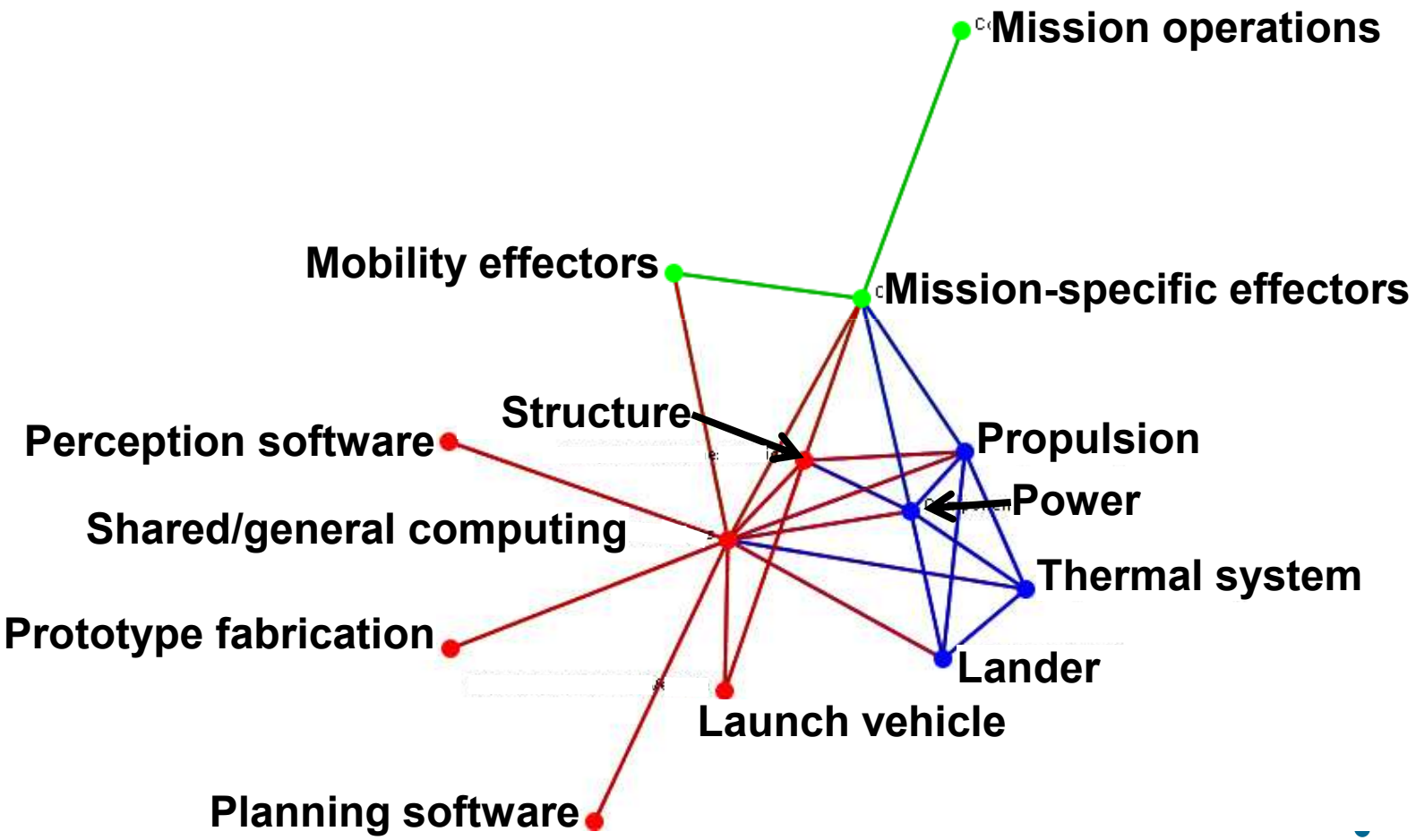
Avionics



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Concluding Vision

- The gray area – work that cross-cuts language constructs – is here to stay
- Use organizational tactics
- Use computations over artifacts generated by development activities
- Explore new data sources, including documents and conversation
  - Activities reveal knowledge
  - Analysis can often make it actionable