Coordination in Global Development

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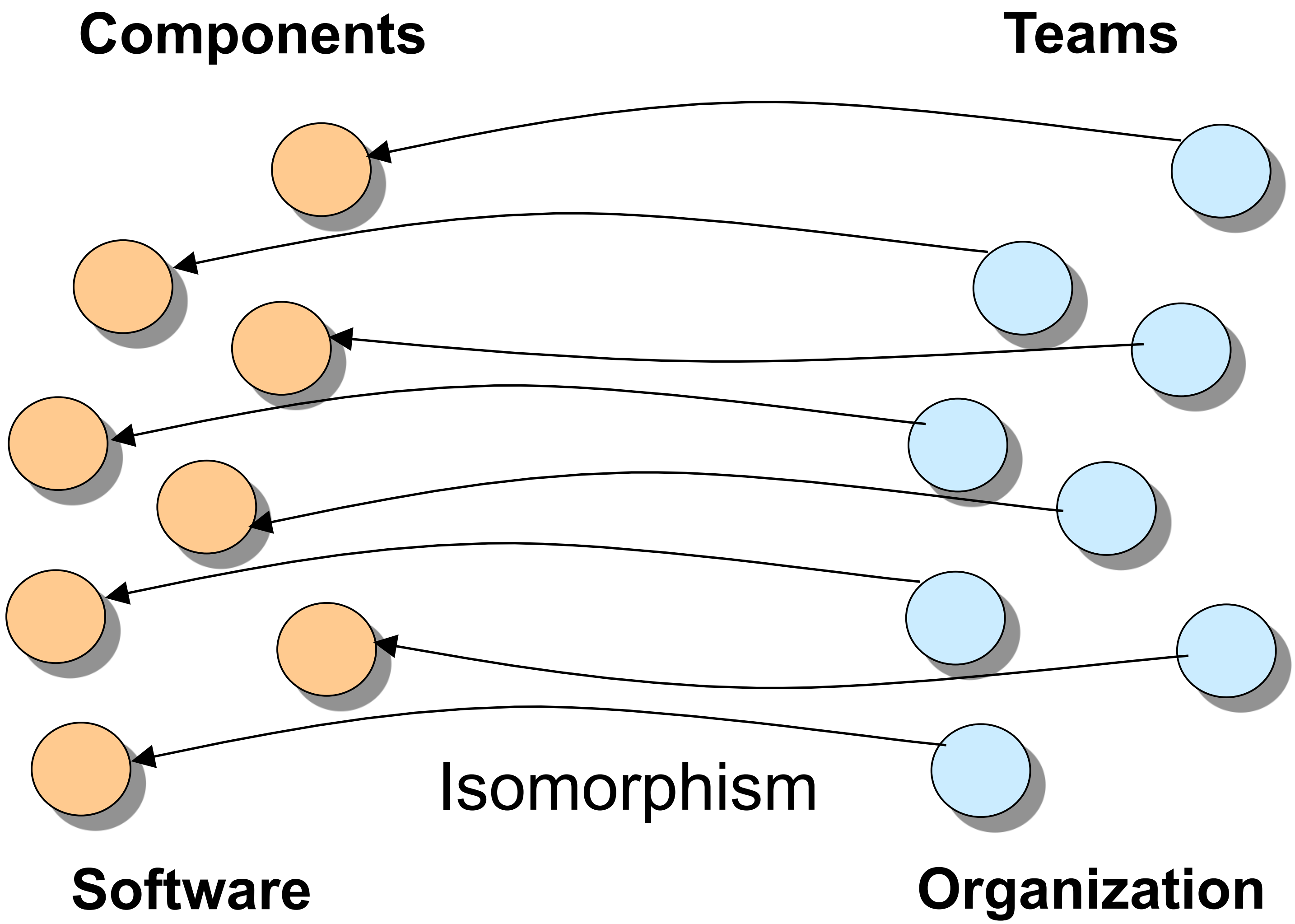
Conway’s Law

- “Any organization that designs a system will inevitably produce a design whose structure is a copy of the organization's communication structure.”

M.E. Conway, “How Do Committees Invent?” *Datamation, Vol.* 14, No. 4, Apr. 1968, pp. 28–31.

Conway's Law



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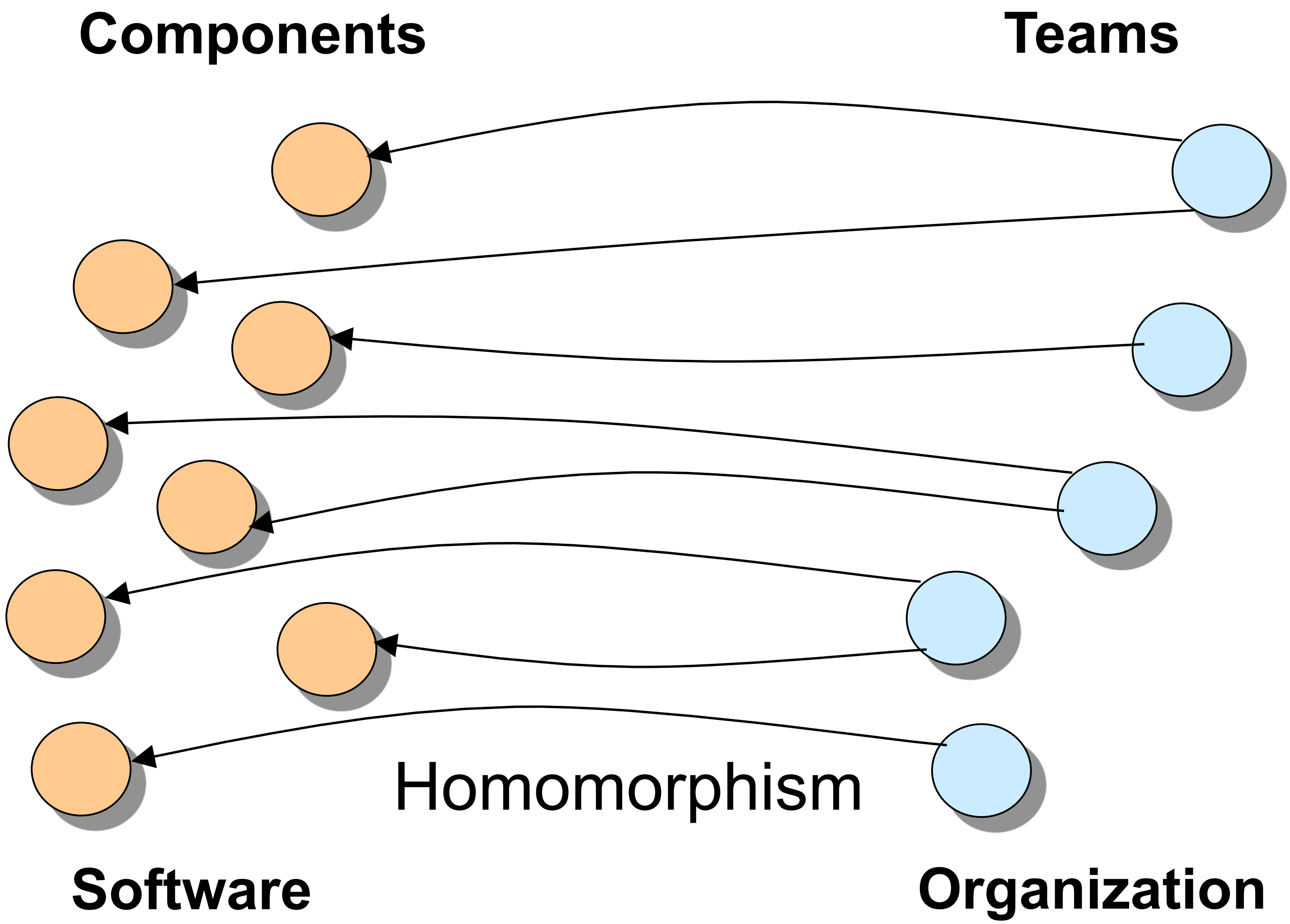
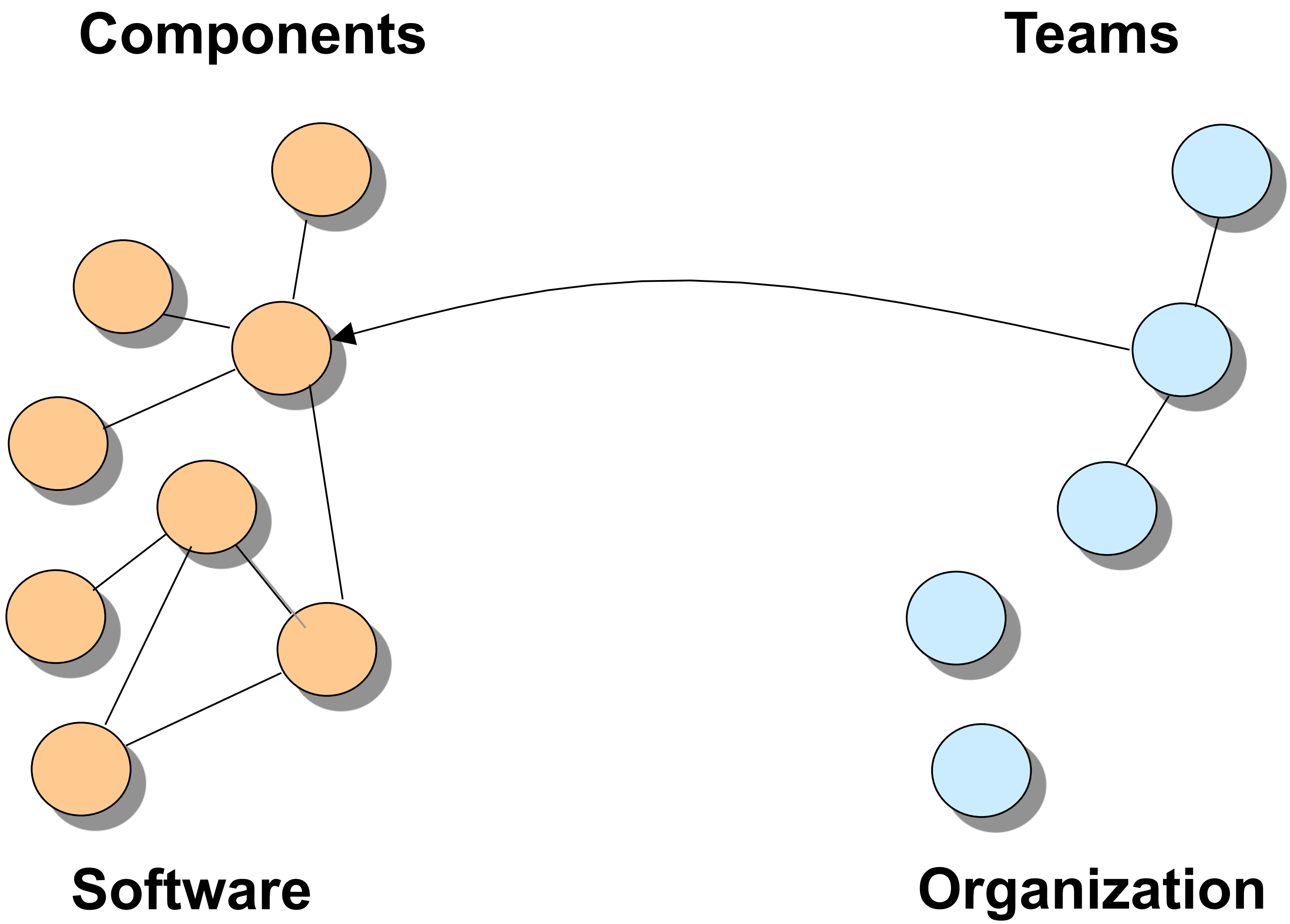
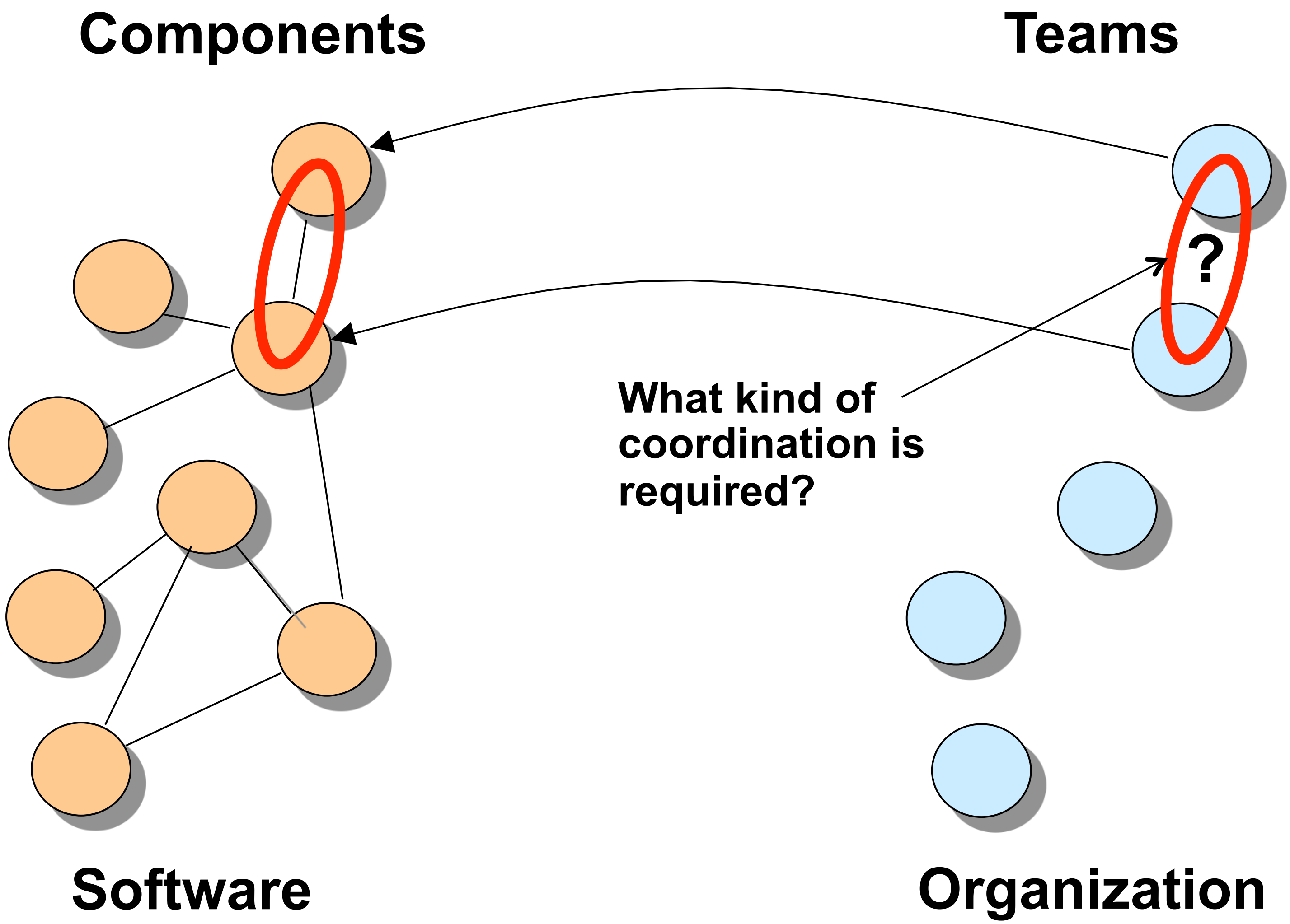


What about the Connectors?



Architectural Decisions + Task Assignment → Required Coordination



Research Program

Empirical Studies
- Behavior of coordination requirements
- Effects of congruence
- Closely-coupled work

Theory Development
- Constraint networks
- Network properties
- Game theory

Applications
- Tools – Tesseract, eMoose
- Tactics -- Distributability

Measuring Coordination Requirements (C_R)

Concept

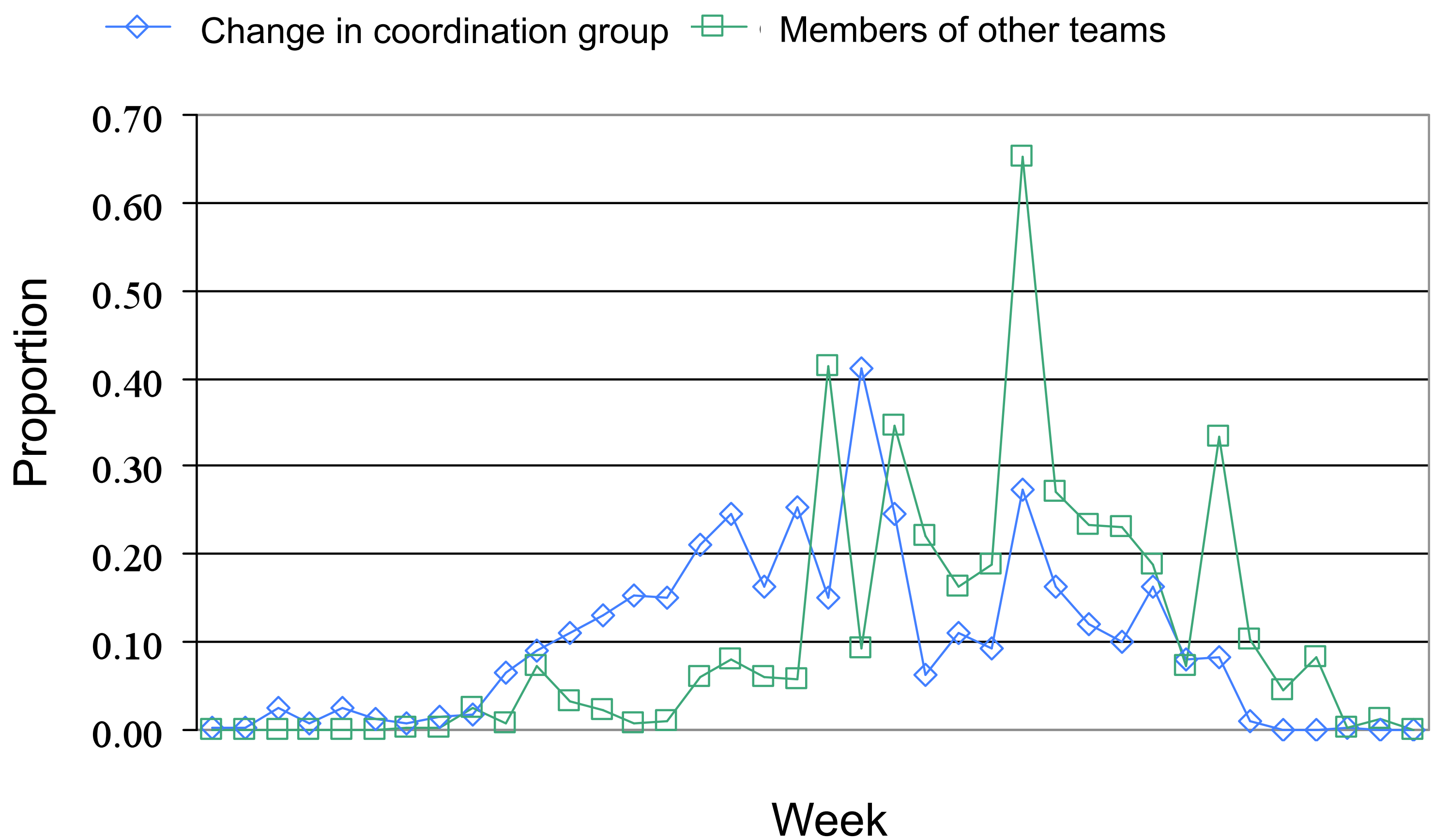
Task Assignments	Task Dependencies		Coordination Requirements
(A)	(D)	(A^T)	(C_R)

$$\begin{bmatrix} a_{11} & \cdots & a_{1k} \\ a_{n1} & \cdots & a_{nk} \end{bmatrix} \times \begin{bmatrix} d_{11} & \cdots & d_{1k} \\ d_{k1} & \cdots & d_{kk} \end{bmatrix} \times \begin{bmatrix} a_{11} & \cdots & a_{1n} \\ a_{k1} & \cdots & a_{kn} \end{bmatrix} = \begin{bmatrix} cr_{11} & \cdots & cr_{1n} \\ cr_{n1} & \cdots & cr_{nn} \end{bmatrix}$$

Developer modified files	Files changed together	Transpose of developer modified files	Who needs to coordinate with whom

Data

Volatility in Coordination Requirements



Measuring Congruence

Coordination Requirements (C_R)		Actual Coordination (C_A)
$\begin{bmatrix} cr_{11} & \cdots & cr_{1n} \\ cr_{n1} & \cdots & cr_{nn} \end{bmatrix}$	$\longleftrightarrow$	$\begin{bmatrix} ca_{11} & \cdots & ca_{1n} \\ ca_{n1} & \cdots & ca_{nn} \end{bmatrix}$

- Team structure
- Geographic location
- Use of chat
- On-line discussion

$$\textit{Diff}\,(C_R, C_A) = \textit{card}\,\{\, \textit{diff}_{ij} \mid cr_{ij} > 0\ \&\ ca_{ij} > 0 \,\}$$

$$\textit{Congruence}\,(C_R, C_A) = \textit{Diff}\,(C_R, C_A) \,/\, |C_R|$$

Results

Table 2: Results from OLS Regression of Effects on Task Performance (+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$).

	Model I	Model II	Model III	Model IV
(Intercept)	2.987**	3.631**	1.572*	1.751*
Dependency	0.897*	0.653*	0.784*	0.712*
Priority	-0.741*	-0.681*	-0.702*	-0.712*
Re-assignment	0.423*	0.487*	0.304*	0.324*
Customer MR	-0.730	-0.821	-0.932	-0.903
Release	-0.154*	-0.137*	-0.109*	-0.098*
Change Size (log)	1.542*	1.591*	1.428*	1.692*
Team Load	0.307*	0.317*	0.356*	0.374*
Programming Experience	-0.062*	-0.162*	-0.117*	-0.103*
Tenure	-0.269*	-0.265*	-0.239*	-0.248*
Component Experience (log)	-0.143*	-0.143*	-0.195*	-0.213*
Structural Congruence		**-0.526***		**-0.483***
Geographical Congruence		**-0.317***		**-0.312***
MR Congruence		**-0.189***		**-0.129***
IRC Congruence		**-0.196***		**--**
Interaction: ReleaseX Structural Congruence		**0.007**		**0.009**
Interaction:ReleaseXGeographical Congruence		**-0.013**		**-0.017**
Interaction: Release X MR Congruence		**-0.009+**		**-0.011+**
Interaction: Release X IRC Congruence		**-0.017***		**--**
N	809	809	1983	1983
Adjusted R^2	0.787	0.872	0.756	0.854

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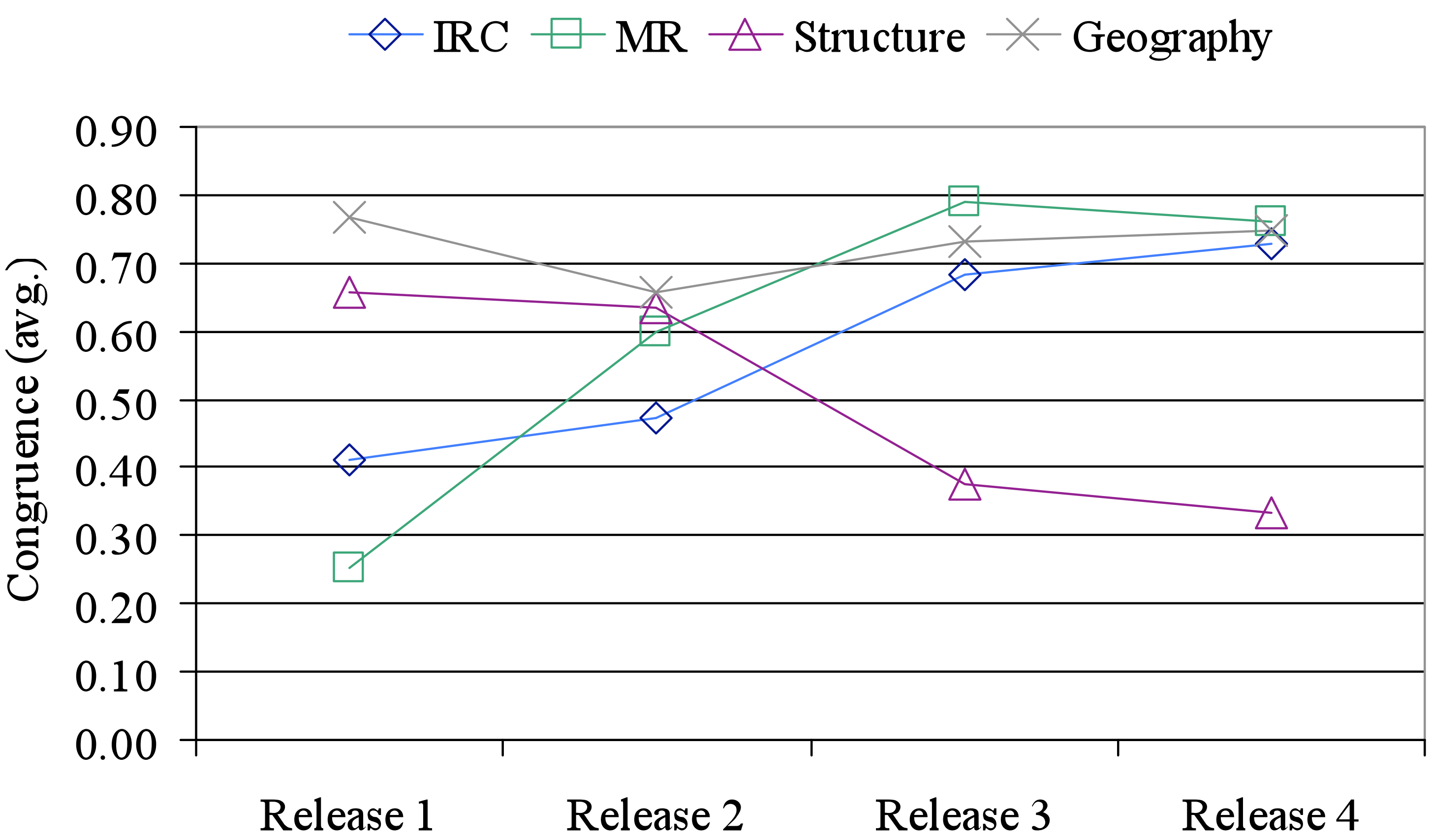
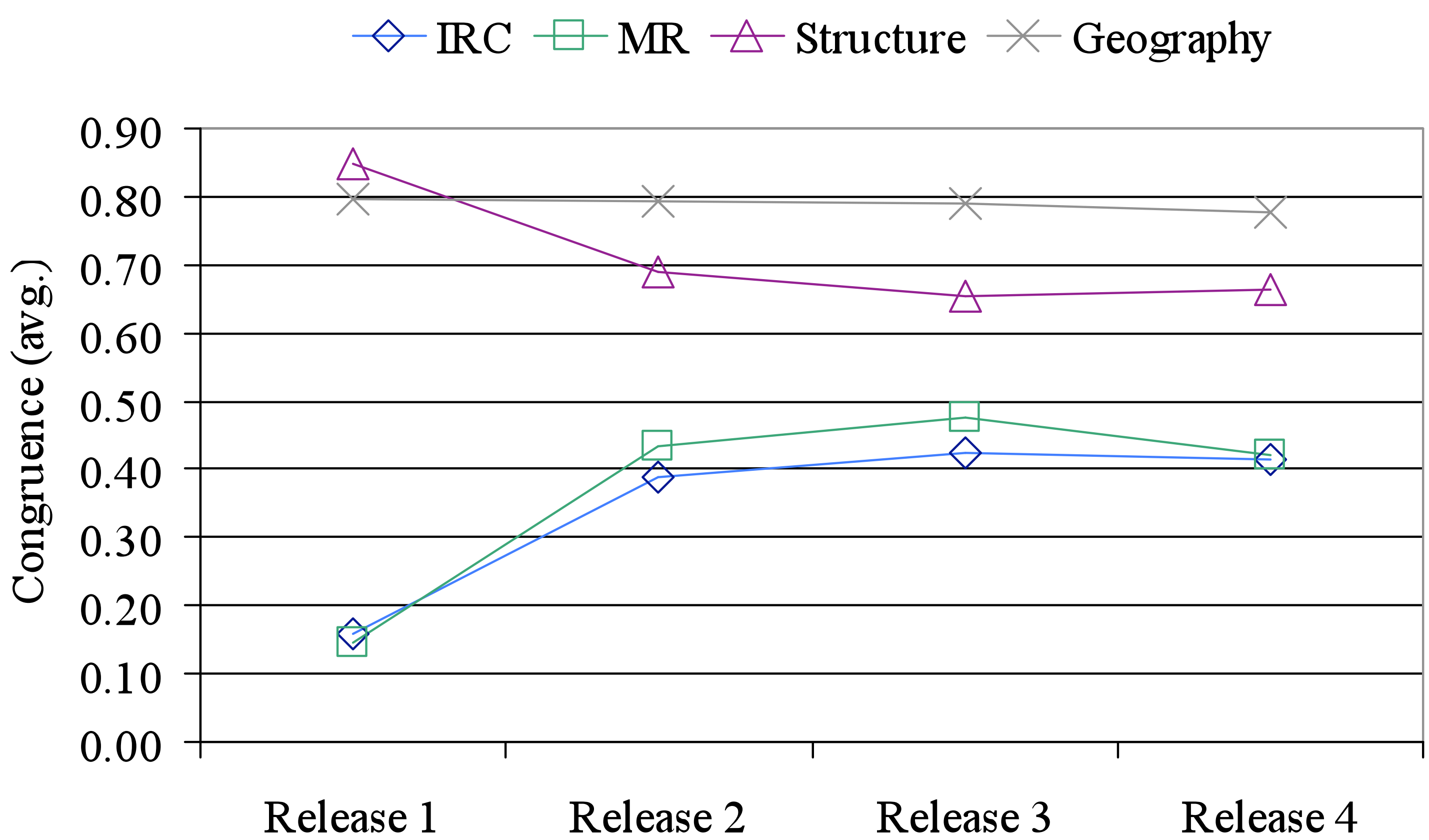
Effects of Congruence

- Time to complete a work item is reduced by *each* of the types of congruence
  - Team structure congruence
  - Geographic location congruence
  - Chat congruence
  - On-line discussion congruence

Average Level of Congruence for Top 18 Contributors



Average Level of Congruence for the Other 94 Developers



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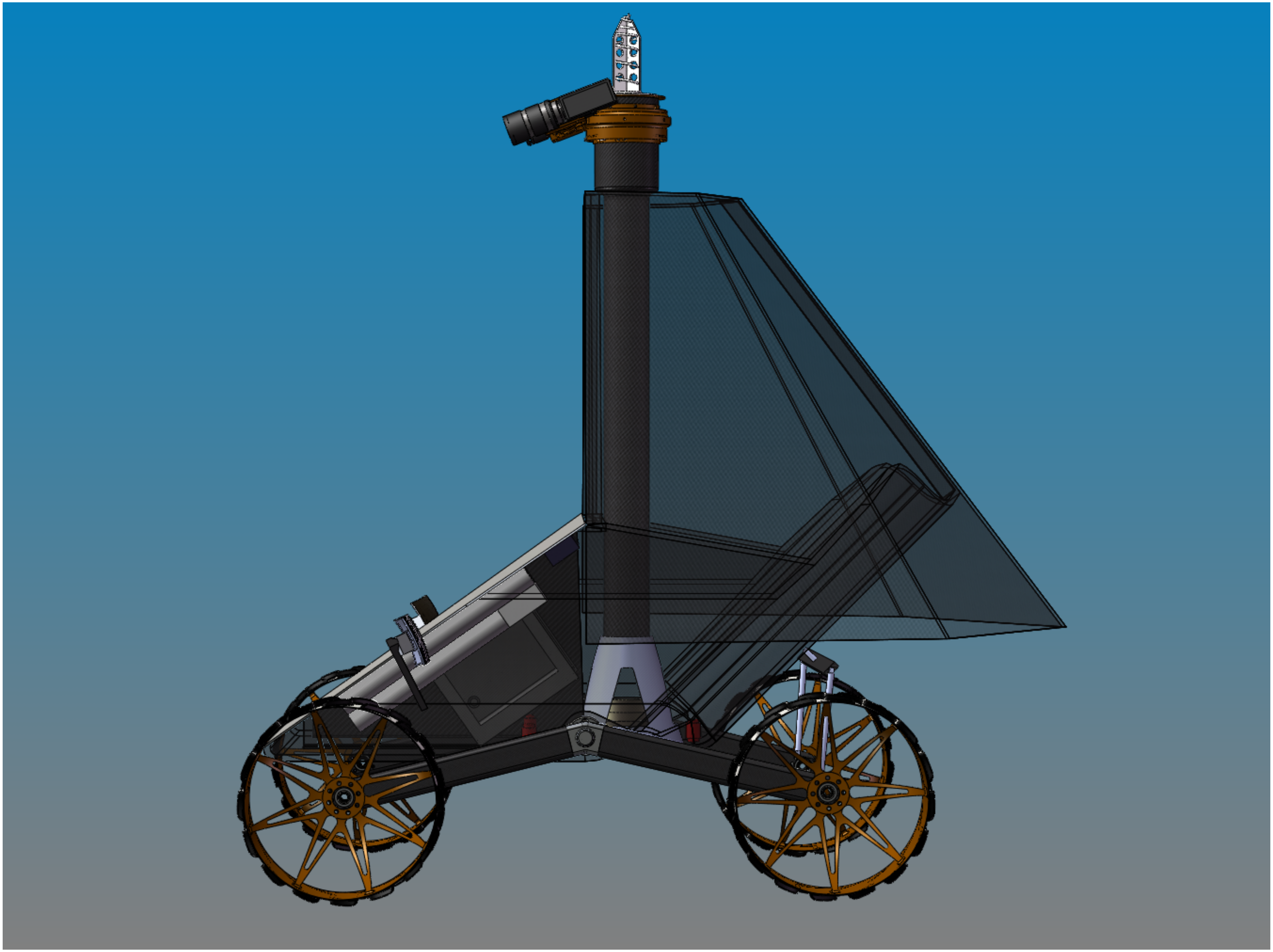
Theoretical Views of Coordination

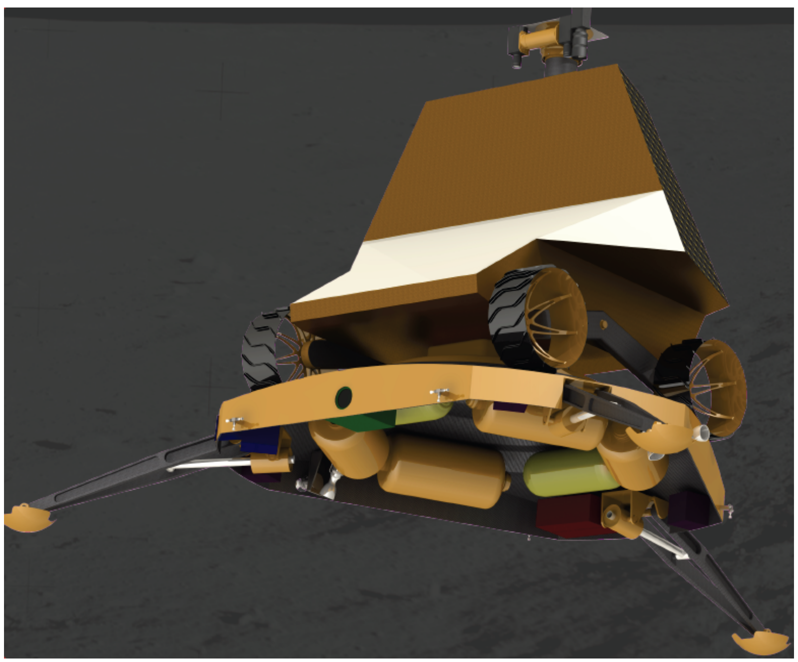
- Coordination theory (Malone & Crowston)
  - Match coordination problems to mechanisms
  - E.g., resource conflict and scheduling
- Distributed Cognition (Hutchins, Hollan)
  - Computational process distributed over artifacts and people
- Distributed AI (Durfee, Lesser)
  - Partial global planning
  - Communication regimens
- Organizational behavior
  - Stylized dependency types, e.g., sequential, pooled
  - Coordination regimens that address each type

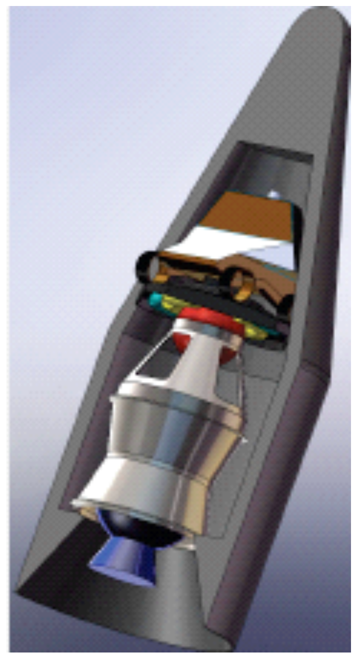
Three Propositions

- P1: Artifact design is a process of making decisions, and these decisions are linked by constraints in a potentially large and complex network (which we call the “constraint network”).
- P2: The need for coordination among individuals and teams arises from the constraints on the decisions they are making.
- P3: What we call task coupling between individuals and between teams is simply the result of the properties of the constraint network and the assignment of decisions to people.



Google Lunar X Prize





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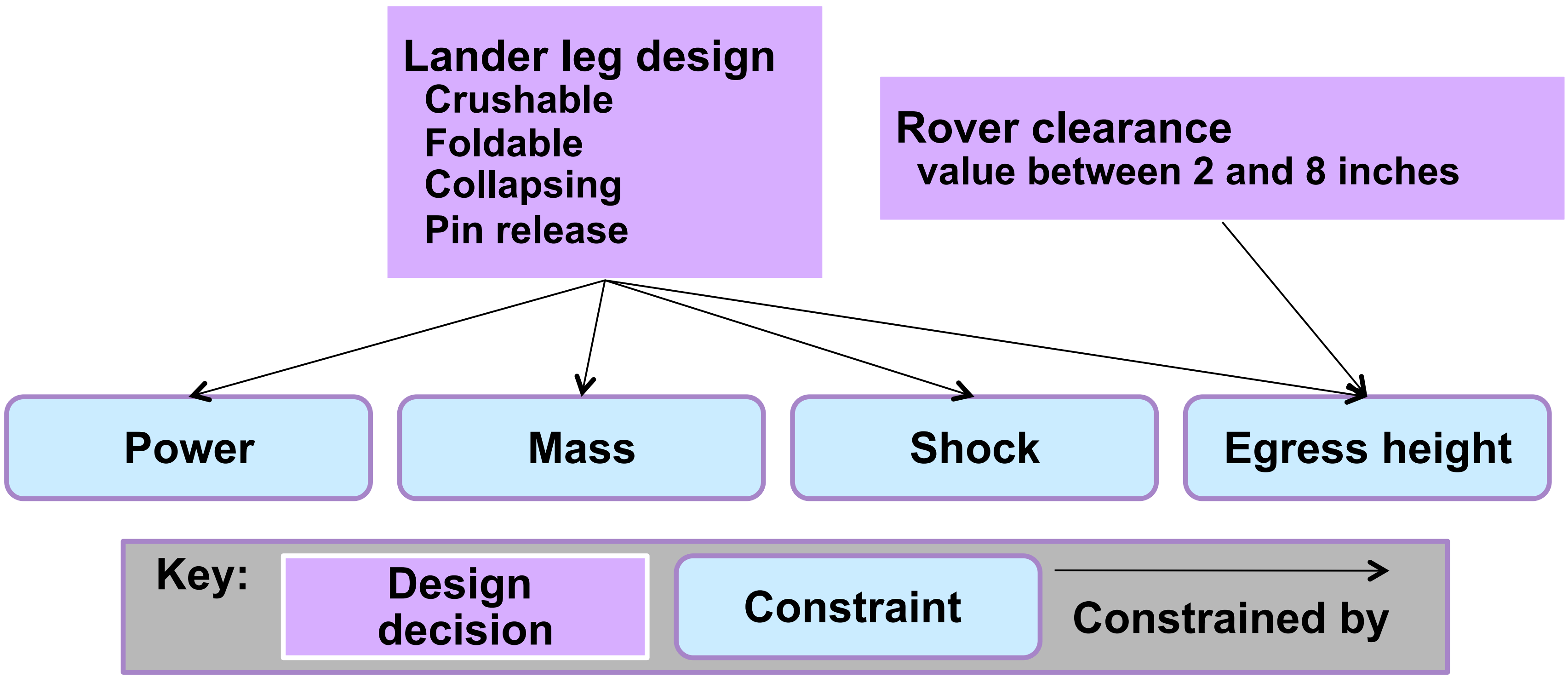
Observed Constraint Networks

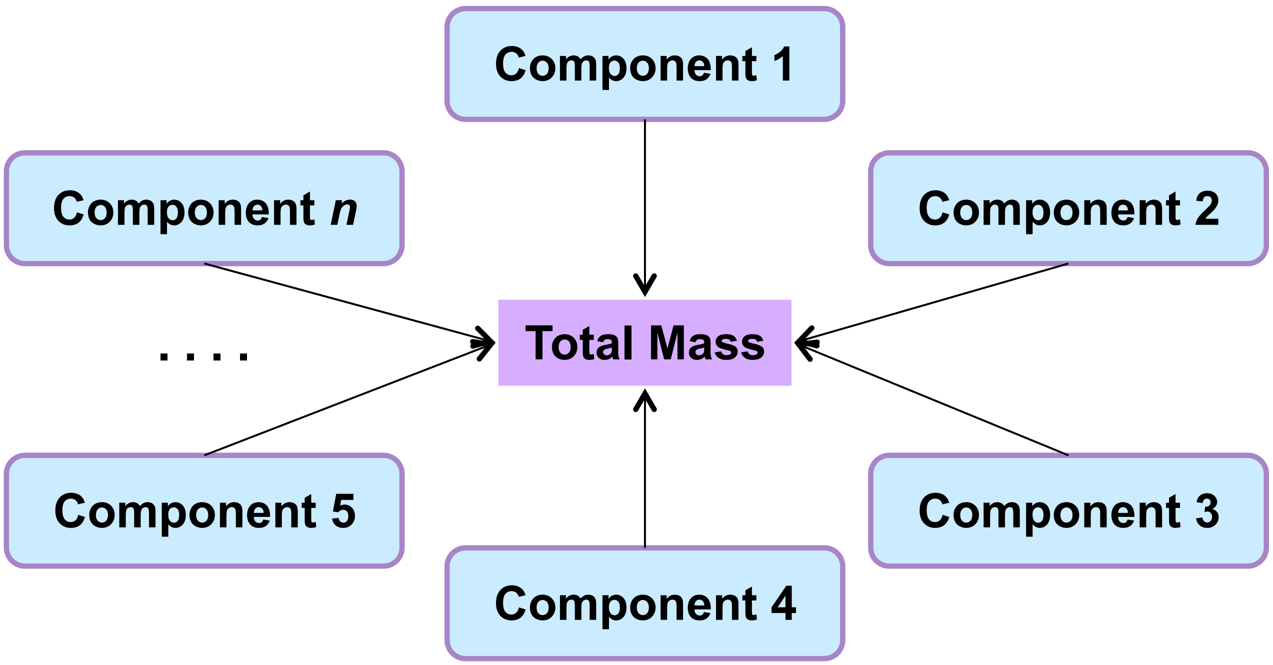


Properties of Constraint Networks

- **Constraint Diffusion**
  - Touches many components
  - Influences many decisions
- **Constraint Violation Detection**
  - When considering a choice, determining if it will violate a constraint
- **Decision Constraint Diversity**
  - Decision is influenced by many different types of constraints

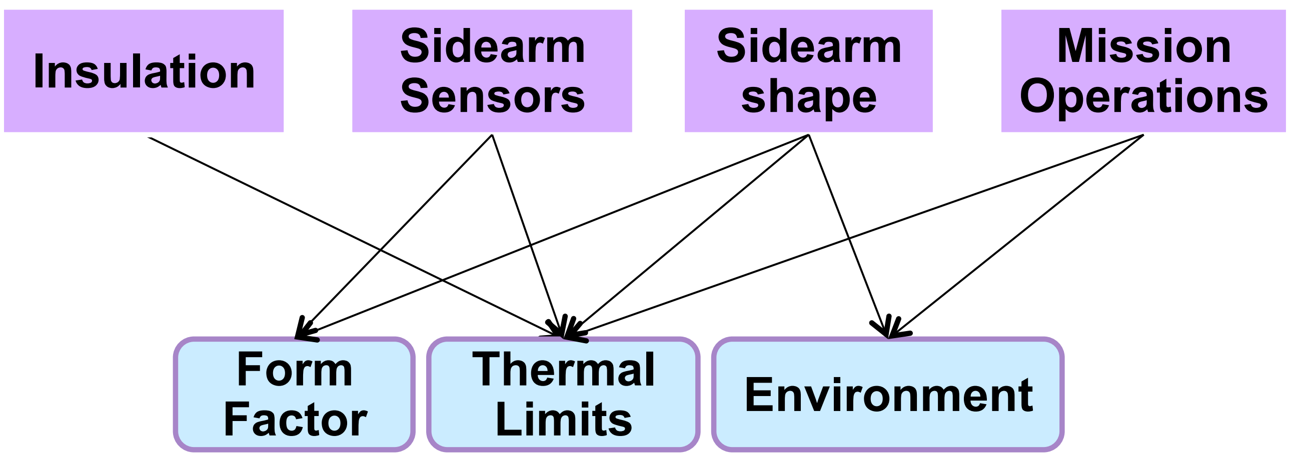
Example:
Total Mass

- High diffusion
- Easy violation detection



Example:
Sidearm Design

- Low constraint diffusion
- Difficult violation detection



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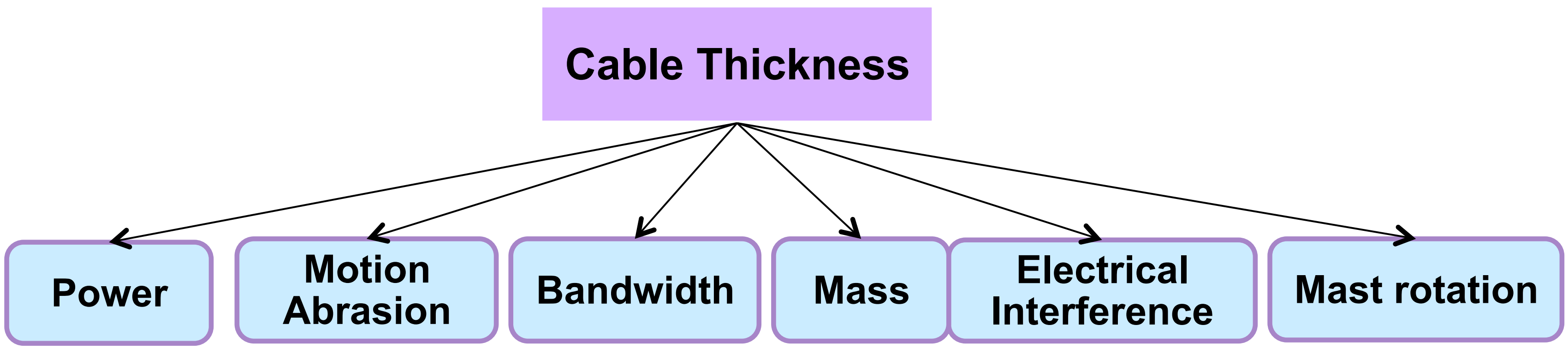
Example:
Antenna Cable

- High decision constraint diversity



Constraint Network Analysis

- Goal
  - Understand how constraint network properties generate detailed coordination requirements
  - Lead to novel ways to support distributed work
- Current activities
  - Aggregate constraint networks
  - Observe evolution over time
  - See how network properties influence speed and errors

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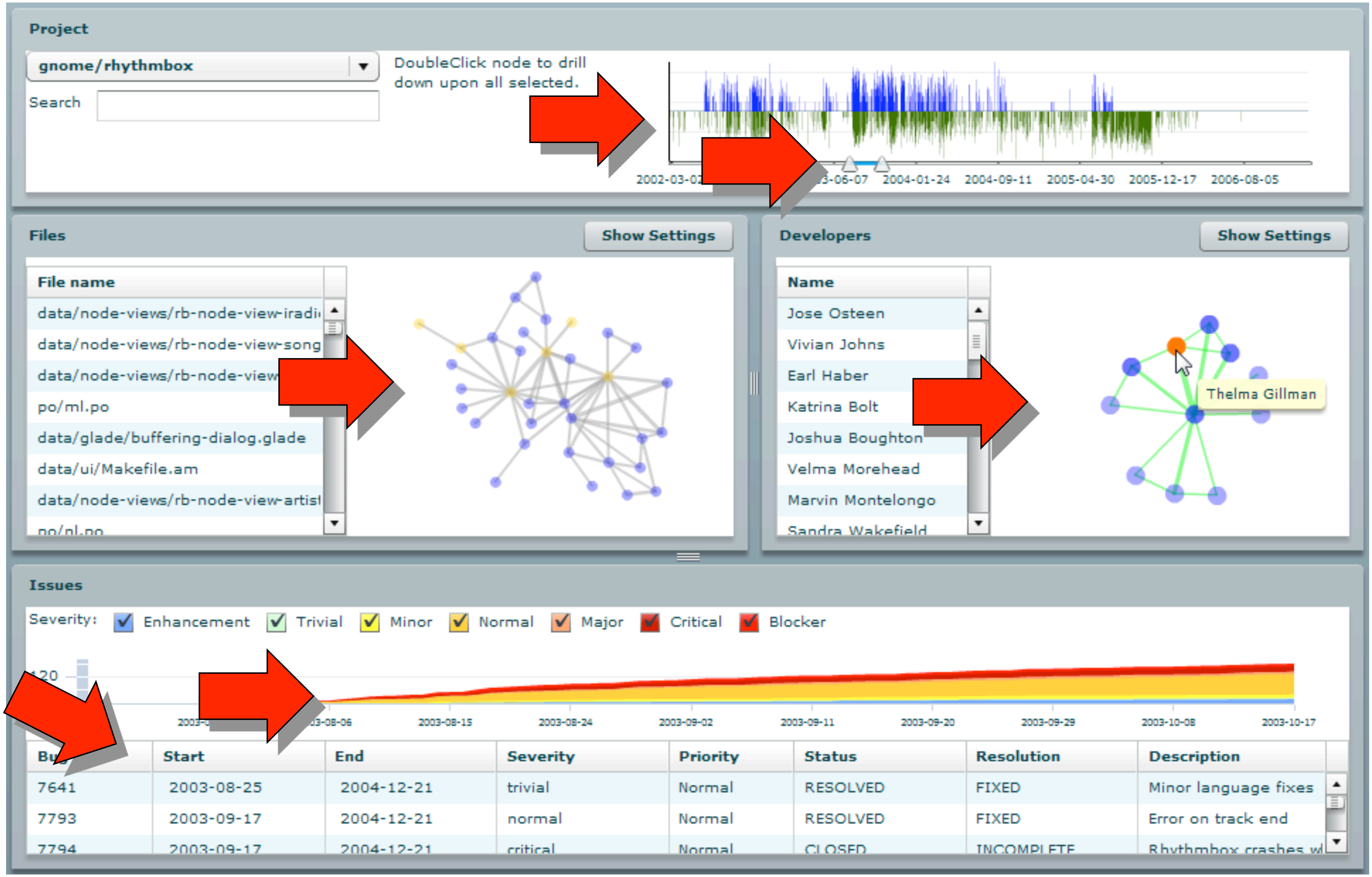
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Search
DoubleClick node to drill down upon all selected.
2002-03-02
2004-01-24
2004-09-11
2005-04-30
2005-12-17
2006-08-05
Files
Show Settings
File name
data/node-views/rb-node-view-iradi
data/node-views/rb-node-view-song
data/node-views/rb-node-view
po/ml.po
data/glade/buffering-dialog.glade
data/ui/Makefile.am
data/node-views/rb-node-view-artist
Developers
Show Settings
Name
Jose Osteen
Vivian Johns
Earl Haber
Katrina Bolt
Joshua Boughton
Velma Morehead
Marvin Montelongo
Thelma Gillman
Issues
Severity: Enhancement Trivial Minor Normal Major Critical Blocker
120
2003-08-15
2003-08-24
2003-09-02
2003-09-11
2003-09-20
2003-09-29
2003-10-08
2003-10-17
Start End Severity Priority Status Resolution Description
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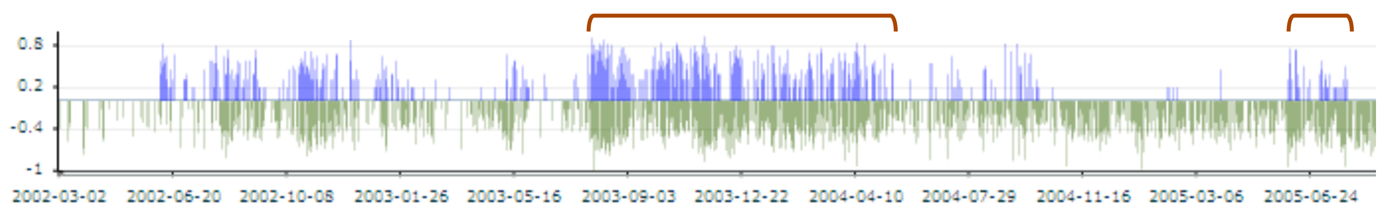
7793 2003-09-17 2004-12-21 normal Normal RESOLVED FIXED Error on track end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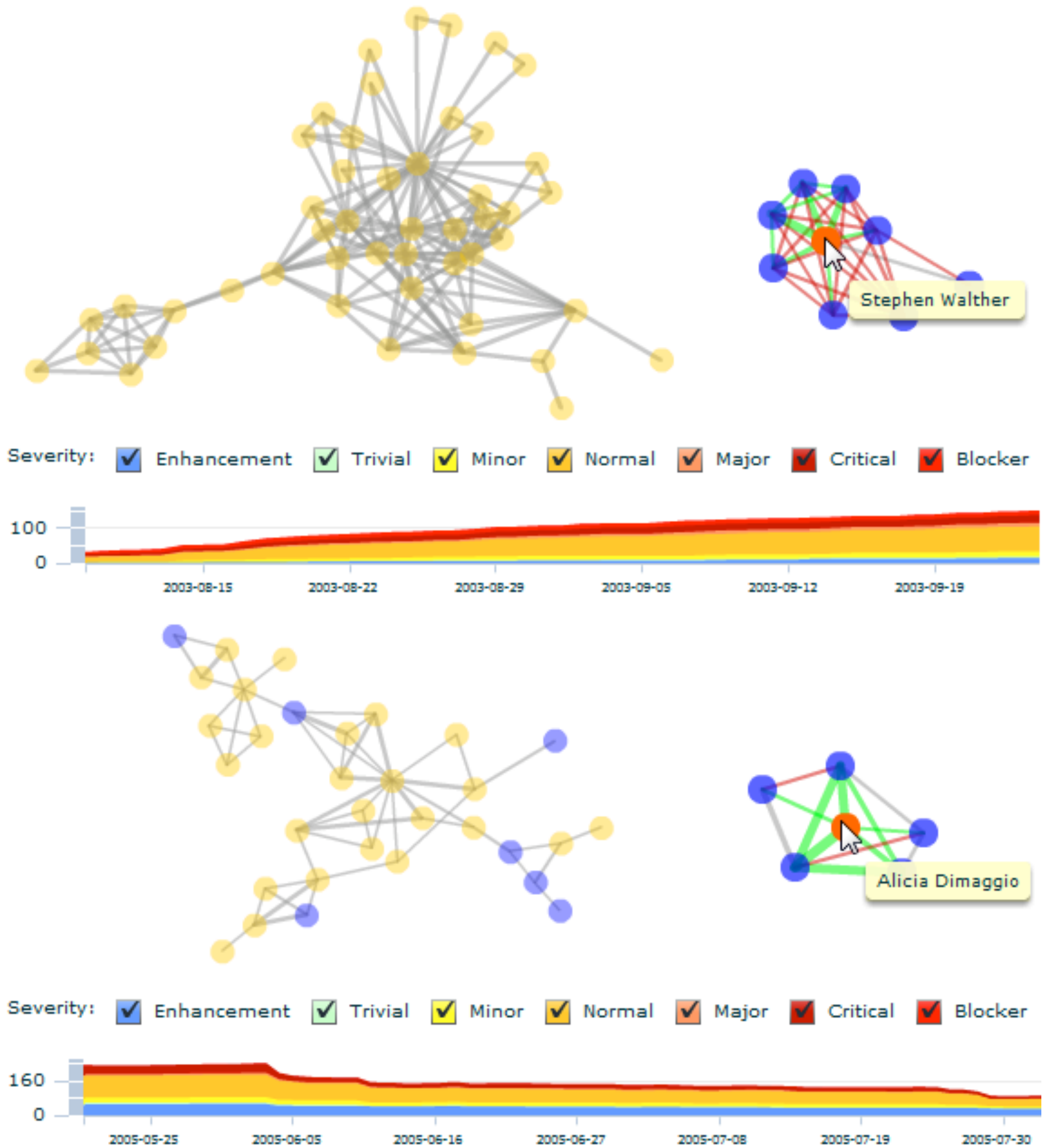
Stephen Walther
Severity: Enhancement Trivial Minor Normal Major Critical Blocker
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2003-09-19
Alicia Dimaggio
Severity: Enhancement Trivial Minor Normal Major Critical Blocker
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2005-07-30

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