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Coordinating Developers

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1-27-11

Agenda

- What is coordination, why is it a problem?
- Framing the problem
  - Face to face
  - Over time, across barriers
- Research directions
  - Congruence
  - Coordination views of architectures
  - Socio-technical patterns
  - Organizational models
  - Socio-technical ecosystems

Coordination

- Managing dependencies between tasks*

*Malone, T.W. and Crowston, K., The interdisciplinary theory of coordination. *ACM Computing Surveys, 26, 1* (1994), p. 87-119.

Face-to-Face Coordination

From Teasley, S. D., Covi, L. A., Krishnan, M. S. and Olson, J. S. Rapid Software Development through Team Collocation. *IEEE Transactions on Software Engineering*, 28, 7 2002), 671-683.

What Must a Tool Support?

(a) Ad-hoc teams formed in front of specific canvases

(b) Clumps of interactions attracted additional participants

Figure 11: Team formation in the half-day group

Dekel, U. Increasing awareness of delocalized information to facilitate API usage. Dissertation, Carnegie Mellon University, Pittsburgh, PA, 2009.

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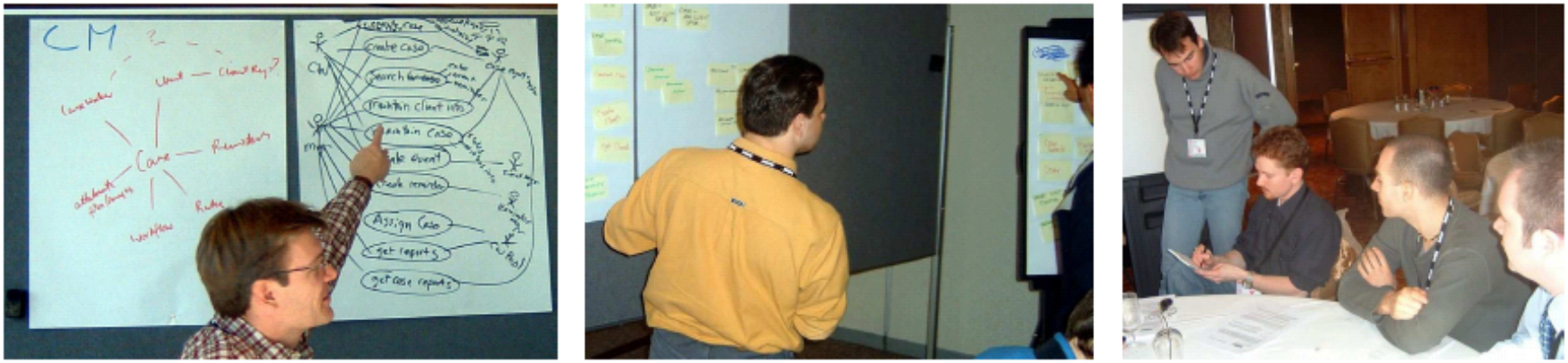
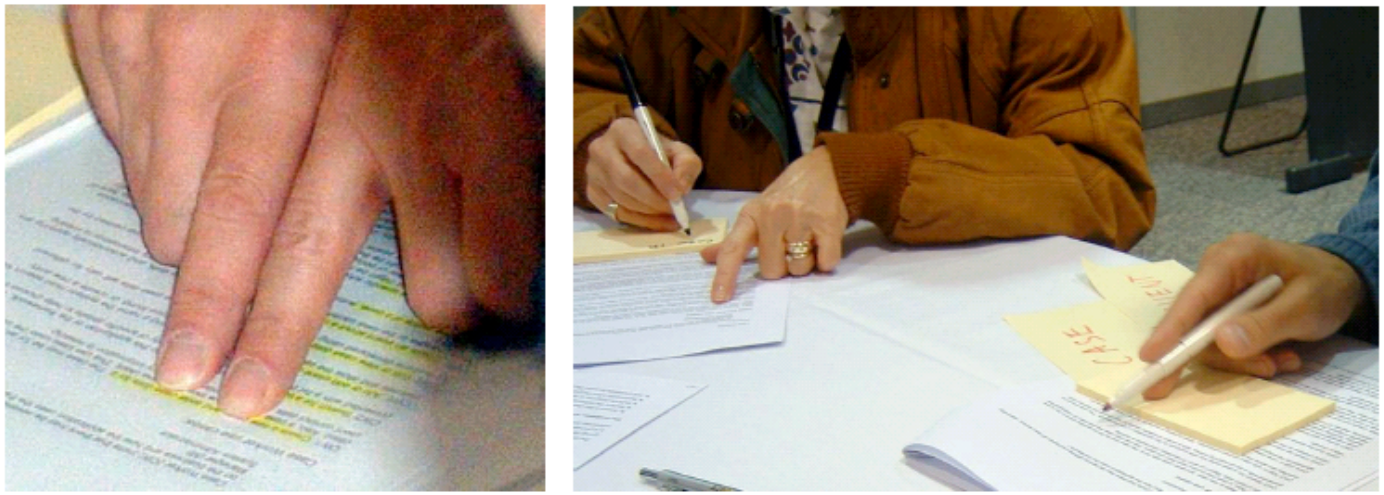
(a) (b) (c) (d)

Figure 14: Gesturing to another person about an item at close proximity



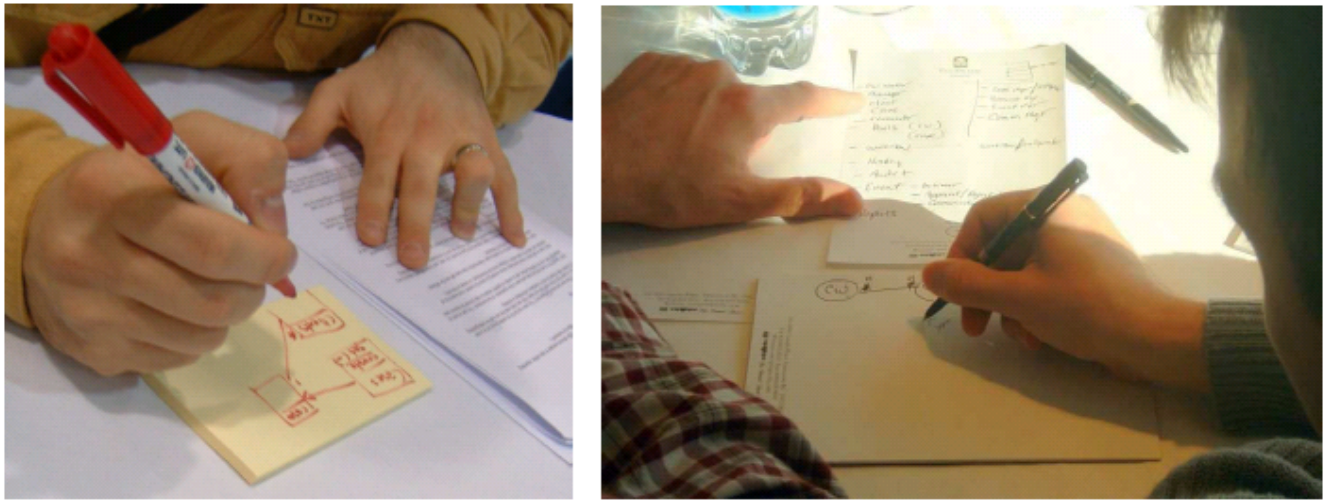
(a) (b) (c)

Figure 15: Pointing at a remote artifact



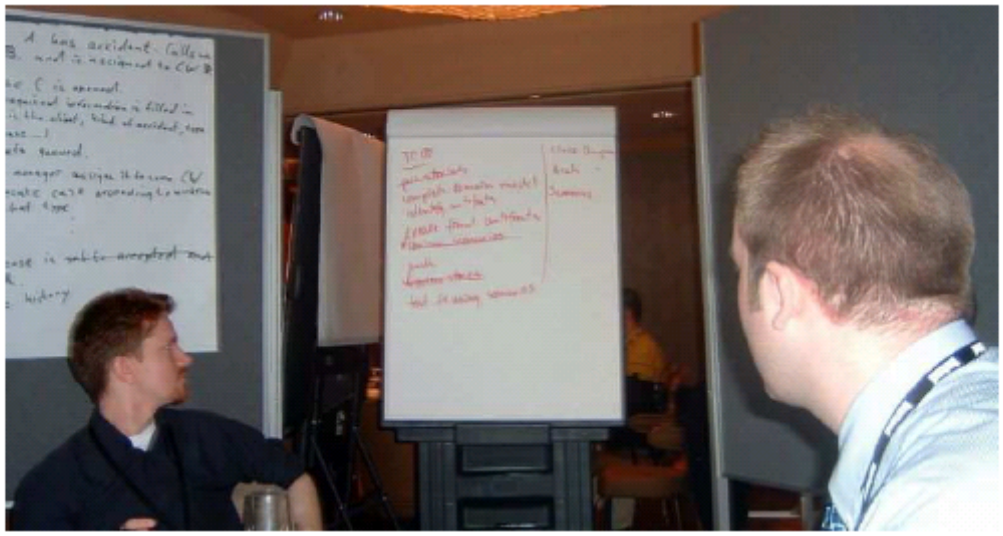
(a) (b)

Figure 12: Maintaining personal focus on one item



(a) (b)

Figure 13: Maintaining personal focus on multiple items



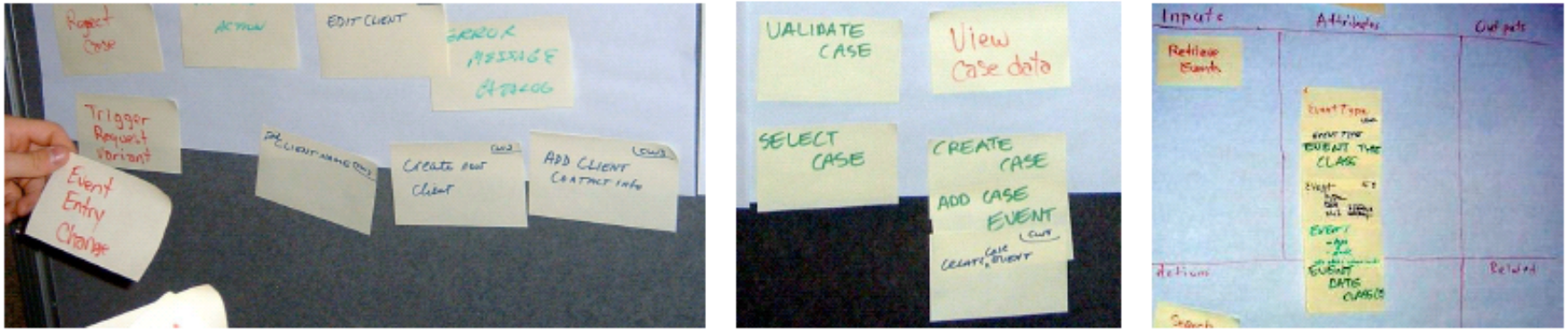
(a)

(b)

(c)

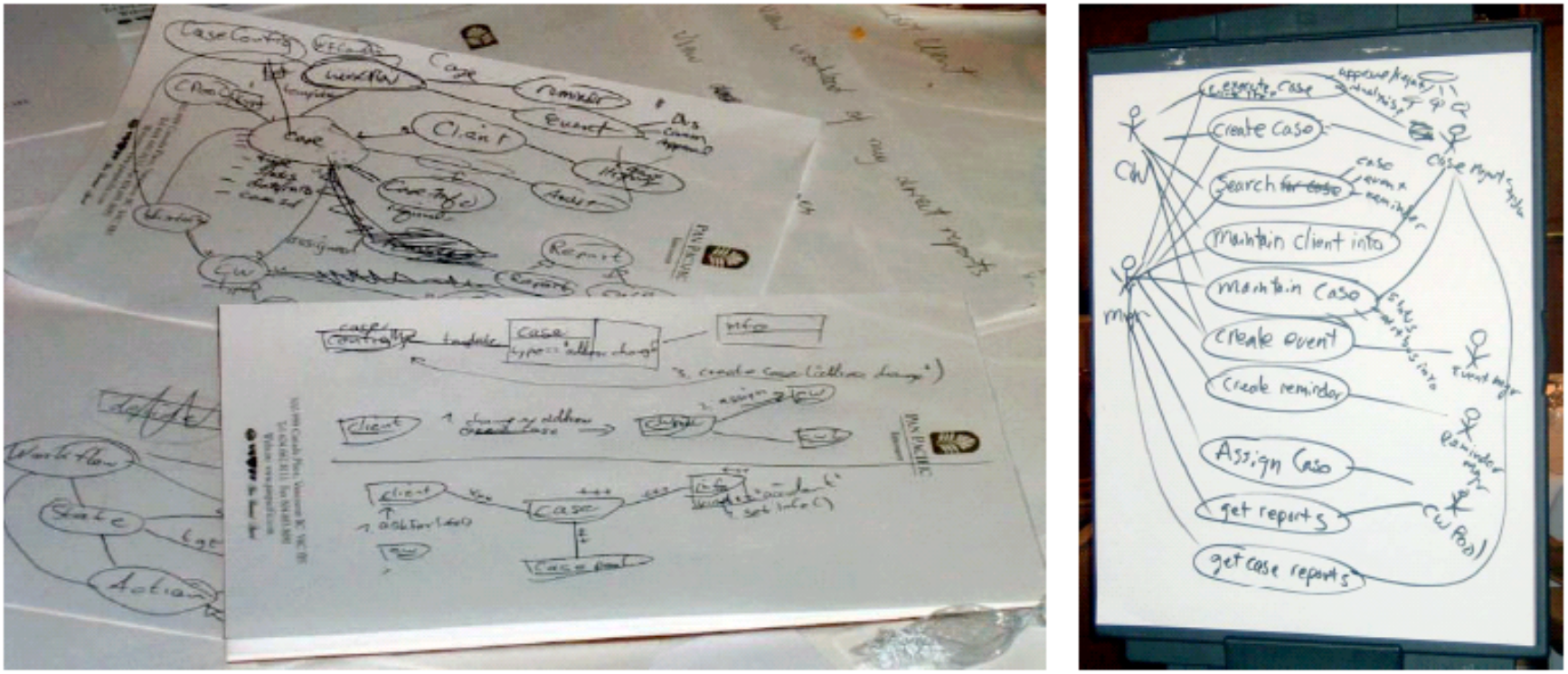
Figure 16: Inferring focus from gaze

Improving Current Tools



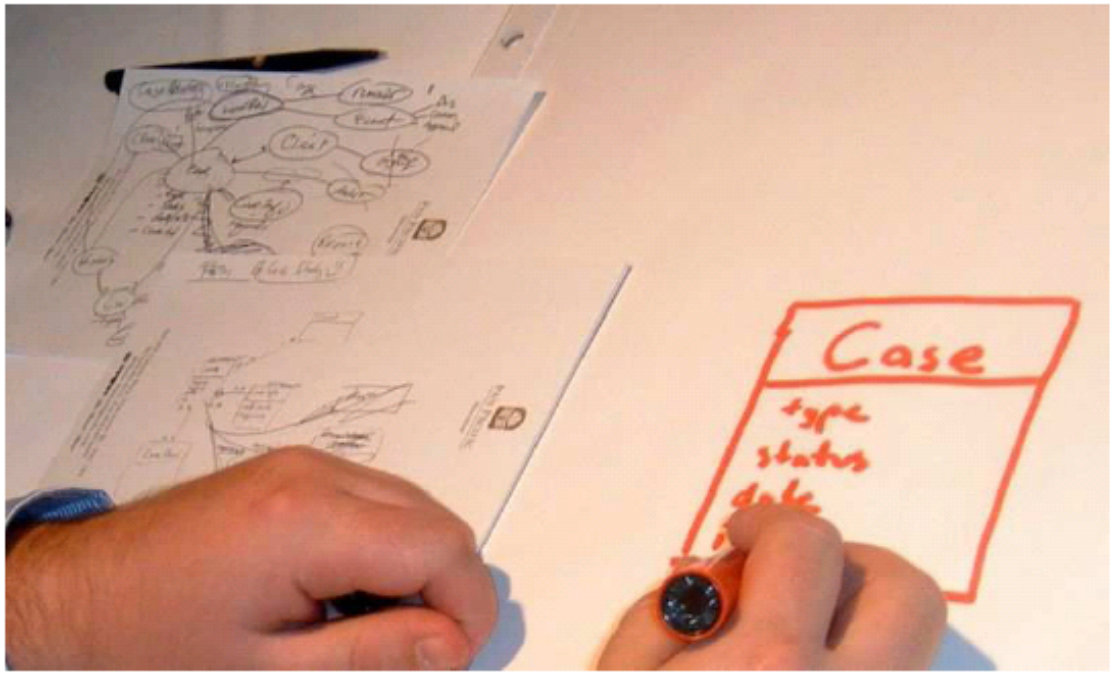
(a) (b) (c)

Figure 3: Forcing too many sticky notes into a limited container



(a) (b)

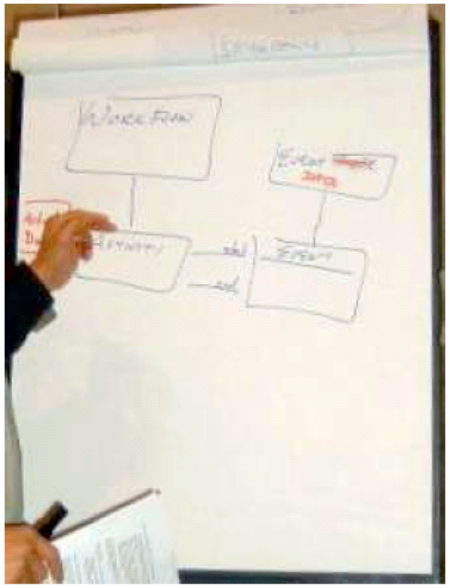
Figure 4: Forcing excessive contents into limited canvas space



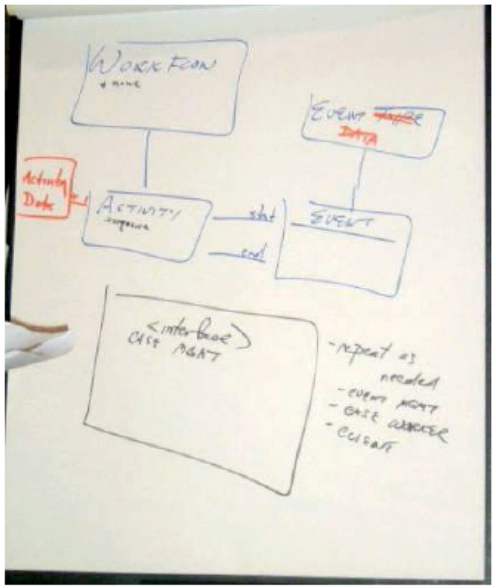
(a) The rescaling of a diagram is an opportunity to clean it up

(b) Rescaling is often a group activity

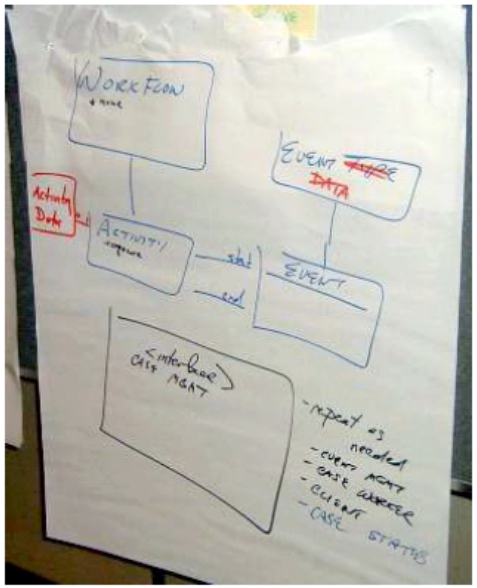
(a) Initial diagram in blue



(b) Changes in red



(c) New elements in black



(d) New comment in blue

Figure 8: A canvas is updated in bursts, implicitly creating versions

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Dual Role of Architectural Decisions

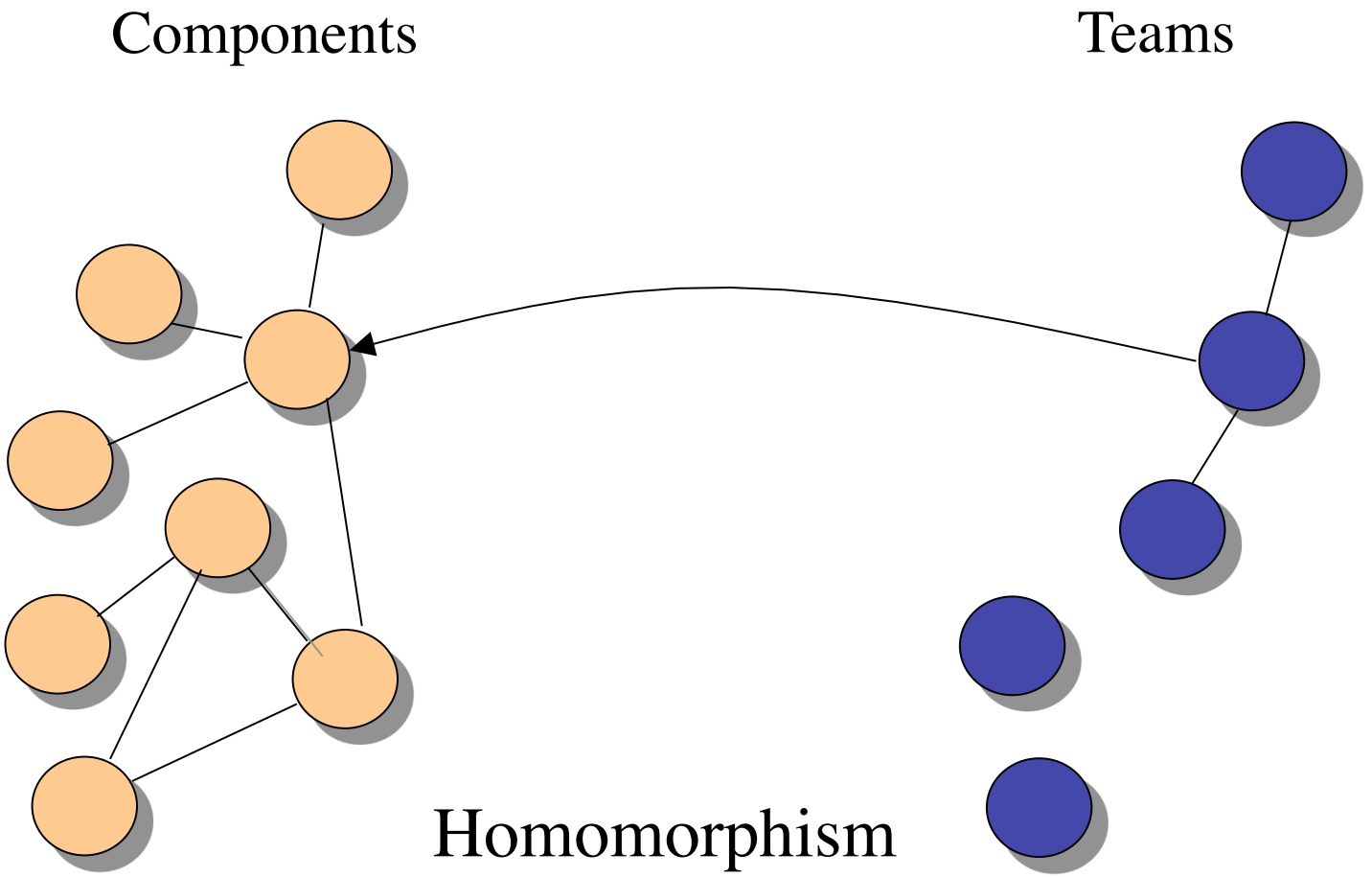
- Lessons from the history of photolithographic alignment equipment*
- Architectural decisions
  - Technical properties
  - Social engineering: shapes coordination problems

*Henderson, R.M. & Clark, K.B. (1990). Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms. *Administrative Science Quarterly*, 35 (1), pp. 9-30.

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.
- Implication: Modularity works as a coordination strategy
- Problem: Modularity has major limitations

What about the Interfaces?



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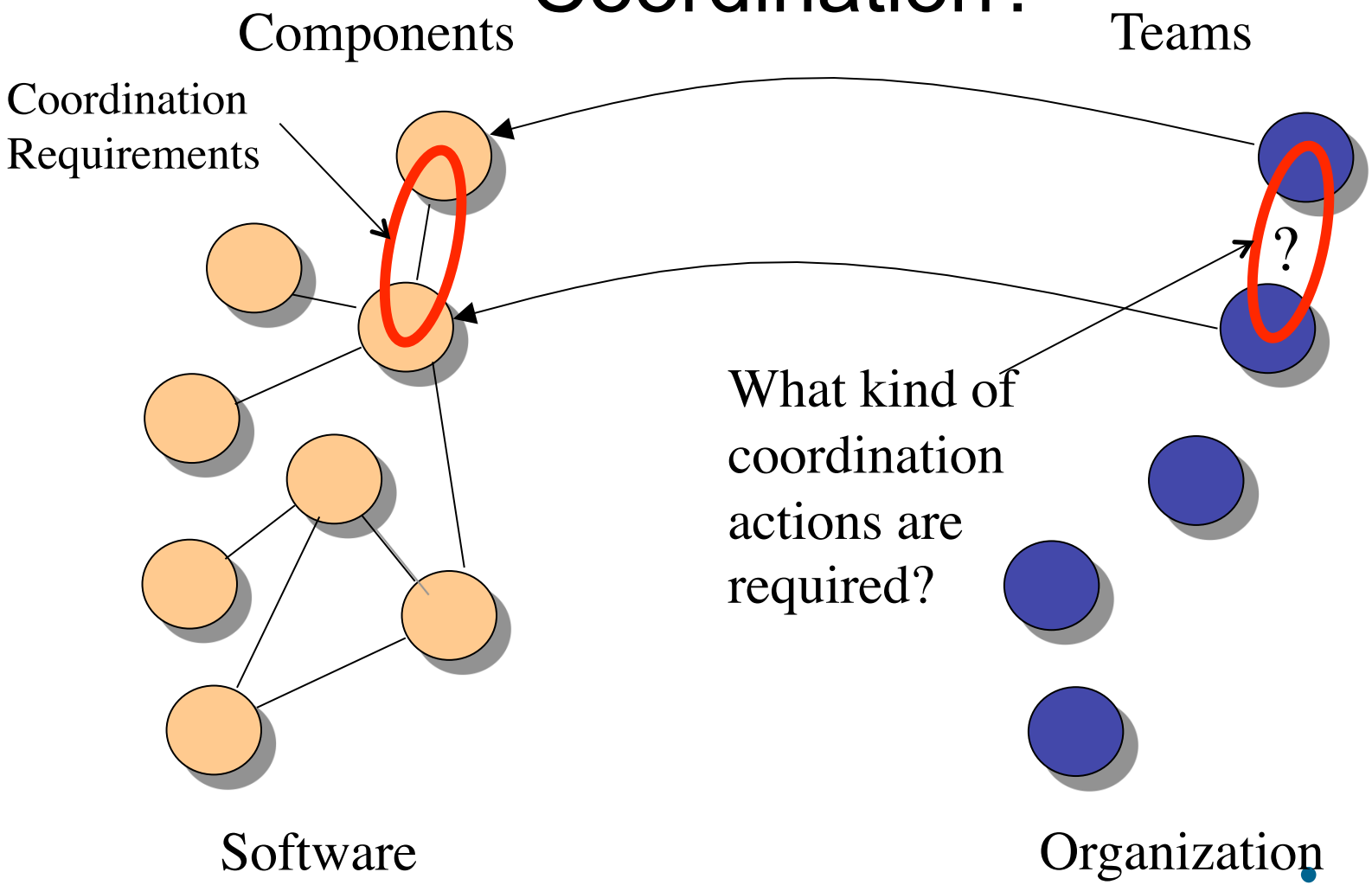
What is Required for Effective Coordination?



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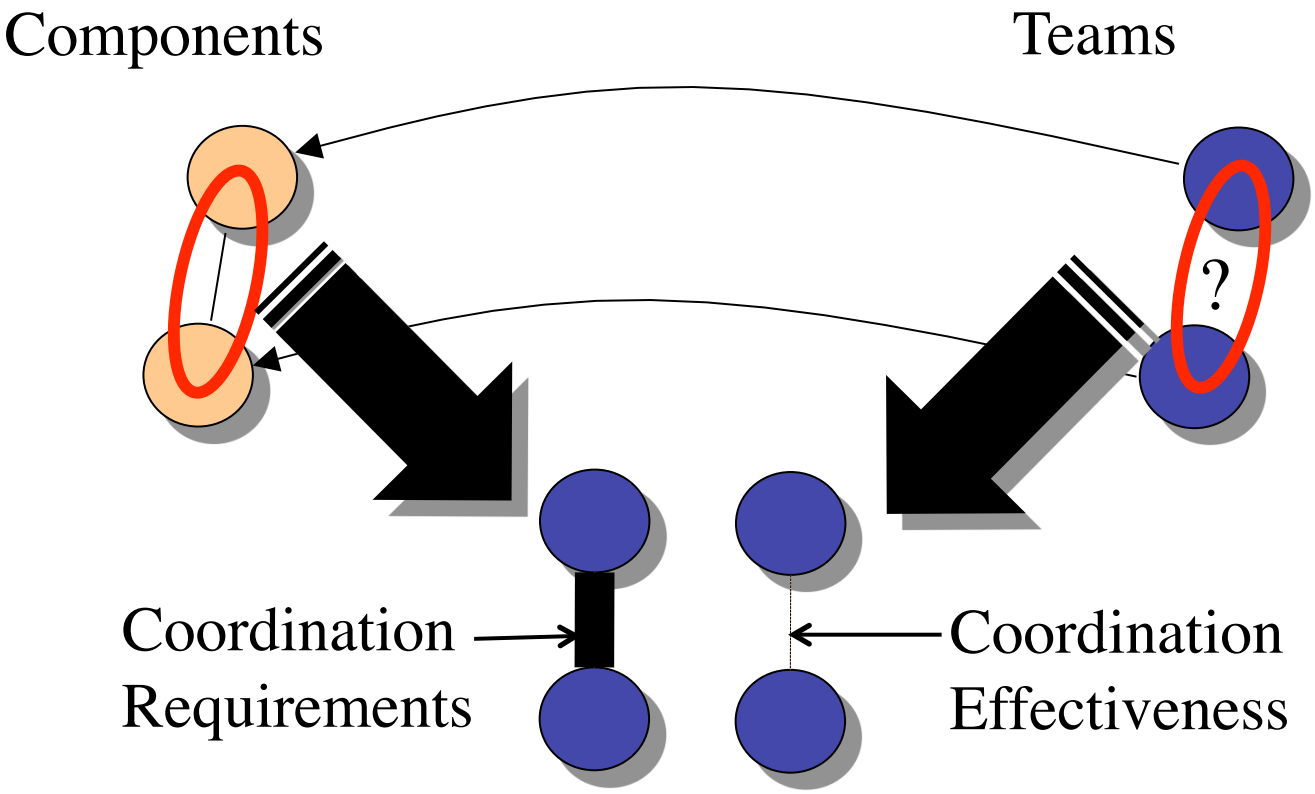
Coordination Requirements: Complexity

- Examples
  - How “big” is an API?
  - How complicated are API usage policies?
  - Features with implementations spanning components
  - Challenging non-functional requirements
    - Performance
    - Security
    - Availability
    - Etc.

Coordination Requirements: Uncertainty

- Examples
  - Allocation of functionality to components
  - Modification and refinement of component interfaces
  - Volatile requirements
  - Dependencies on other systems that are changing
    - Hardware
    - Firmware
    - Middleware
    - Etc.

Congruence



What determines coordination effectiveness?

Software

Organization

Coordination Effectiveness

- Coordination capacity
  - Relatively enduring conditions
- Coordination actions
  - Things people do

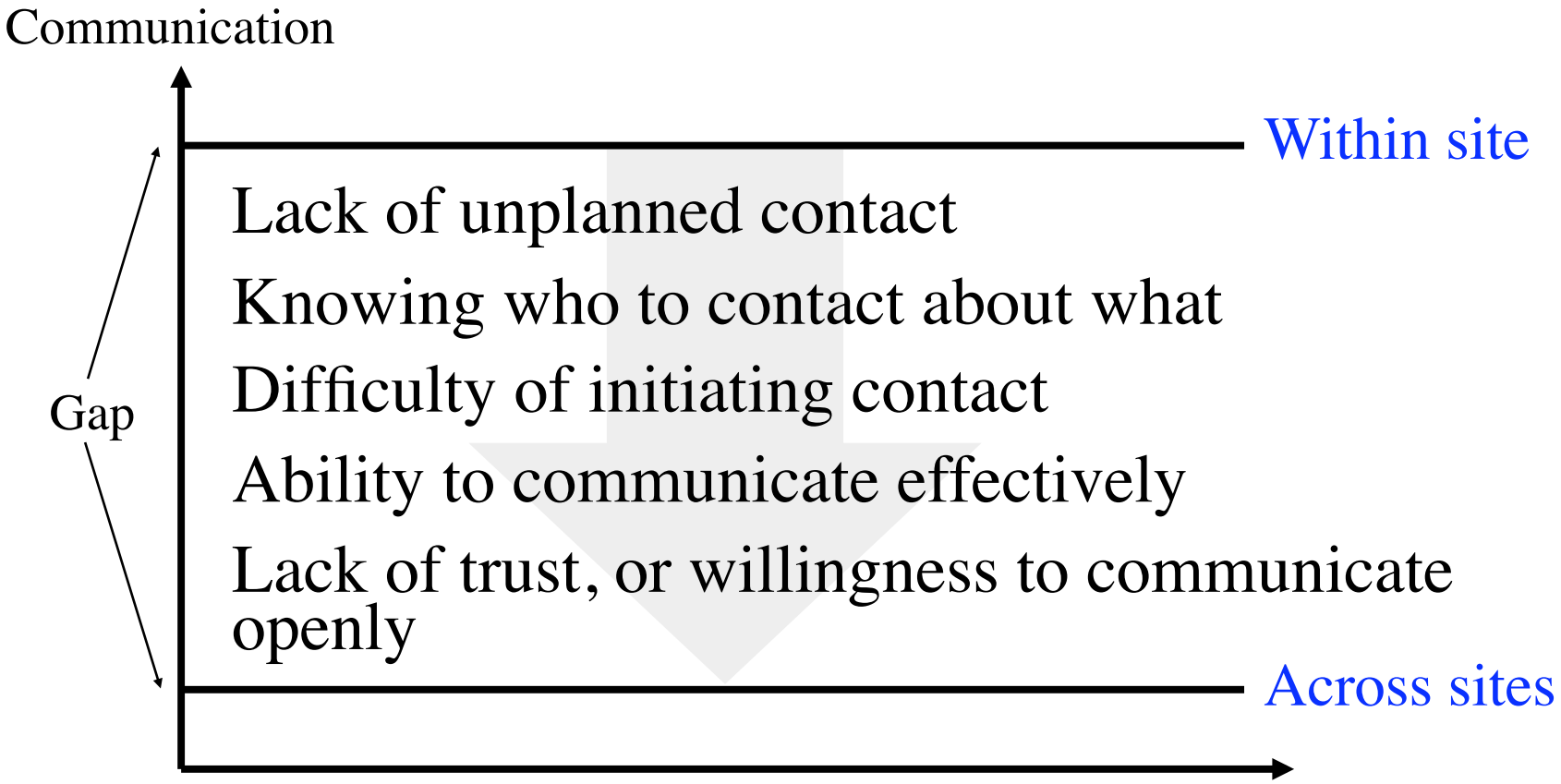
Many Factors Affect Coordination Capacity

- Organizational factors, e.g.,
  - Geographic distribution
  - Divergent processes
  - Different management practices
  - Communication infrastructure
- People factors, e.g.,
  - Experience working together
  - Domain and technology expertise
  - Language skills

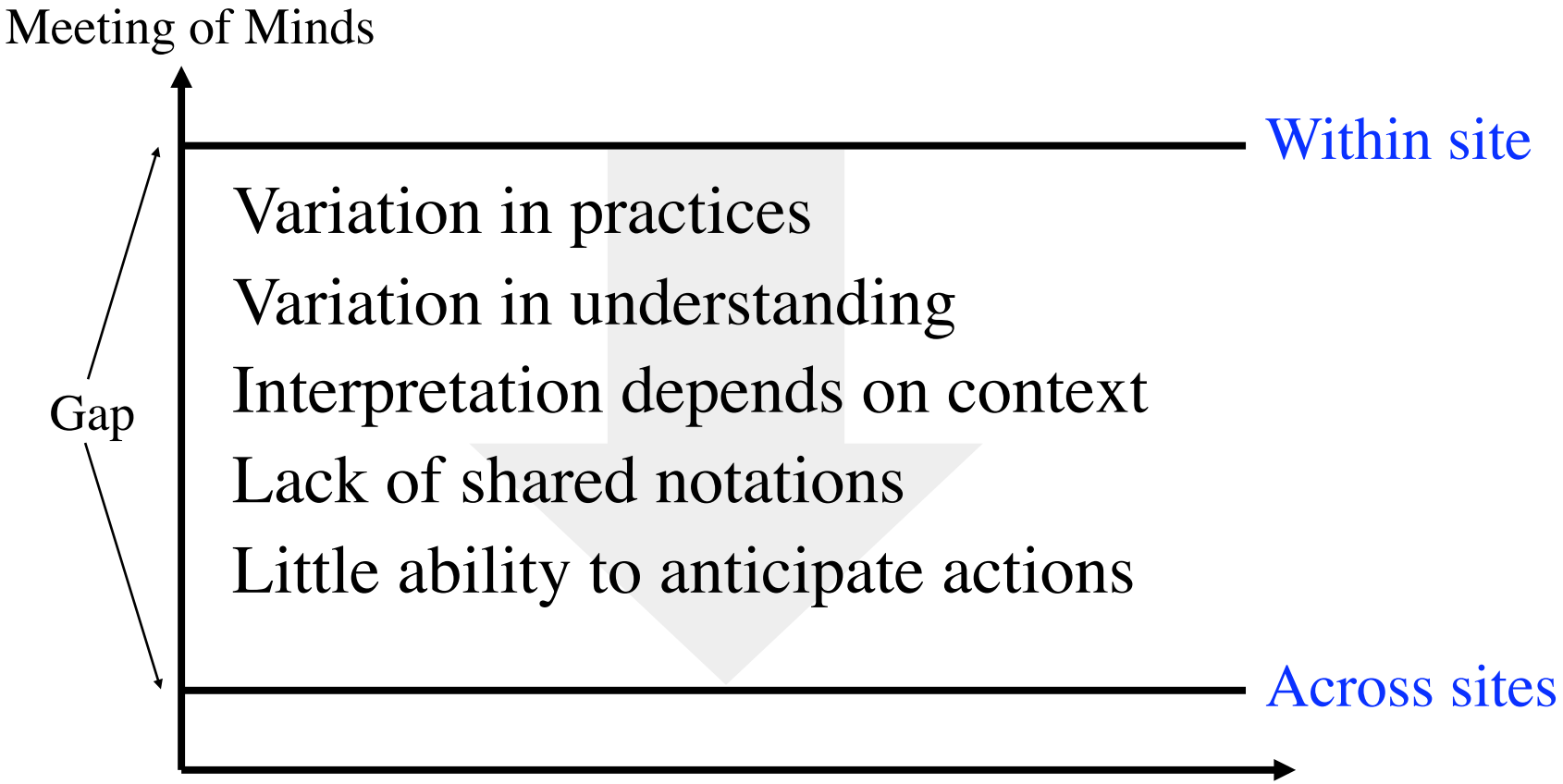
Types of Coordination Actions

- Preparation, e.g.,
  - Plans
  - Specifications
  - Defined processes
- Shared representation, e.g.,
  - Metrics dashboard
  - Posting test results
  - “Living” documents
- Communication, e.g.,
  - Meetings
  - “Informal” communication

Distance Breaks Down Communication



Distance Breaks Down
Preparation and Shared Representations



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Measuring Coordination Requirements

- Dependencies among tasks:

  matrix D where $d_{ij} \neq 0$ means that task i and task j are dependent **Files changed together**

- Assignments of workers to tasks:

  matrix A where $a_{kl} \neq 0$ indicates that worker k is assigned to task l **Developer modified file**

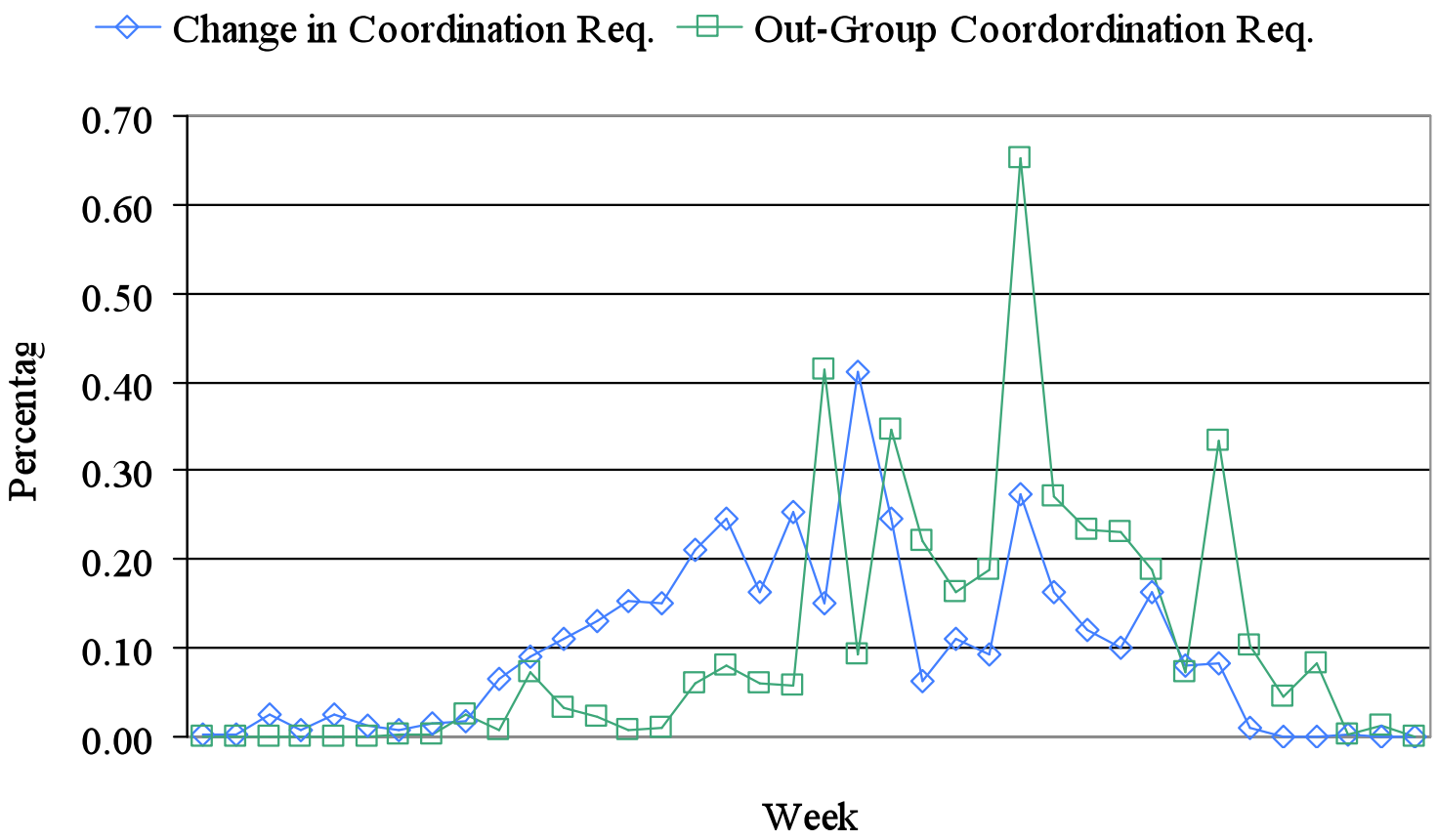
- Coordination requirements:

  $ADA^T = R$, where $r_{mn} \neq 0$ indicates that worker m and worker n have dependencies in their tasks

Coordination Requirements for some unit of work or period of time

From Cataldo, et al, 2006

Volatility in Coordination Requirements



From Cataldo, et al, 2006

Measuring Congruence

Coordination Requirements (*R*)

$$\begin{bmatrix} 1 & 0 & 0 & 1 \\ 0 & 1 & 0 & 0 \\ 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Coordination Behavior (*B*)

$$\begin{bmatrix} 1 & 0 & 0 & 1 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

- Team structure
- Geographic location
- Use of chat
- On-line discussion in MR system

From Cataldo, et al, 2006

Summary of Findings

- Each type of congruence is associated with shorter development times
- We can measure coordination requirements and congruence
- Coordination requirements are volatile and extend beyond the team

- Tesseract

From Cataldo, et al, 2006

Some Research Questions

- Make use of congruence computations
- Expand beyond code changes
- Other (better) ways of computing congruence

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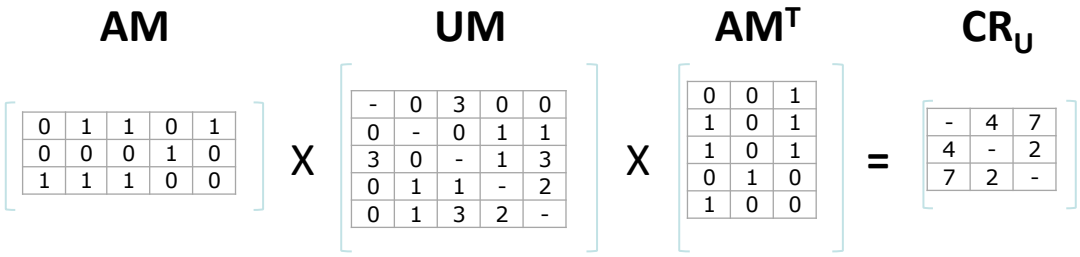

- How to measure uncertainty and complexity early?
- How to predict coordination capacity?
- Tool support for predictive modeling

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Pattern Template*

- Example
- Context
- Problem
  - Description
  - Forces influencing the solution
- Solution
  - Description
  - Diagram
- Pattern understood in terms of tactics
- Variants
- Known uses
- Consequences
- Related patterns
- Credits

*Buschmann, F.; Meunier, R.; Rohnert, H.; Sommerlad, P.; & Stal, M. *Pattern-Oriented Software Architecture: A System of Patterns*. Chichester, NY: Wiley, 1996

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Organizational Models

- Separate by product structure
  - different parts of product potentially developed at different sites
- Separate by process steps
  - execute different process steps at different sites
- Separate by release
  - new development separated from maintenance of previous releases
- Separate into core and custom parts
  - develop a core product at a single site, and customize for different markets and customers at satellite sites
- Co-locate functional experts
  - experts in, e.g., call processing, user interfaces, etc., located together

Adapted from Grinter, R.E., Herbsleb, J.D., & Perry, D.E. (1999). The geography of coordination: Dealing with distance in R&D work. In Proceedings, ACM Conference on Supporting Group Work (GROUP 99), Phoenix, AZ, November 14-17, pp. 306-315.

For Each Model . . .

- Indications
- Risks that must be managed
- Coordination mechanisms, e.g.,
  - interface specifications
  - process descriptions (handoff points)
  - project management tools
- Communication practices and technologies

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Q&A