



Center for  
***LifeLong  
Learning  
& Design***

University of Colorado at Boulder

**Wisdom is not the product of schooling  
but the lifelong attempt to acquire it.**  
- Albert Einstein

## Distributed Intelligence: From Reflective Practitioners to Reflective Communities

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# Overview

- Basic Message
- Design and Collaborative Design
- Individual and Social Creativity
- Distributed Intelligence
- Four Dimensions of Distributed Intelligence based on Distances and Diversity: **spatial**, **temporal**, **conceptual**, and **technological**
- Examples
  - **EDC: Envisionment and Discovery Collaboratory**
  - **CLever: Cognitive Levers – Helping People Help Themselves**
- The Future
- Conclusions

# The Basic Message

- complex (design) problems transcend the unaided, individual human mind is a ubiquitous activity → distributed intelligence
- distributed intelligence creates **distances** → these distances are not only **spatial**, but also **temporal**, **conceptual**, and **technological**
- **research agenda**: explore these distances as **opportunities** to bring humans and media together to achieve new levels of social creativity

# Design and Collaborative Design

- **design versus natural science**
  - **natural science**: how things are
  - **design**: how things ought to be(Herbert Simon “Sciences of the Artificial”)
- the need for **collaborative design** because design problems are
  - **complex** → requiring **social creativity** in which stakeholders from different disciplines have to **collaborate**
  - **ill-defined** → requiring the **integration of problem framing and problem solving**
  - **have no (single) answer** → **argumentation support**
  - **unique (“a universe of one”)** → requiring **learning when the answer is not known**

# Social Creativity

- **the Renaissance scholar does not exist anymore** — the unaided, individual human mind is limited
  - the great individual → the great group
  - “how the mind works is dependent on the tools at its disposal” (Bruner)
- **distinct domain of human knowledge exist** → of critical importance: mutual appreciation, efforts to understand each other, increase in socially shared cognition and practice (source: Snow, C. P. (1993) “The Two Cultures”, Cambridge University Press, Cambridge, UK)
- exploit the “**symmetry of ignorance**” as an opportunity

# Individual versus / and Social Creativity

*"The strength of the wolf is in the pack,  
and the strength of the pack is in the wolf."*  
— Rudyard Kipling

## ▪ individual:

- practitioners participating in collaborative inquiry and creation need individual reflective time
- without such reflection it is difficult to think about contributions to social creativity

## ▪ social

- the Western belief in individualism romanticizes the solitary process → the reality is that scientific and artistic forms emerge from joint thinking, passionate conversations, and shared struggles
- the mind — rather than driving on solitude — is dependent upon the reflection, renewal, and trust inherent in sustained human relationships and empowerment and augmentation with media

# Distributed Intelligence (or Distributed Cognition)

- **claim:** distributed intelligence provides an effective theoretical framework for understanding what humans can achieve and how artifacts, tools, and socio-technical environments can be designed and evaluated to empower humans beings and changing tasks
- claim: working with people with **cognitive disabilities**
  - creates new unique challenges for theories about distributed intelligence
  - provides a deeper understanding of distributed intelligence

# Distributed Intelligence

- **traditional view:**
  - human cognition exists solely ‘inside’ a person’s head
  - studies on cognition have disregarded the social, physical, and artifactual surroundings in which cognition takes place
- **new view: cognition is distributed among**
  - individuals
  - collaborative efforts to achieve shared objective in cultural surroundings
  - individuals and the tools and artifacts provided by culture
  - claim: in real life (in contrast to the classroom and the psychological laboratory) mental work is rarely done **without the assistance of tools**
- **challenge: develop, apply, and evolve a distributed intelligence framework**
  - learning, education, and instruction
  - social creativity
  - collaborative human-computer systems
  - cognitive disabilities and assistive technology

## Distance: Spatial Dimension

- bringing spatially distributed people together: supports the shift that ***shared concerns*** rather than shared location becomes the prominent defining feature of a group of people interacting with each other
- allows more people to be included, thus **exploiting local knowledge**
- success model: **open source communities** — see analysis of open source communities as success models
- transcending the barrier of spatial distribution is of particular importance in **locally sparse populations** — see CLever project: “Cognitive Levers: Helping People Help Themselves”

## Distance: Temporal Dimension

- design processes often take place over many years, with initial design followed by extended periods of **evolution and redesign**
- importance of
  - **design rationale**
  - **redesign and reuse** (“*complex systems evolve faster if they can build on stable subsystems*” (Simon) — CodeBroker system by Yunwen Ye
- **reflexive CSCW** = environments supporting the same individual user, who can be considered as two different persona at points of time that are far apart (see: Thimbleby, H., Anderson, S., & Witten, I. H. (1990) "Reflexive CSCW: Supporting Long-Term Personal Work," *Interacting with Computers*, 2(3), pp. 330-336)

# Meta-Design

- **meta-design** = how to create new media that allow users to act as designers and be creative
- **why meta-design?**
  - design as a process is tightly coupled to use and continues during use
  - support emerging, unintended, and subversive uses, not just anticipated ones
  - do not only build new technologies but seed new practices, new genres, new communities
  - avoid that most of the design intelligence is forced to the earliest part of the design process, when everyone knows the least about what is really needed
- **further information:** Fischer, G., Giaccardi, E., Ye, Y., Sutcliffe, A. G., & Mehandjiev, N. (2004) "Meta-Design: A Manifesto for End-User Development," *Communications of the ACM*, 47(9), pp. 33-37.

# Distance: Conceptual Dimension— Exploiting Diversity

- **diversity**
  - not only a constraint to deal with — but an **opportunity** to generate new ideas, new insights, and new environments
  - **challenge:** not to reduce heterogeneity and specialization, but to support it, manage it, and integrate it by finding ways to build bridges between local knowledge sources and by exploiting *breakdowns, conceptual collisions, and epistemological pluralism* as sources for innovation
- **Communities of Practice (CoPs)**, defined as groups of people who share a professional practice and a professional interest
- **Communities of Interest (Cols)**, defined as groups of people (typically coming from different disciplines) who share a common interest, such as framing and solving problems and designs artifacts

## Communities of Practice (CoPs): Homogenous Design Communities

- **characterization:** practitioners who work as a community in a certain domain
- **examples:** architects, urban planners, research groups, software developers, software users, .....
- **learning:**
  - masters and apprentices
  - **legitimate peripheral participation (LPP)** → one accepted, well-established center and a clear path of learning towards this center
  - develop a notion of belonging
- **problems:** avoid **group-think**
- **systems:** **domain-oriented design environments** (e.g.: kitchen design, computer network design, voice dialogue design, .....)

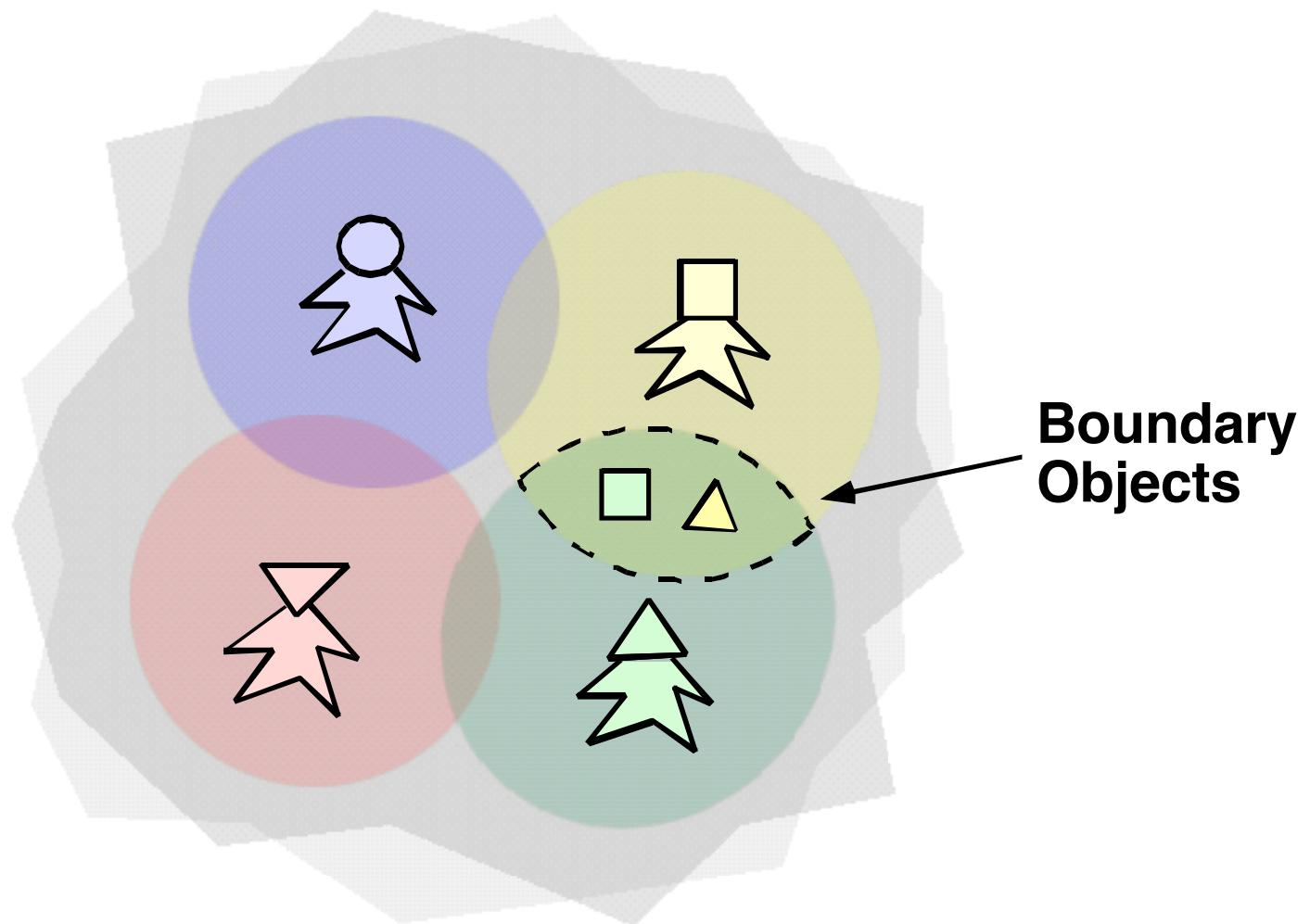
## **Communities of Interest (Cols): Heterogeneous Design Communities**

- **characterization** = bring different CoPs together based on a shared interest in the framing and resolution of a major design problem
- **examples**: large scale software developments projects, transportation planning, digital fluency, reinventing universities as learning organizations
- **learning:**
  - informed participation
  - exploit the symmetry of ignorance
  - learn by crossing boundaries
  - build bridges between diverse cultures (academia and industry, software designers and software users, ....)
- **problems and challenges**: establishing common ground, creating boundary objects, mutual appreciation
- **systems: Envisionment and Discovery Collaboratory**

## Fundamental Challenges Facing Cols

- establish a **common ground**
- building a **shared understanding of the task at hand** (which often does not exist up-front)
- learning to communicate with others who have a **different perspective**
- **multiple centers of expertise** which emerge, change and drift and no single, clear path of learning
- need for **boundary objects** and **boundary crossers**
- Cols support **pluralistic societies** which can cope with complexity, contradictions, and a willingness to allow for differences in opinions

## Cols and Boundary Objects



# Distance “Technological Dimension”

*“You cannot use smoke signals to do philosophy.  
Its form excludes the content”. (Postman, 1985)*

- **claim: there is no media-independent communication and interaction**
  - tools, materials, and social arrangements always mediate activity
  - the possibilities and the practice of design are functions of the media with which we design
- **some global objectives:**
  - media as extensions of human (McLuhan)
  - intelligence augmentation (Engelbart, Kay)
  - domain orientation to support human problem-domain interaction (Redmiles)
  - end-user development and meta-design (Nardi)
  - beyond the desktop: pervasive and ubiquitous computing (Dourish)
  - digital fluency — make domain experts independent of high-tech scribes

# The Envisionment and Discovery Collaboratory



## **Research Themes Pursued with the Envisionment and Discovery Collaboratory**

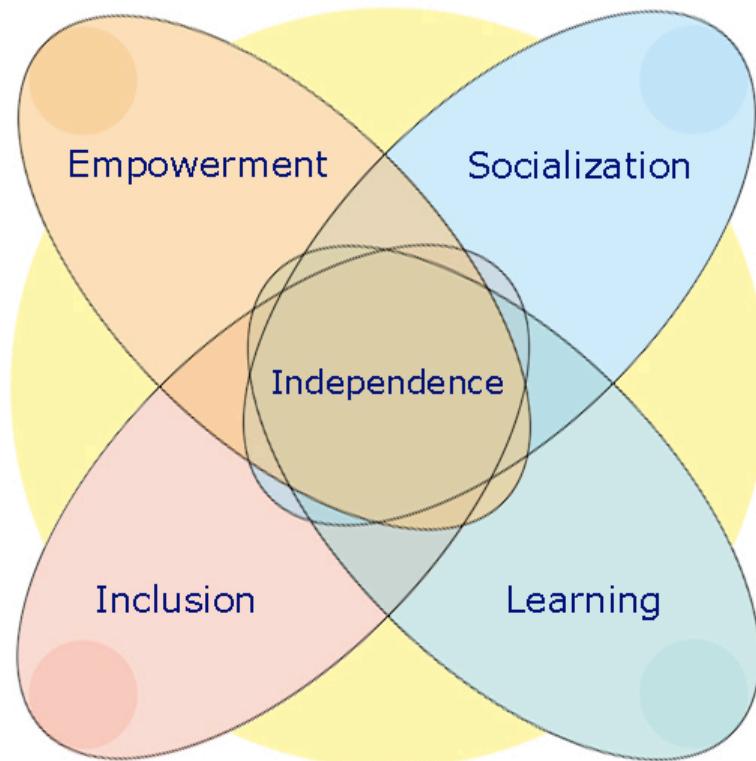
- access → **informed participation** (making all voices heard)
- design → **meta-design** (beyond “closed” worlds such as Simcity)
- individual creativity → **social creativity**
- communities of practice → **communities of interest** (reflective communities, boundary objects, shared understanding)
- **computing beyond the desktop:** embodied interaction (computationally enhanced physical objects), parallel interactions, context awareness, ....

## Cognitive Levers (**CLever**) – Helping People Help Themselves

- supported by the **Coleman Institute** (August 2000 – August 2006)
- The **Coleman Institute at the University of Colorado**
  - funded by a **250 Million \$ Endowment** from **Bill and Claudia Coleman** for research on *Cognitive Disabilities*
  - supports research across many different disciplines
  - objective: “give people a voice that do not have one”
- more information about **CLever**:  
<http://l3d.cs.colorado.edu/clever/>

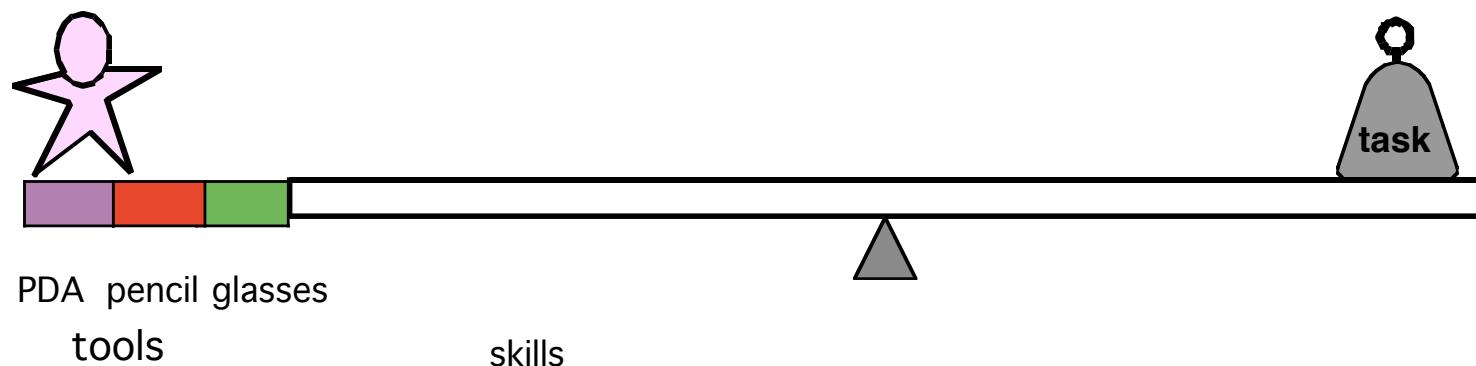


## CLever: The Vision and the Intellectual Coherence



# Distributed Intelligence and Cognitive Disabilities

- “**anatomy is not destiny**” (Neil Postman)
  - “*The invention of eyeglasses in the twelfth century not only made it possible to improve defective vision but suggested the idea that human beings need not accept as final either the endowments of nature nor the ravages of time. Eyeglasses refuted the belief that anatomy is destiny by putting forward the idea that our minds as well as our bodies are improvable!*”
- “***give me a lever long enough and I can move the world***”



## Selected CLever Projects

- **Web2gether: Online Community Environment** — supporting the members of a community (*Rogerio dePaula*)
- **TEA: The Evaluation Assistant** — matching the needs of individuals to specific technologies (*Anja Kintsch*)
- **MAPS: Memory Aiding Prompting Systems** — creating new “knowledge” (scripts) by end-users who have no interest or technical knowledge (*Stefan Carmien*)
- **Mobility-for-All: Human Centered Public Transportation Systems** — exploiting the power of ubiquitous, wireless technologies (*Jim Sullivan*)
- **Lifeline: Remote Monitoring** — integrate the human and the technical system (*Andrew Gorman*)

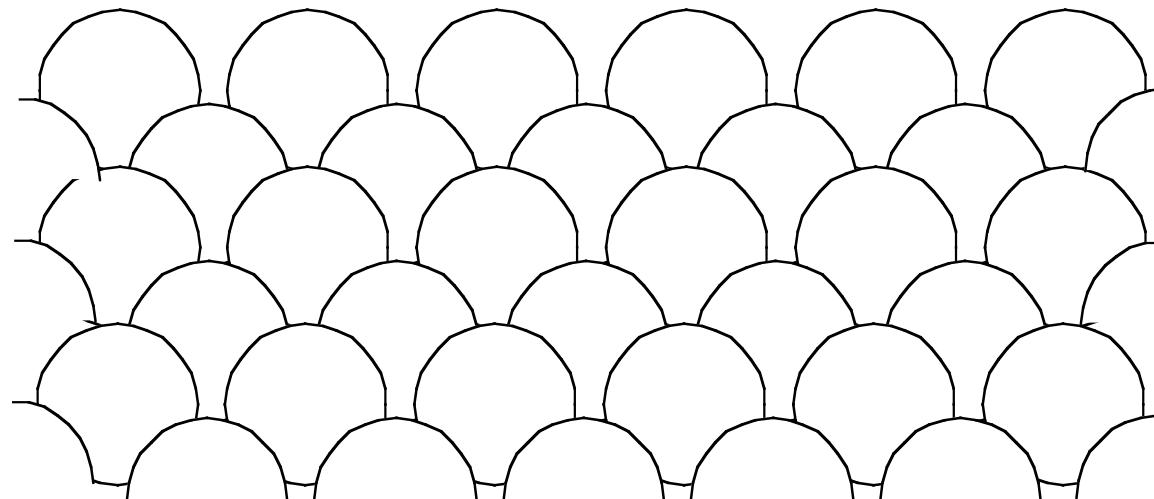
## The Story Shown in the Multi-Media Presentation

- **specific:** a woman with cognitive disabilities (memory problems, no capacity for planning and remembering) and her mother
- **general:** the scenario shows *socio-technical environments* to help people with
  - cognitive disabilities
  - elderly people (e.g., with Alzheimer)
  - out-of-town visitors
  - foreigners
  - everyone
- innovative technologies to “simplify” the use of public transportation systems
  - personal device such as personal digital assistants (PDAs) and mobile phones
  - global positioning systems (GPS)
  - web-based collaboration tools

# Beyond the Individual Human Mind: Fish-Scale Model

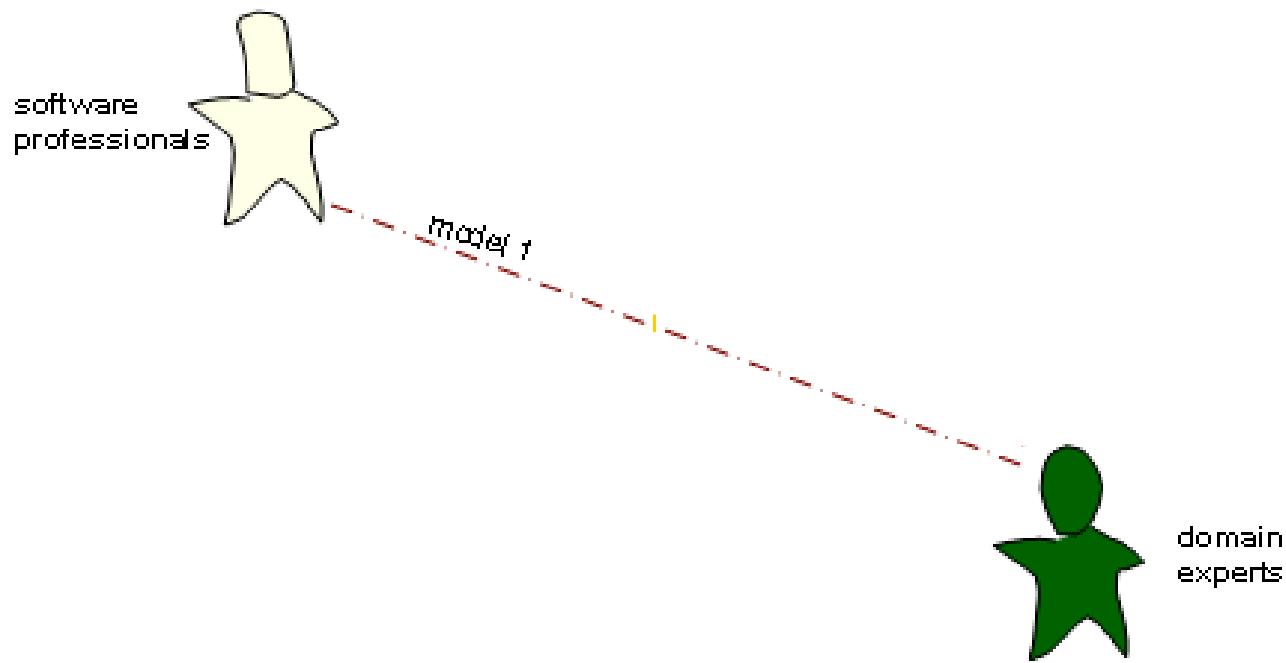
**source:** Campbell, D. T. (1969) "Ethnocentrism of Disciplines and the Fish-Scale Model of Omniscience." In M. Sherif, & C. W. Sherif (Eds.), Interdisciplinary Relationships in the Social Sciences, pp. 328-348.

- the key to address complex problems is
  - **not** in "*Leonardos who are competent in all sciences*" or in "*educating the intellectual superhuman*" who knows everything
  - but to achieve "***collective comprehensiveness through overlapping patterns of unique narrowness***"

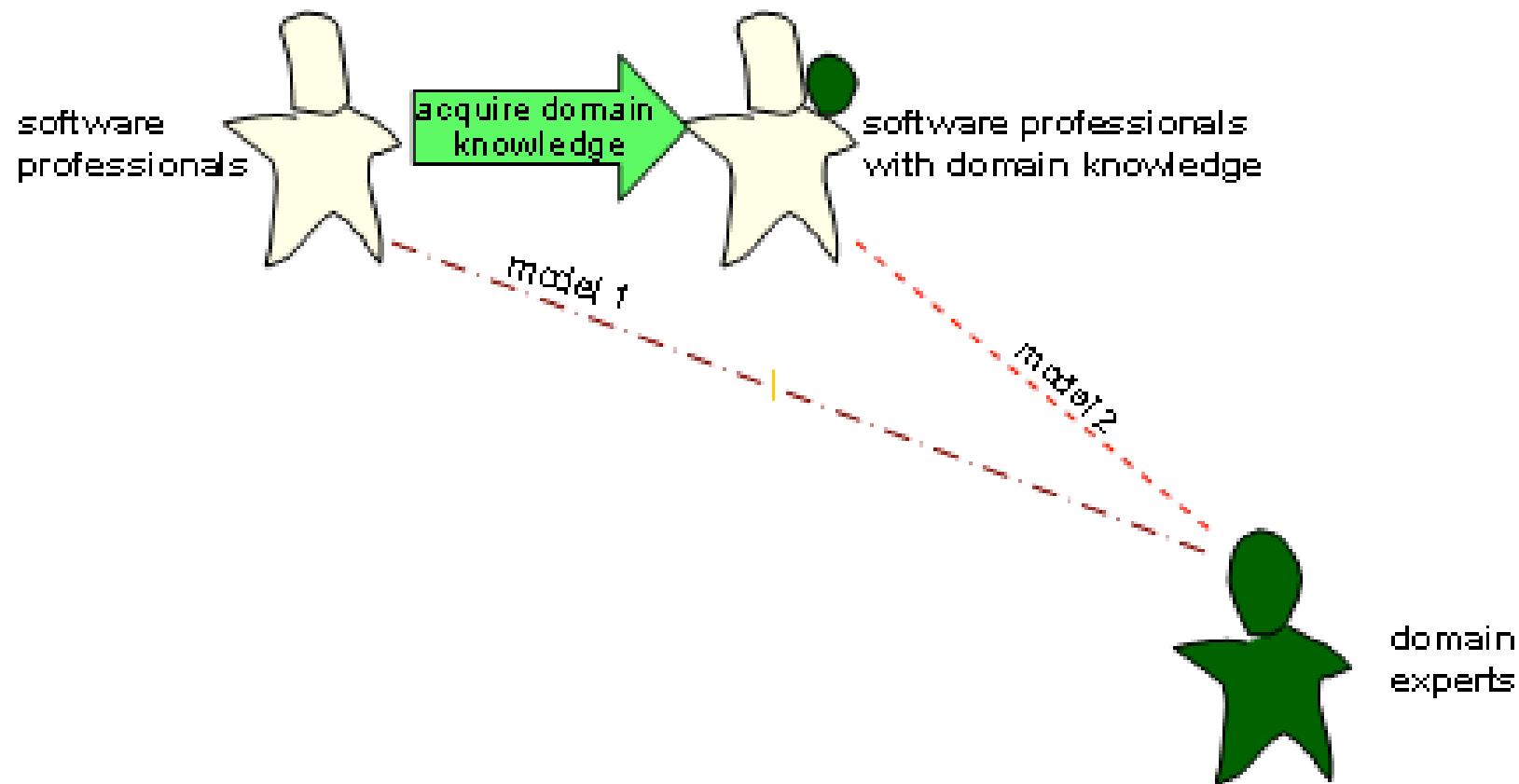


# Reflective Practitioners → Reflective Communities

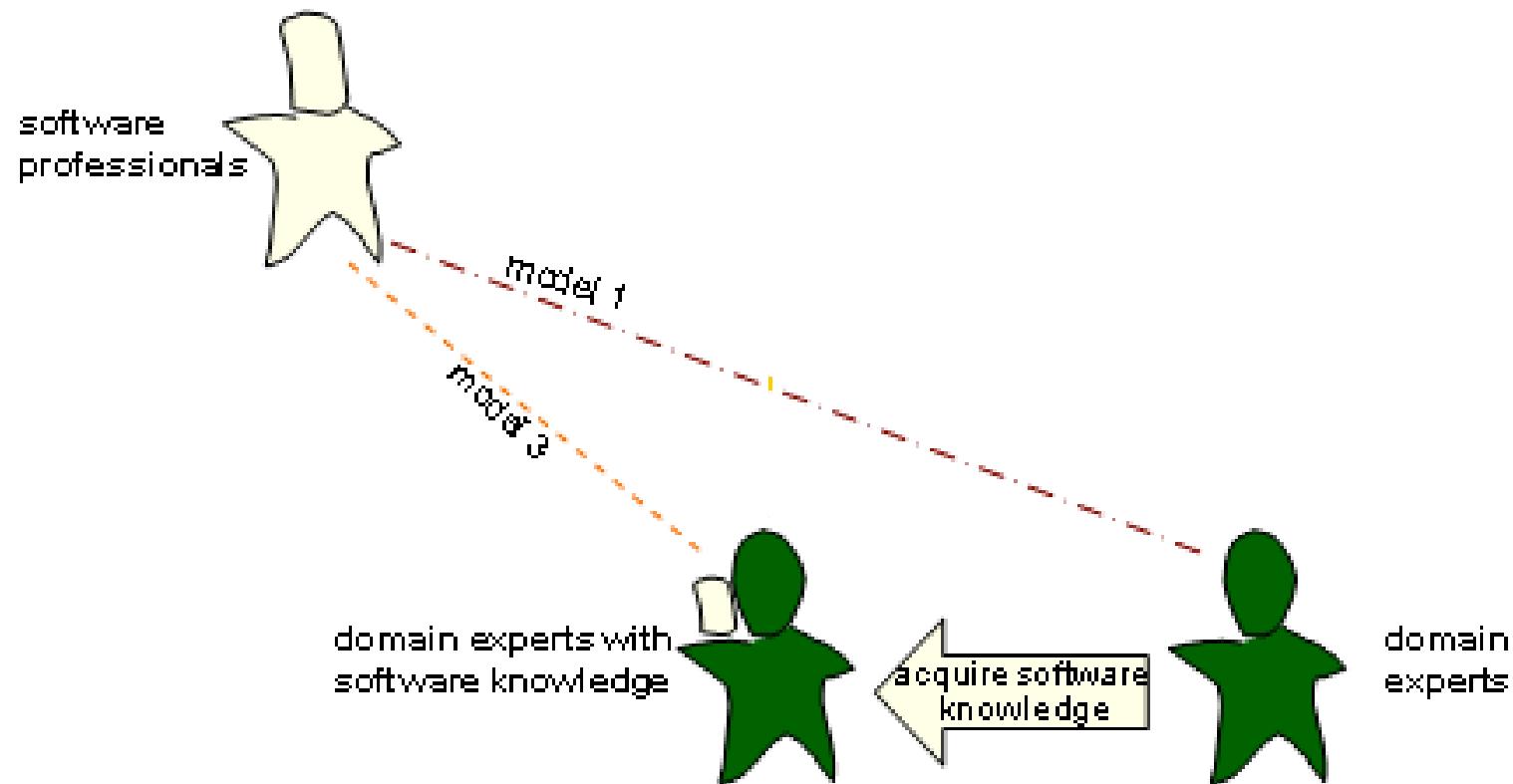
**Large Conceptual Distance – Limited Common Ground**



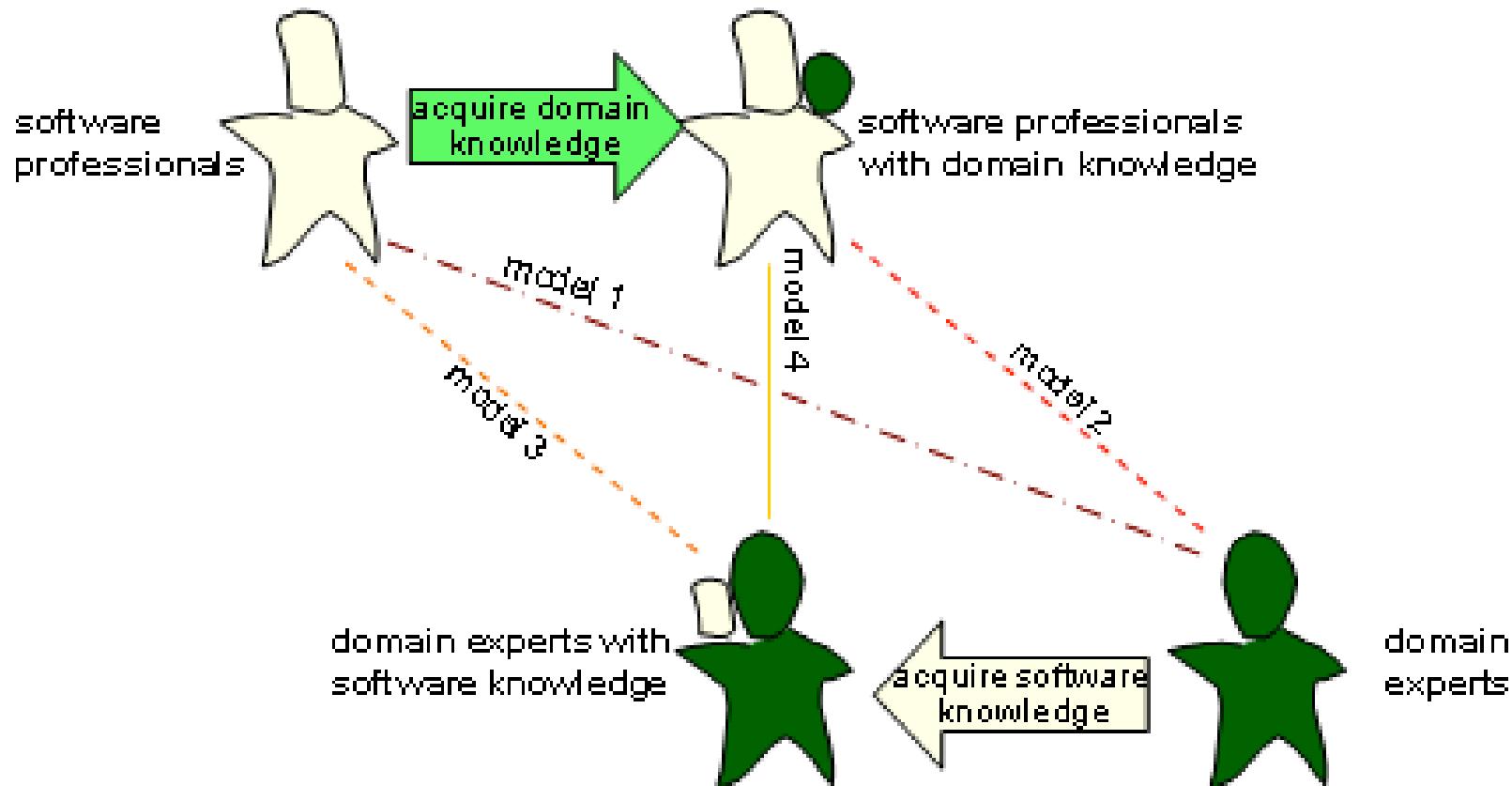
# Software Professionals Acquiring Domain Knowledge



# Domain Experts Acquiring Media Knowledge



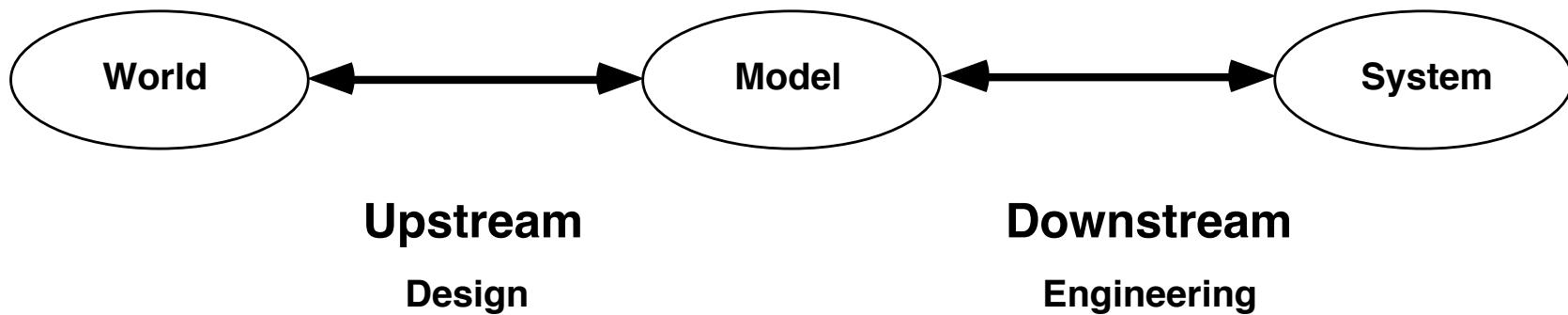
# From Reflective Practitioners to **Reflective Communities**



# The Future

- doing **basic research** on **real problems**
- **mega**-problems:
  - transcending the unaided, individual human mind
  - aging populations
  - new divisions of labor
  - outsourcing

# Outsourcing and Education in Computer Science



- **upstream: world → model / specification**
  - ill-defined problems → integration of problem framing and problem solving
  - collaboration and communication between different stakeholders
  - failure leads to ***design disasters*** (wrong problem is solved)
  
- **downstream: model / specification → implementation / system**
  - well-defined problems → dealing with difficult technical problems (e.g.: creating reliable code)
  - failure leads to ***implementation disasters*** (wrong solution to the right problem)

# Computer Science Education and Outsourcing

	<b>upstream activities</b>	<b>downstream activities</b>
themes	creative work, communication, collaboration, context, integration of problem framing and problem solving, fuzzy requirements, customer satisfaction	programming, programming languages, compilers, rule-based behavior (tax returns, call centers)
emphasis in current CS programs	X	XXXXX
future jobs (not being outsourced)	XXXXX	X

# Self-Application

- **tools for living** (“distributed intelligence”)  $\leftrightarrow$  **tools for learning** (“scaffolding with fading”)
- **transdisciplinary** education and collaboration
  - universities without walls
  - courses-as-seeds
- **undergraduate** research apprenticeship program (URAP)
  - <http://l3d.cs.colorado.edu/urap/>
- formal education in universities as the seeding of a “**lifelong bonding**” relationship (collaboration with Hal Abelson, MIT)

# Conclusions

- **claims:**

- the complexity of (design) problems transcends the unaided, individual human  
→ **distributed intelligence**
- these distances are not only **spatial**, but also **temporal**, **conceptual**, and  
**technological**

- **contributions:**

- unaided, individual human mind → **socio-technical environments**
- design → **meta-design**
- communities of practice → **communities of interest**
- reflective practitioners → **reflective communities**