DELTALAB

Computational Ecosystems

Tech-enabled communities to advance human values

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Delta Lab | Design, Technology, and Research (DTR) | Northwestern University

How can we create scalable solutions to human problems and advance desired human values in the absence of a technology that can overcome real-world constraints?

Design, Technology, and Research (DTR)

Spring 2014

Design, Technology, and Research (DTR)

Winter 2016

How can
a single faculty mentor
train 20+ students

scale solutions

How can
a single faculty mentor
train 20+ students
to cultivate self-directed learners
and build new knowledge

scale solutions

advance desired human values

How can
a single faculty mentor
train 20+ students
to cultivate self-directed learners
and build new knowledge
in the absence of a technology
that scales mentor time?

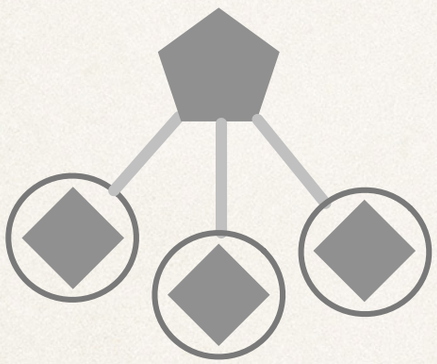
scale solutions

advance desired human values

address real-world constraints

Best human solution

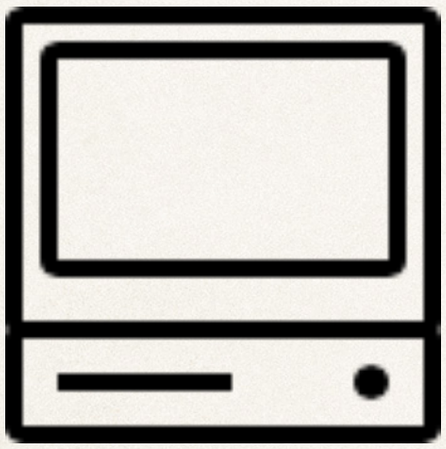
Apprenticeship



"apprenticeship requires a very small teacher-to-learner ratio that is not realistic in the large educational systems of modern economies."

[Collins & Kapur, 2005]

Best machine solution



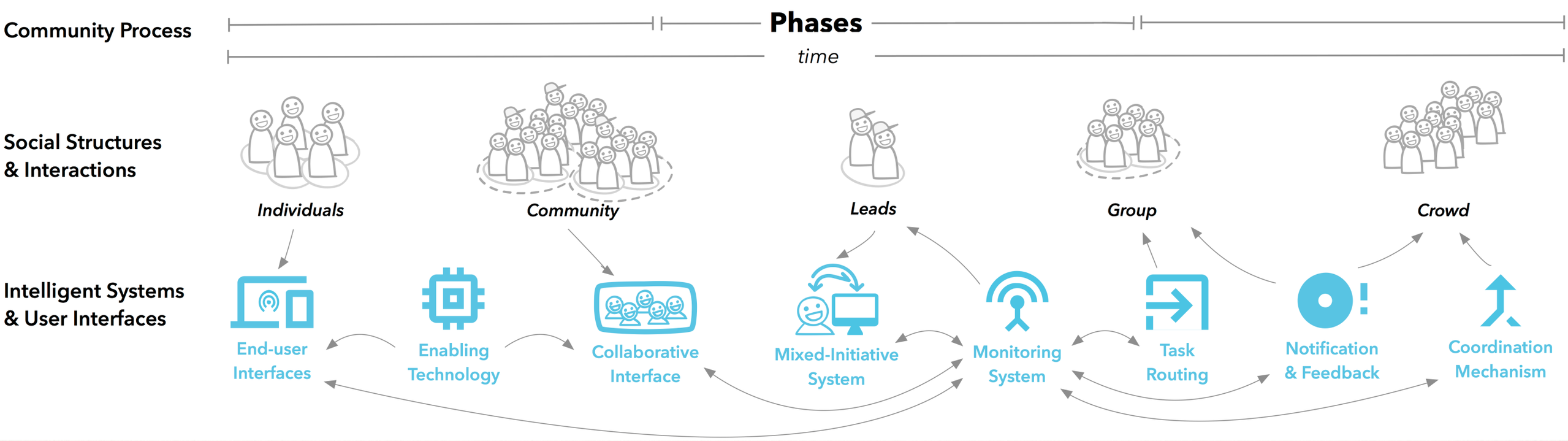
No AI technology can replace the mentor in the foreseeable future.

[Jarvela & Hadwin, 2013]

Options

- Wait for a technological silver bullet
- Compromise
- Or…?

Computational Ecosystems



A call for systems: having great components is not enough.

Atul Gawande

"...We've been obsessed in medicine with components. We want the best drugs, the best technologies, the best specialists, but we don't think too much about how it all comes together. It's a terrible design strategy actually."

TED 2012

A call for systems: having great components is not enough.

Atul Gawande

"Making systems work is the great task of our generation of physicians and scientists. I would go further to say that making systems work - whether in health care, education, climate change, and making a pathway out of poverty - is the great task of our generation as a whole."

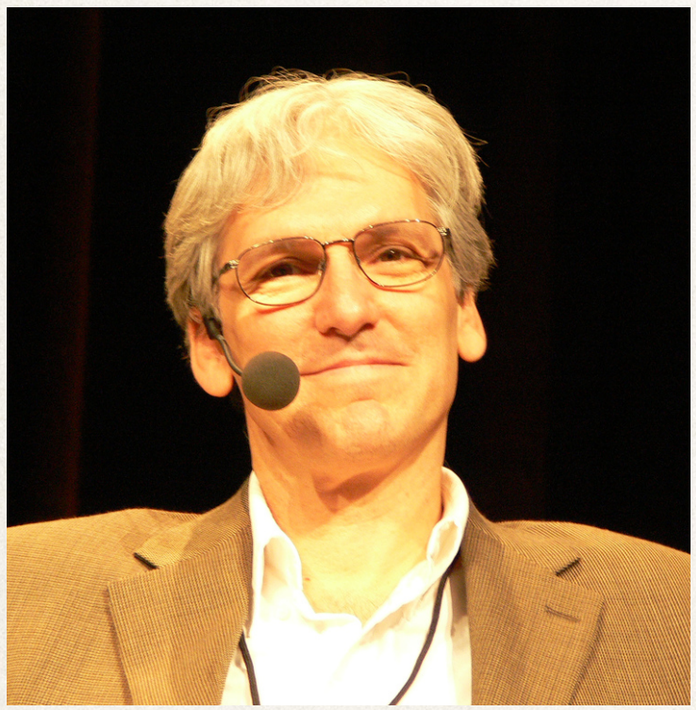
A call for systems thinking in AI

Eric Horvitz

"I'm pretty sure that the next leaps in AI will come from integrative systems, rather than wedges. [We need to] focus on building a system where the whole is greater than the parts."

TechRepublic, 2015

A call for systems thinking in HCI

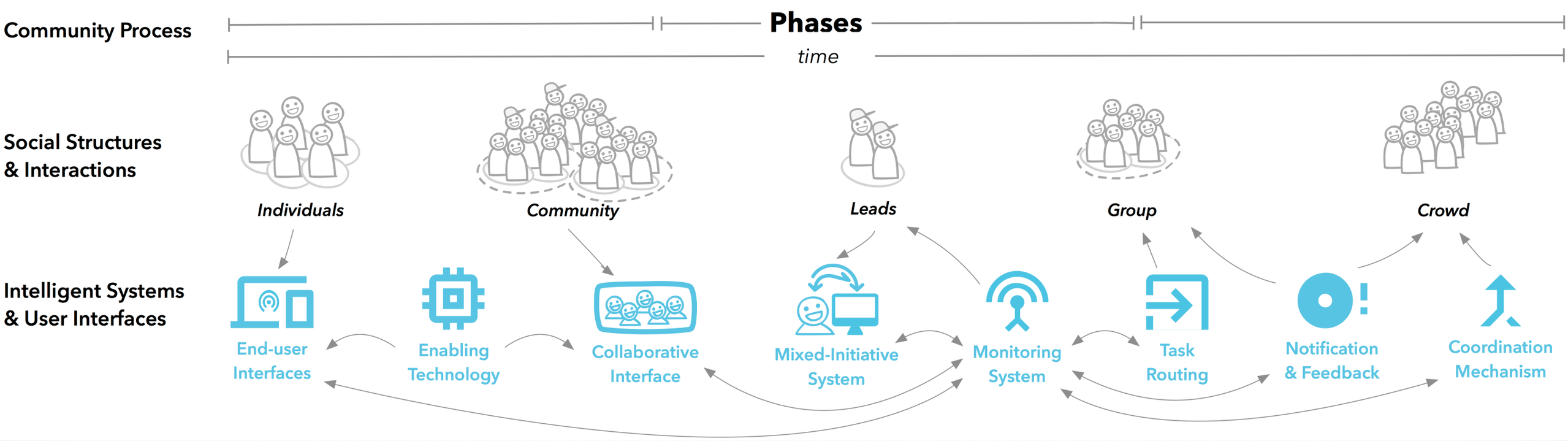


George Furnas

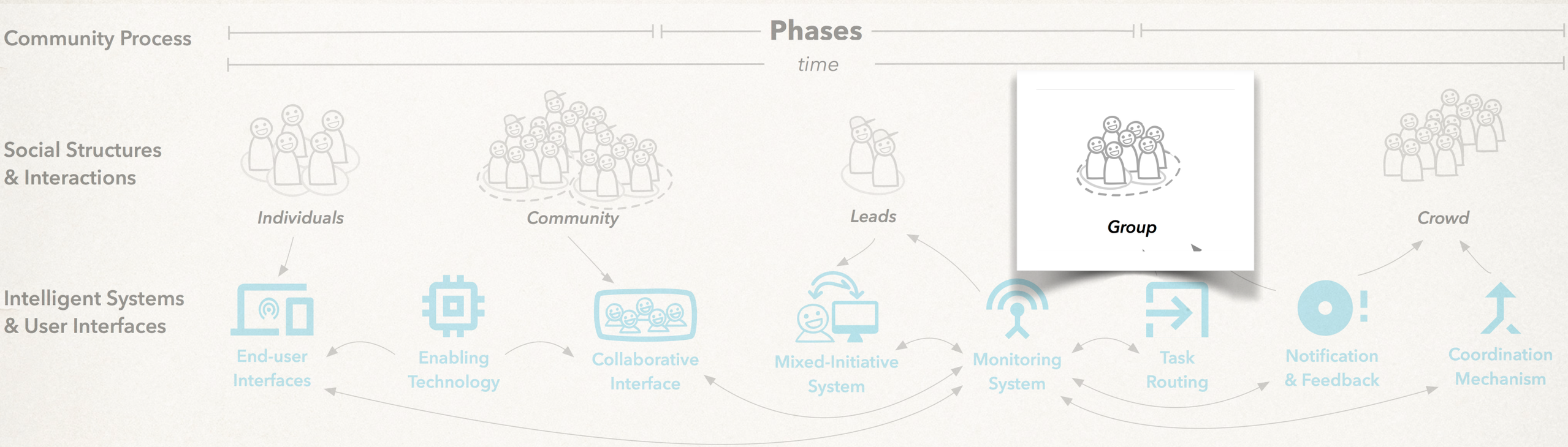
"It is likely that our designs will be more successful if we become more mindful of this bigger picture, [the mosaic of responsive, adaptive systems]."

Future Design Mindful of the MoRAS, 2000

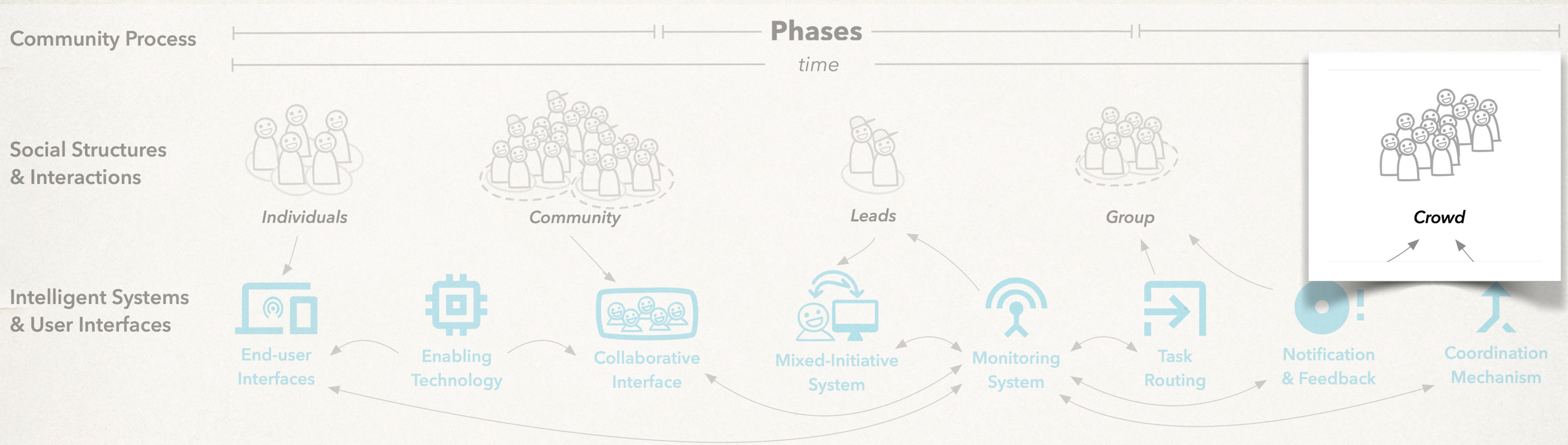
Advancing the approach…



Typically…


Community Process
Phases
time
Social Structures & Interactions
Individuals
Community
Leads
Group
Crowd
Intelligent Systems & User Interfaces
End-user Interfaces
Enabling Technology
Collaborative Interface
Mixed-Initiative System
Monitoring System
Task Routing
Notification & Feedback
Coordination Mechanism

Typically…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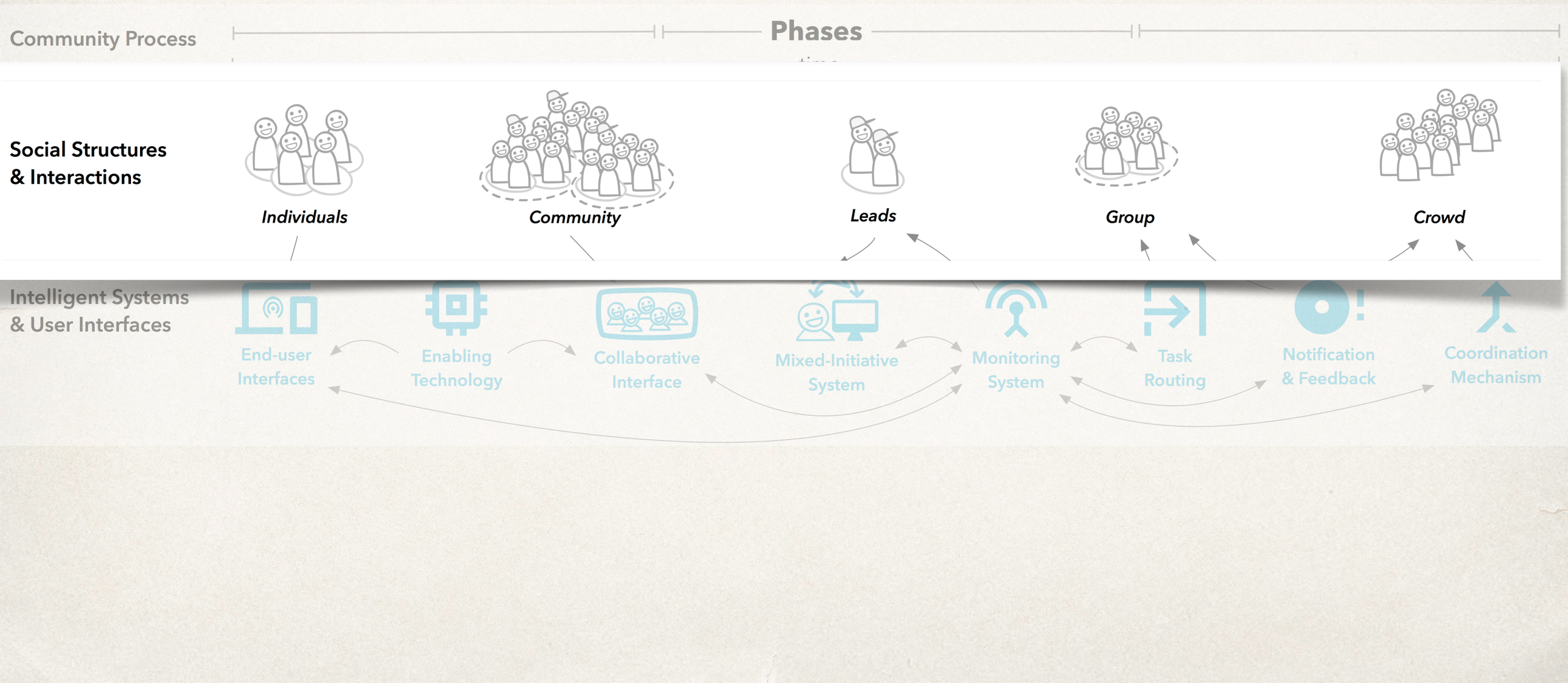
Advancing the approach…



Typically…

Community Process — **Phases** — *time*

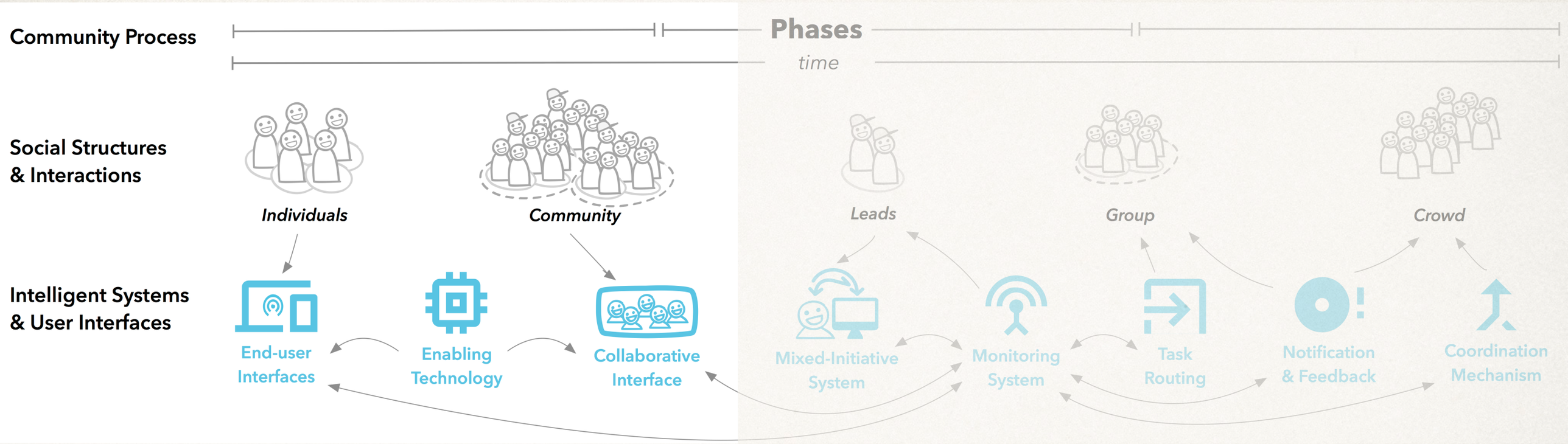
Social Structures & Interactions

Individuals · *Community* · *Leads* · *Group* · *Crowd*

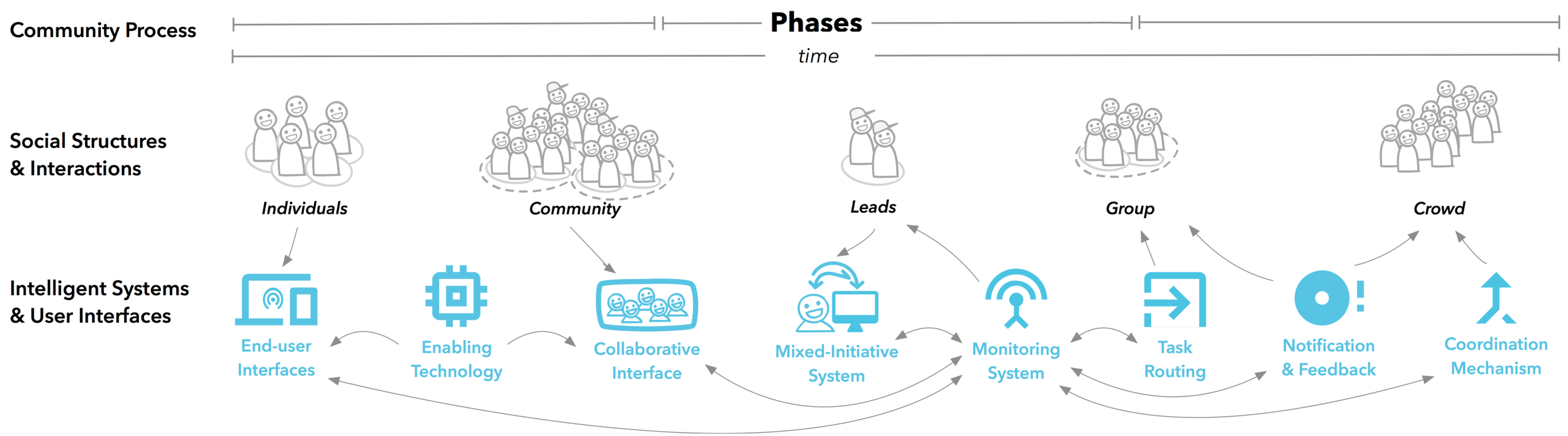
Intelligent Systems & User Interfaces

End-user Interfaces · Enabling Technology · Collaborative Interface · Mixed-Initiative System · Monitoring System · Task Routing · Notification & Feedback · Coordination Mechanism

Advancing the approach…



Computational ecosystems are systems, designed as integrative solutions.



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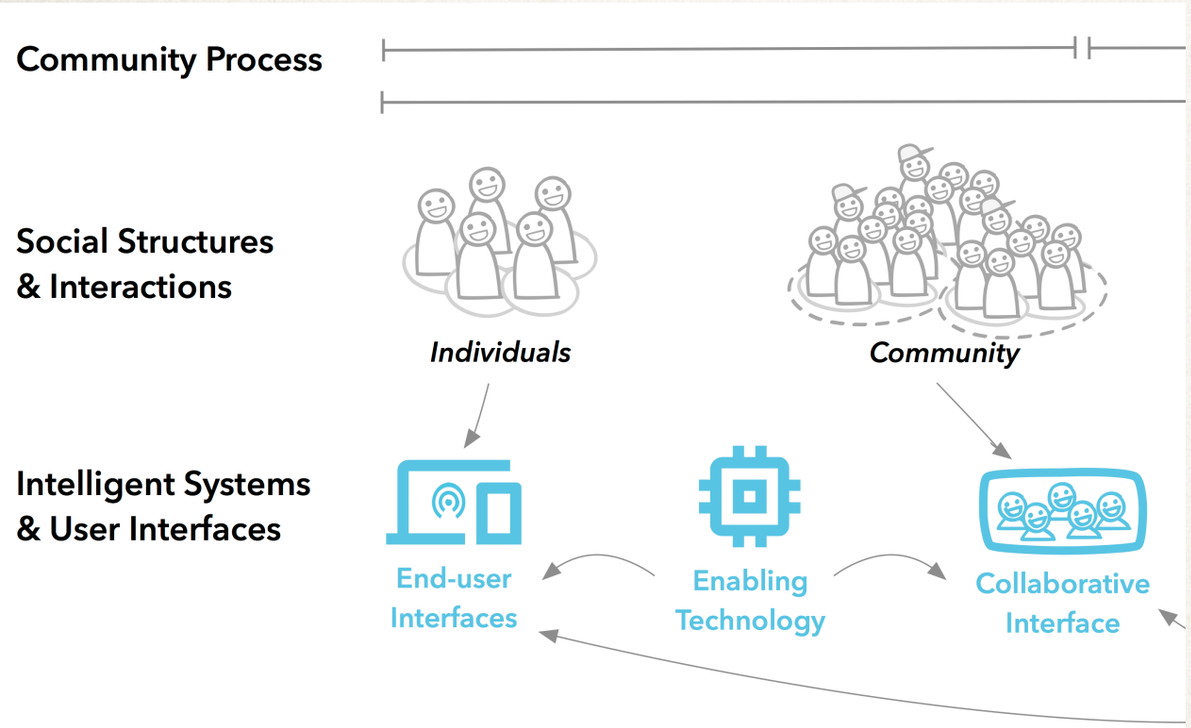


- **Computational thinking**: decompose and distribute problem solving to diverse people or machines across the ecosystem.

- **Ecological thinking**: create sustainable processes and interactions that support ecosystem members and proper ecosystem function.

Rest of the talk

- Two examples:
  - Community-based planning
  - Research training
- Our latest work in computational ecosystems
  - Supporting human practices
  - Supporting human experiences
- Role of computational ecosystems in advancing human values

Community-informed planning

an inclusive process that scales and advances the goals of its members

	X01 D	X02 E	X03 F	X04 G	X05 A	X06 B	X07 C	X08 Q	X09 H	I	X10 J	X11 K	X12 L	X13 M	X14 N	X15 O	P X16 S16
Thursday	Award talks 2400	471 Int. Tech. + Dev.	Panels 481	452	424	Larger courses 207	Larger courses 207	424	257	219	400	400	393	Smaller courses 42	Smaller courses 40	Smaller courses 70	S16 S165
9:30-10:50	Award lecture 1201	TOUCH TEXT ENTRY 1202	Panel-110 "Material Interactions" - From Atoms & Bits to Entangled Practices 1203 Mikael Wiberg (M), Hiroshi Ishi, Daniela Rosner, Anna Vallgarda, Paul Dourish, Petra Sundström, Tobie Kerridge Mark Rolston	DO YOU SEE WHAT I SEE? 1204	ORGANIZING THE RECOVERY 1205	cr124 From Discourse-based Models to UIs Automatically Optimized for Your Smartphone 1206 Hermann Kaindl	cr102 Agile User Experience and UCD William Hudson 1207	TEACHING W/ NEW INTERFACES 1208	INTERACTIONS BEYOND THE DESKTOP 1209		RIGHT WHERE I AM: UX IN COMPLEX ENVIRONMENTS 1216	HEALTH + CHILDREN 1211	alt.chi 1212	cr125 Cognitive Crash Dummies: Predicting Performance from Early Prototypes Bonnie E. John 1213	cr147 Designing for Persuasion Aaron Marcus 1214	S16 1215	S16 1216
11:30-12:50	Video 1301	BIGGER IS BETTER: LARGE + MULTIPLE DISPLAY ENVIRONMENTS 1302	Panel-116 Politics, Power, and Passion: Engaging U.S. Policymakers 1303 Janet Davis, Harry Hochheiser, Juan Pablo Hourcade, Jeff Johnson, Lisa P. Nathan, Janice Tsai	"WHAT A LOVELY GESTURE" 1304	HARNESSING CROWDS: CROWDSOURCING & PEER PRODUCTION 1305	1306 CR 124 Unit 2 Kaindl	1307 CR 102 Unit 2 Hudson	BETTER TOGETHER 1306	ME & MY MOBILE 1309		UNDERSTANDING GAMERS 1310	TIME + TASK MANAGING WORK LIFE 1311	alt.chi 1312	CR 125 Unit 2 Bonnie John 1313	cr139 Methodology for Evaluating Experience of Mobile Applications Used in Different Contexts of Daily Life 1314 Katarzyna Wac	S16 1315	S16 1316
14:30-15:50	Rehearsal X	"USE BEFORE" 1402	Panel-101 1403 How-to-guide: Collaborating with executives in a pro-design world Jonnie Lai, Chris Maliwat, Iram Mirza, Mark Rolston, Craig Villamor, Larry Tesler	GIVES US FITTS 1404	FROM MY FRIENDS 1405	cr135 1406 Selecting UCD Methods that Maximize Benefits and Minimize Project Risks Nigel Bevan	cr127 1407 Putting Conceptual Models to Work Austin Henderson	CULTURE, [illegible] + CREATIVITY 1408	PROGRAMMING, PERFORMANCE & SENSE MAKING 1409		1410	LEARNING'S COMPLEX NEEDS 1411	USABILITY / USER RESEARCH 1412	1413	1414 CR 139 Unit 2	1415 S16	1416 S16

Challenges for organizers

- Lack information about the diverse preferences, constraints and knowledge held by community members

- Lack tools for managing the complexity of planning.

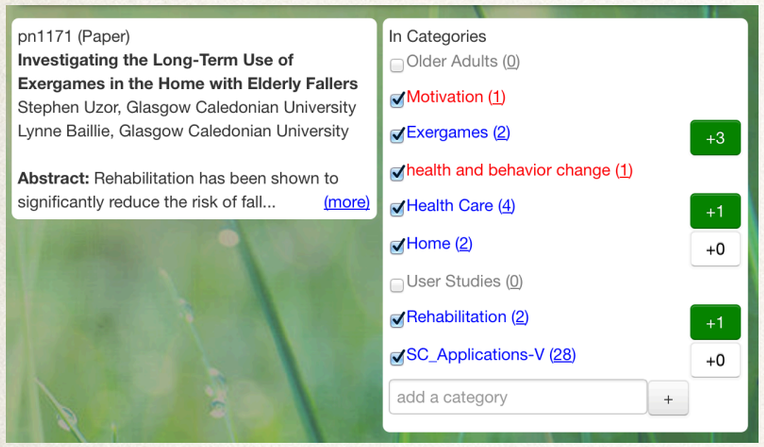
Cobi: Community-informed planning

1. Engage the entire community in the planning process

2. Give organizers tools to manage the complexity of planning and resolve conflicts

1. Engage the entire community in the planning process

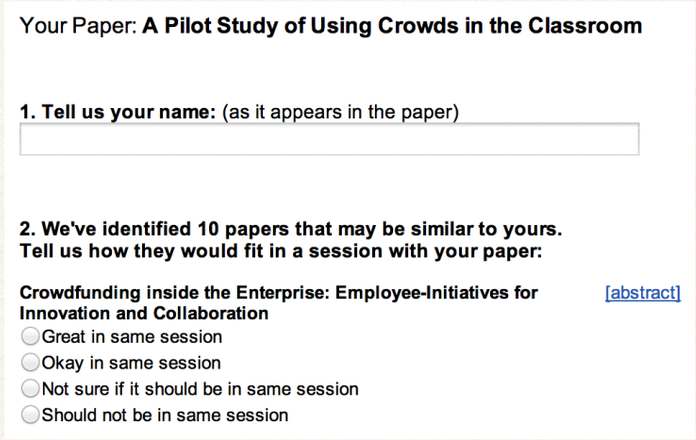
Committeesourcing



make sessions

[Chilton et al.]

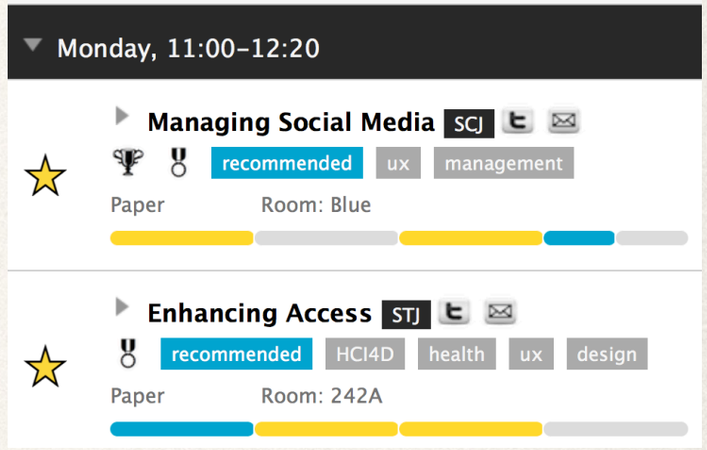
Authorsourcing



collect affinities

[Andre et al.]

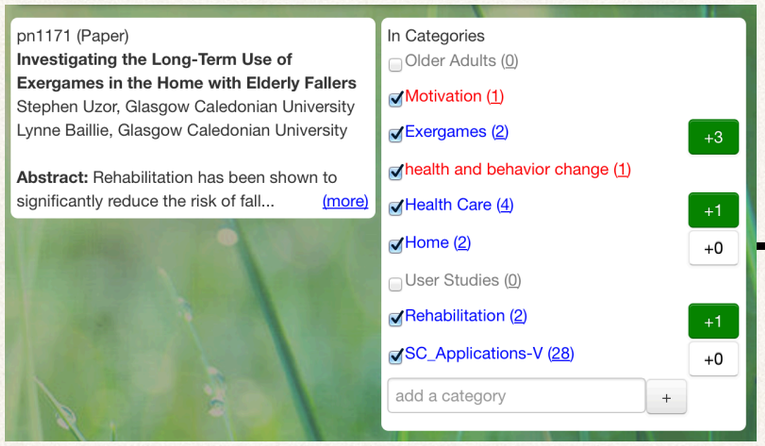
Attendeesourcing



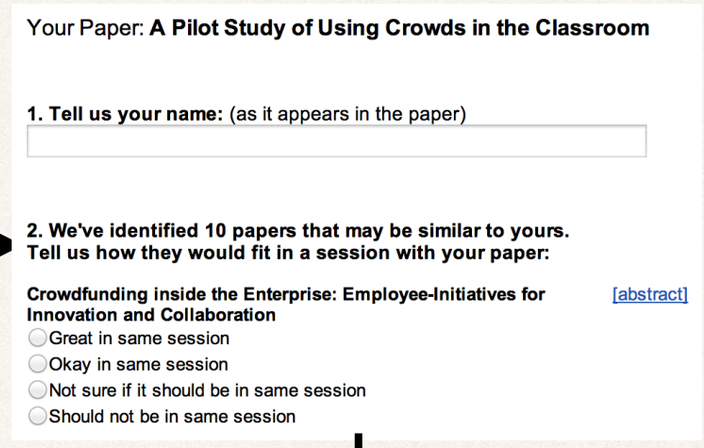
collect preferences

[Bhardwaj et al.]

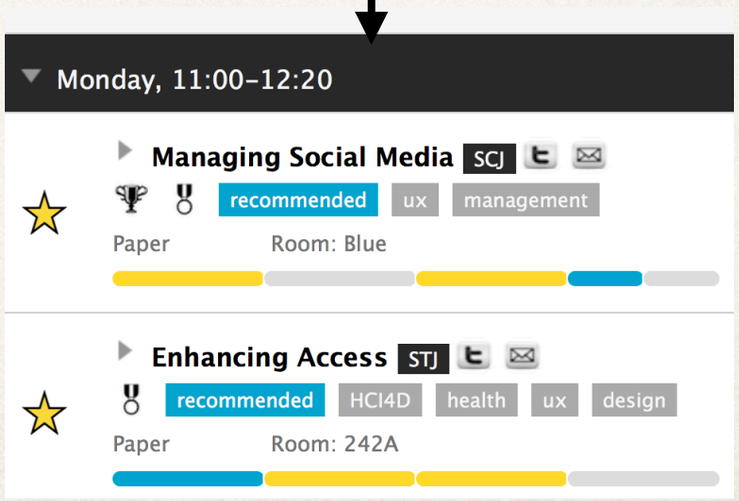
Core idea: incentive chaining



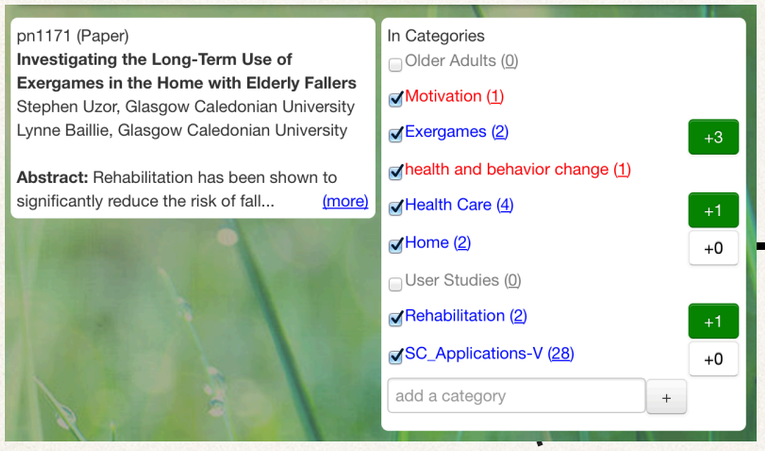
expert categories

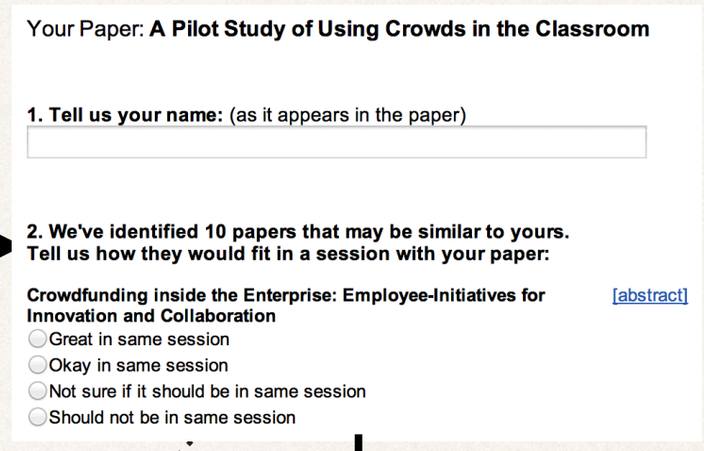


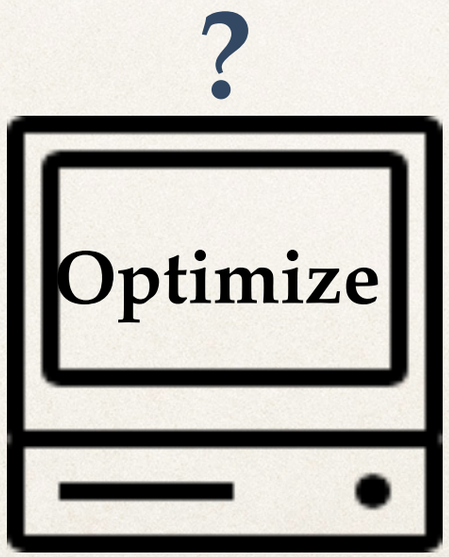
affinities as seed

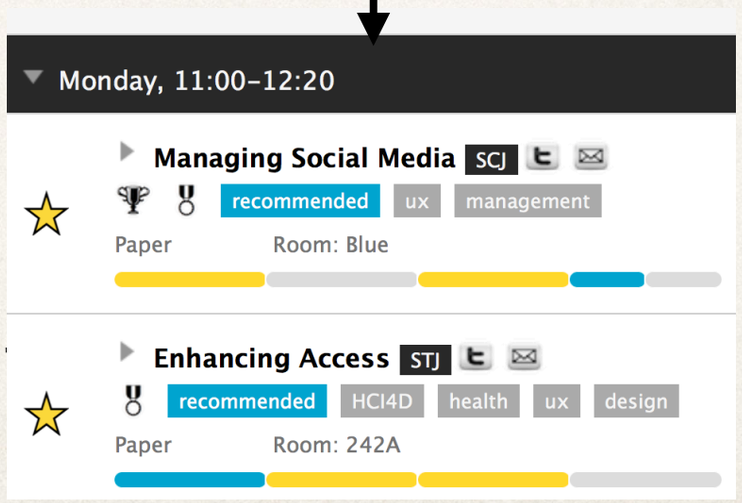


2. Help organizers resolve conflicts

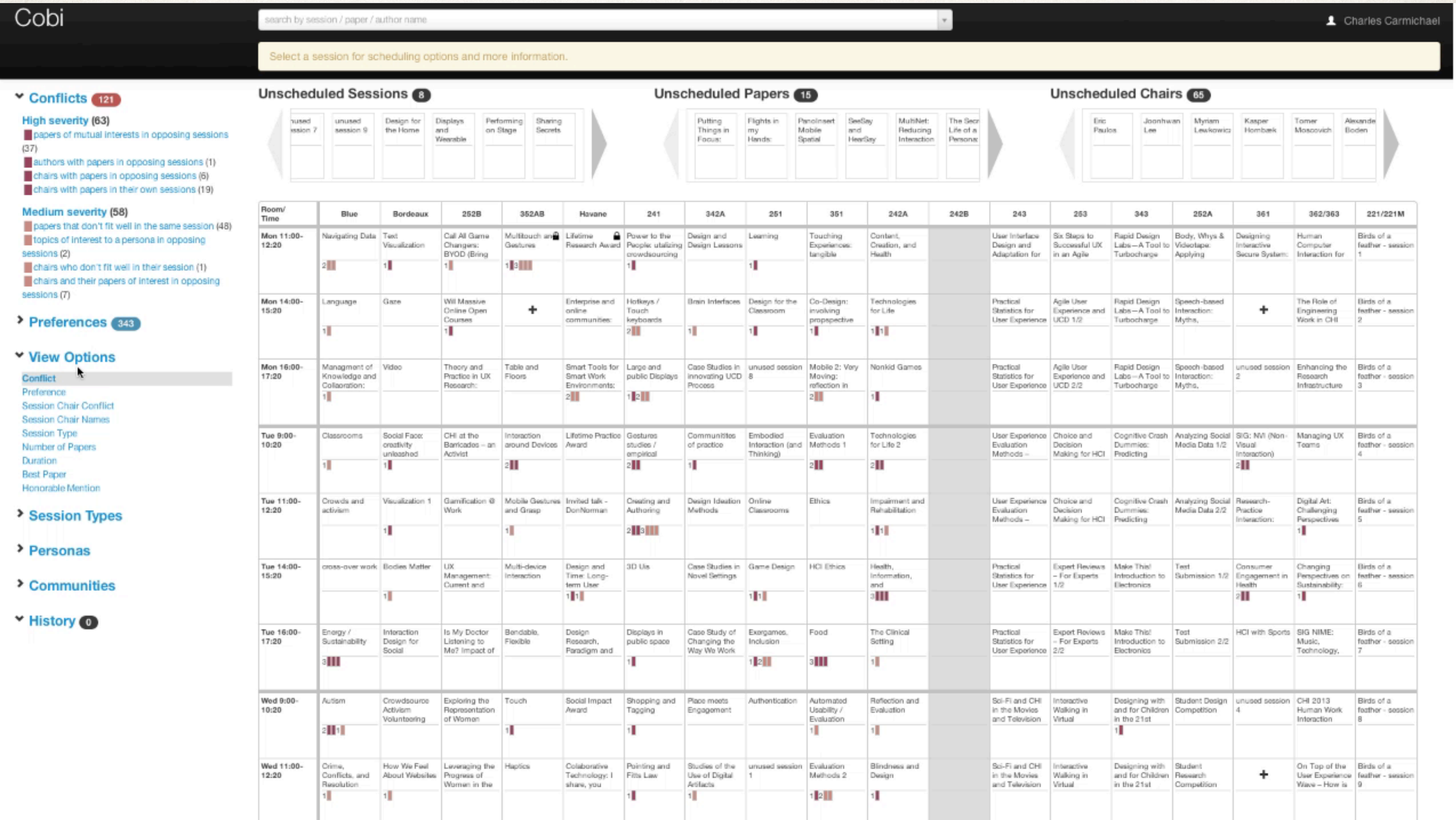








Core idea: Community-informed mixed-initiative interface [Kim et al]

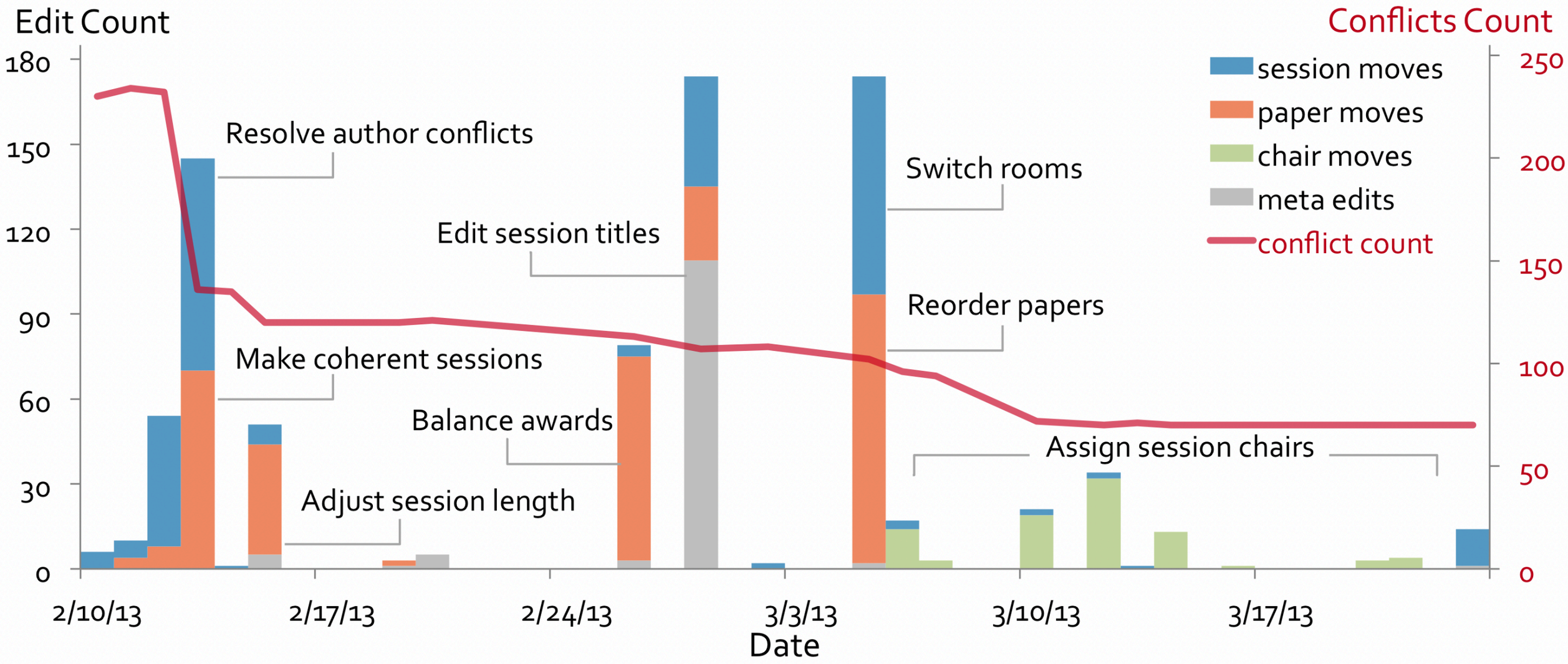


Outcomes

1. inclusive process that engaged 1500 community members in planning

2. reduced organizers' time from 100 hours to 5 hours

3. organizers produced better schedules by resolving 100+ previously hidden conflicts while also advancing other planning goals


Edit Count
Conflicts Count
180
150
120
90
60
30
0
250
200
150
100
50
0
session moves
paper moves
chair moves
meta edits
conflict count
Resolve author conflicts
Edit session titles
Switch rooms
Reorder papers
Make coherent sessions
Balance awards
Assign session chairs
Adjust session length
2/10/13
2/17/13
2/24/13
3/3/13
3/10/13
3/17/13
Date

Computational Ecosystem: Community-Informed Planning

- Collaborative planning across crowds, groups, and organizers

- Chain contributions across the ecosystem

- Mixed-initiative interfaces empower organizers to make informed decisions using community input, system recommendations, and their tacit knowledge

scale research training: cultivating self-directed learners

Students need regulation skills

- **Regulation skills**: cognitive, metacognitive, motivational, and emotional skills for reaching a goal *[Jarvela & Hadwin. 2013]*

- Independent research requires regulation skills including **planning** and **seeking help** to overcome challenges.

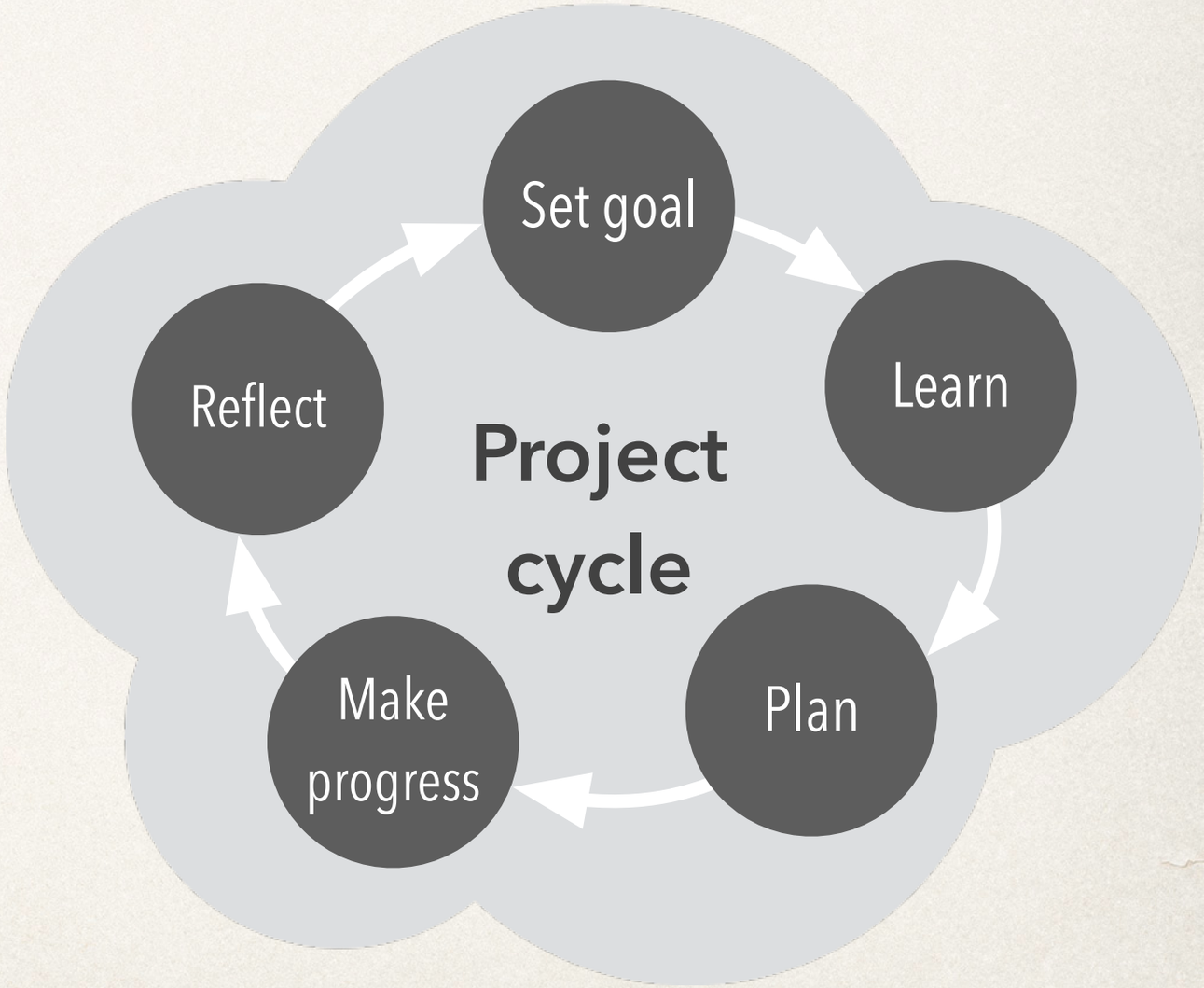
- Students lacking these skills are confined to rote tasks, or can struggle to make progress.

Agile Research Studio (ARS)

[Z. et al.]

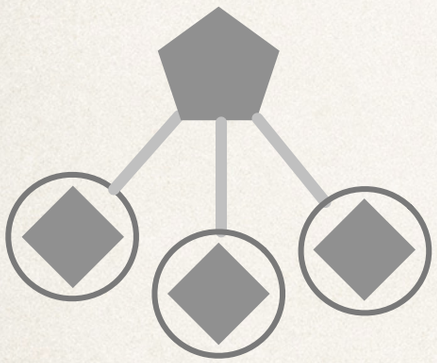
- Model for research training in a learning community

- All students, regardless of seniority, conduct independent research and receive authentic research practice.



ARS scales faculty time

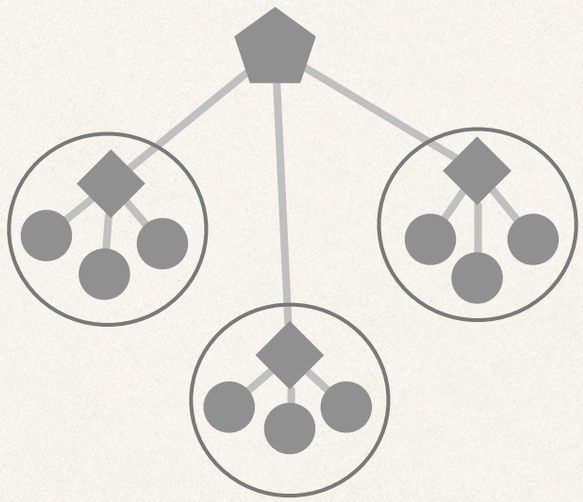
Apprenticeship



very small teacher to student ratio

[Collins, 2005]

Hierarchical, 1:1:1

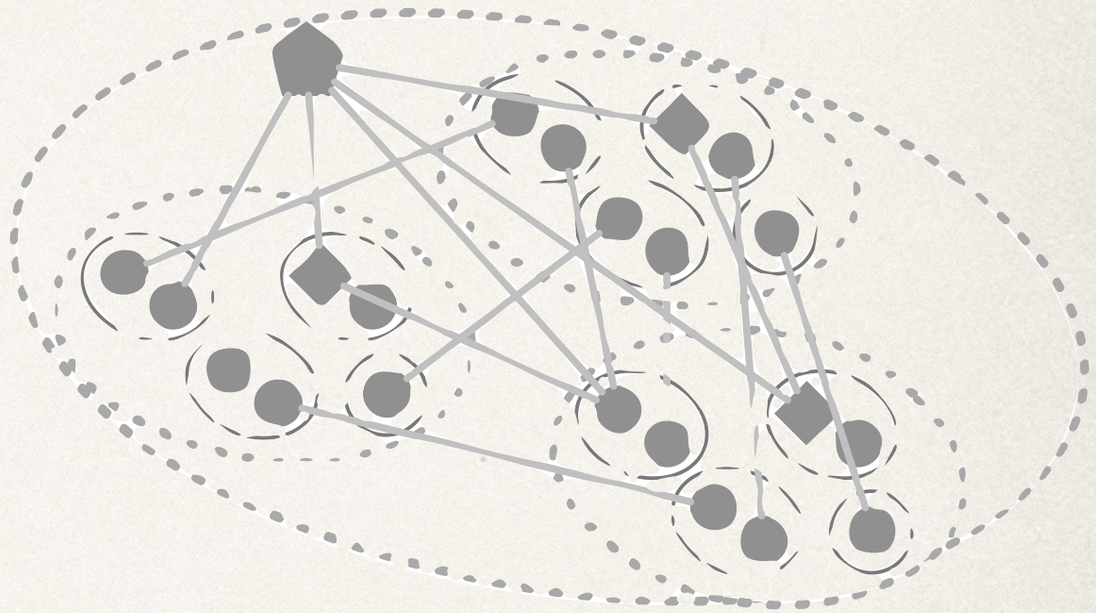


grad students are novice mentors

[Shulman, 1986]

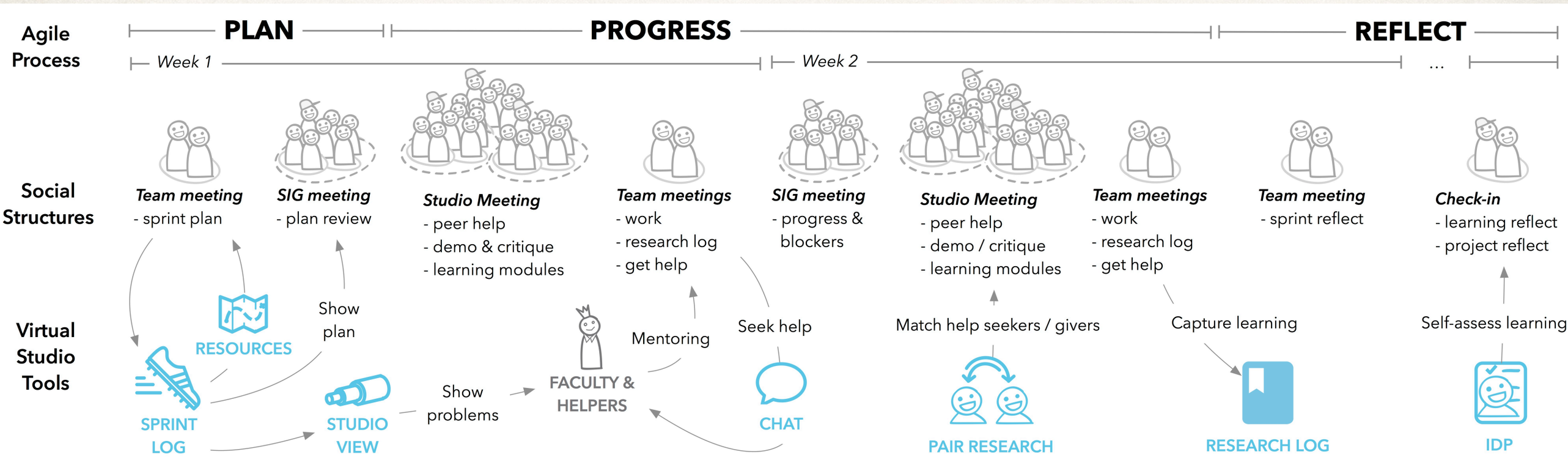
The ARS approach:

Dispersed Control



overcome 1:X

[Bain & Weston, 2012]



To learn more:

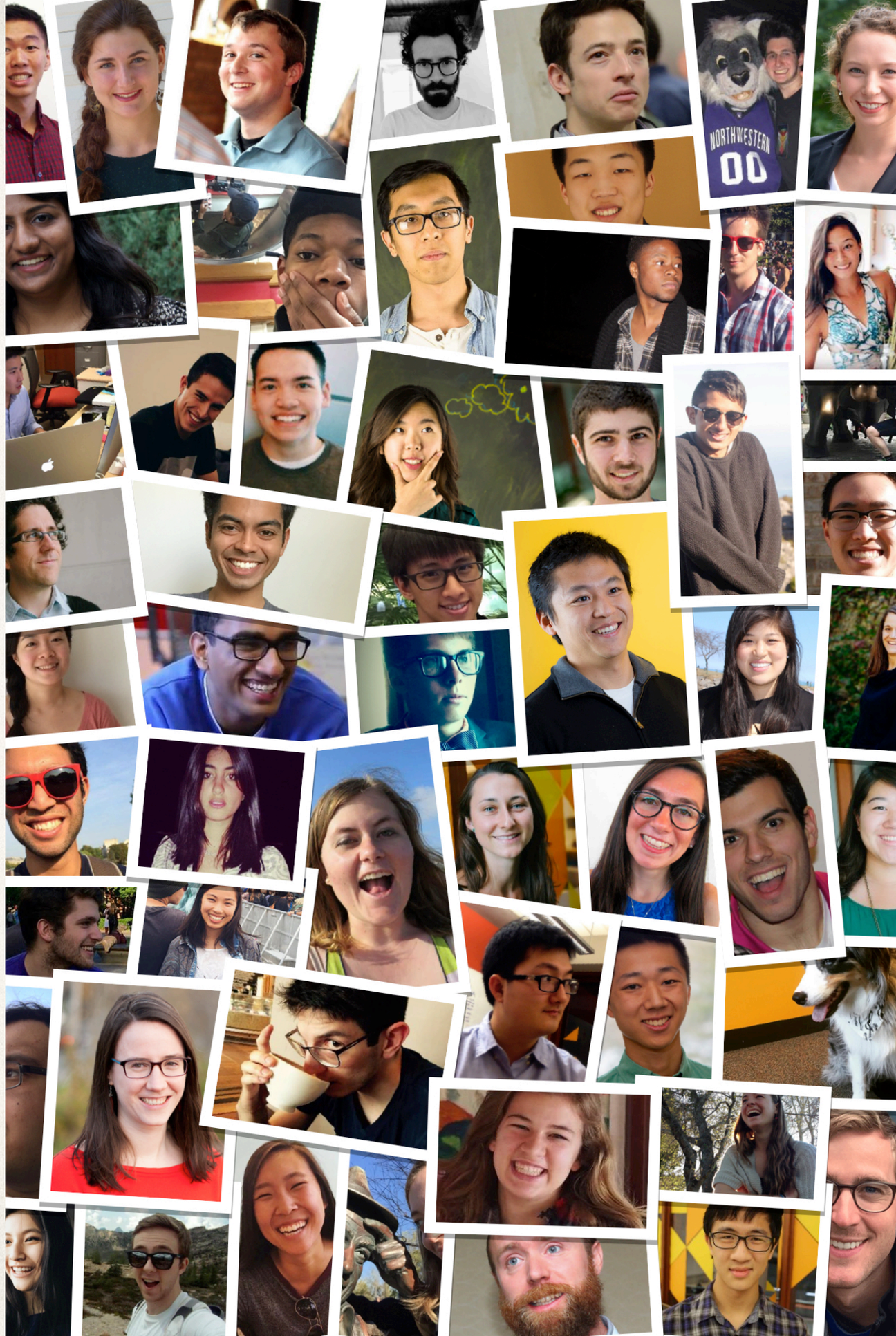
agileresearch.io

forward.movie

dtr.northwestern.edu/letters

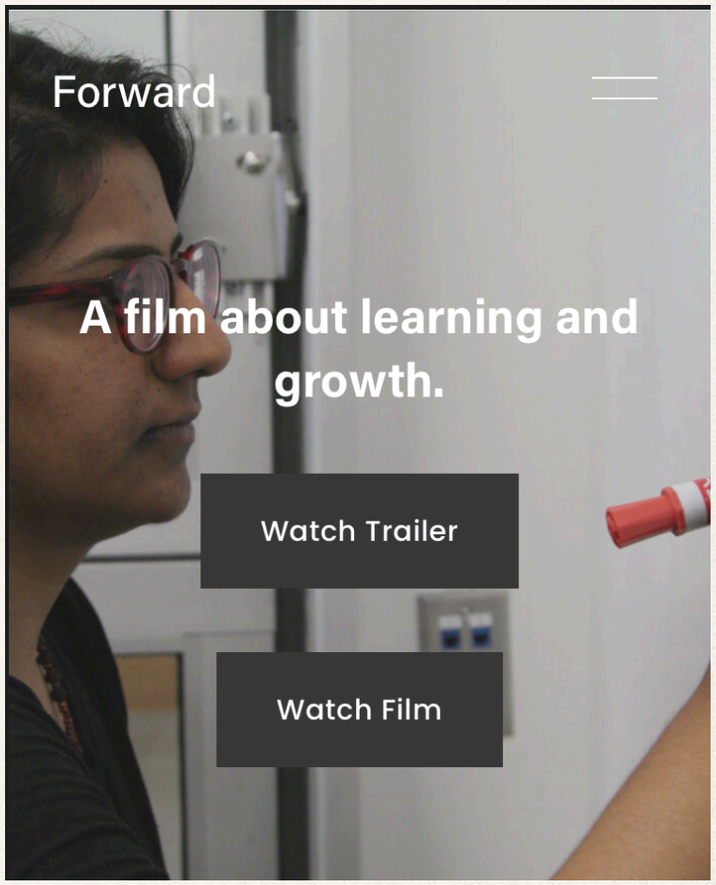
Outcomes (10 yrs)

- 160 students (139 UG, 9 MA, 14 PhDs) who led 70+ research projects.
- 46% women. 80%+ this quarter!
- 70 undergraduate research grants
- 30 papers + extended abstracts; 7 winners at major ACM Student Research Competitions
- 40% of DTR undergraduates placed at Apple, Google, Microsoft, Meta, and Amazon; others have founded their own companies.



Success beyond Northwestern

- Founded Agile Research University (ARU) to support 70+ faculty at universities across the world using the ARS model (even in the humanities!)
- Produced the DTR documentary, *Forward*
- DTR annual letters to start deeper conversations on mentoring and learning
- Founded cross-institutional junior faculty support group

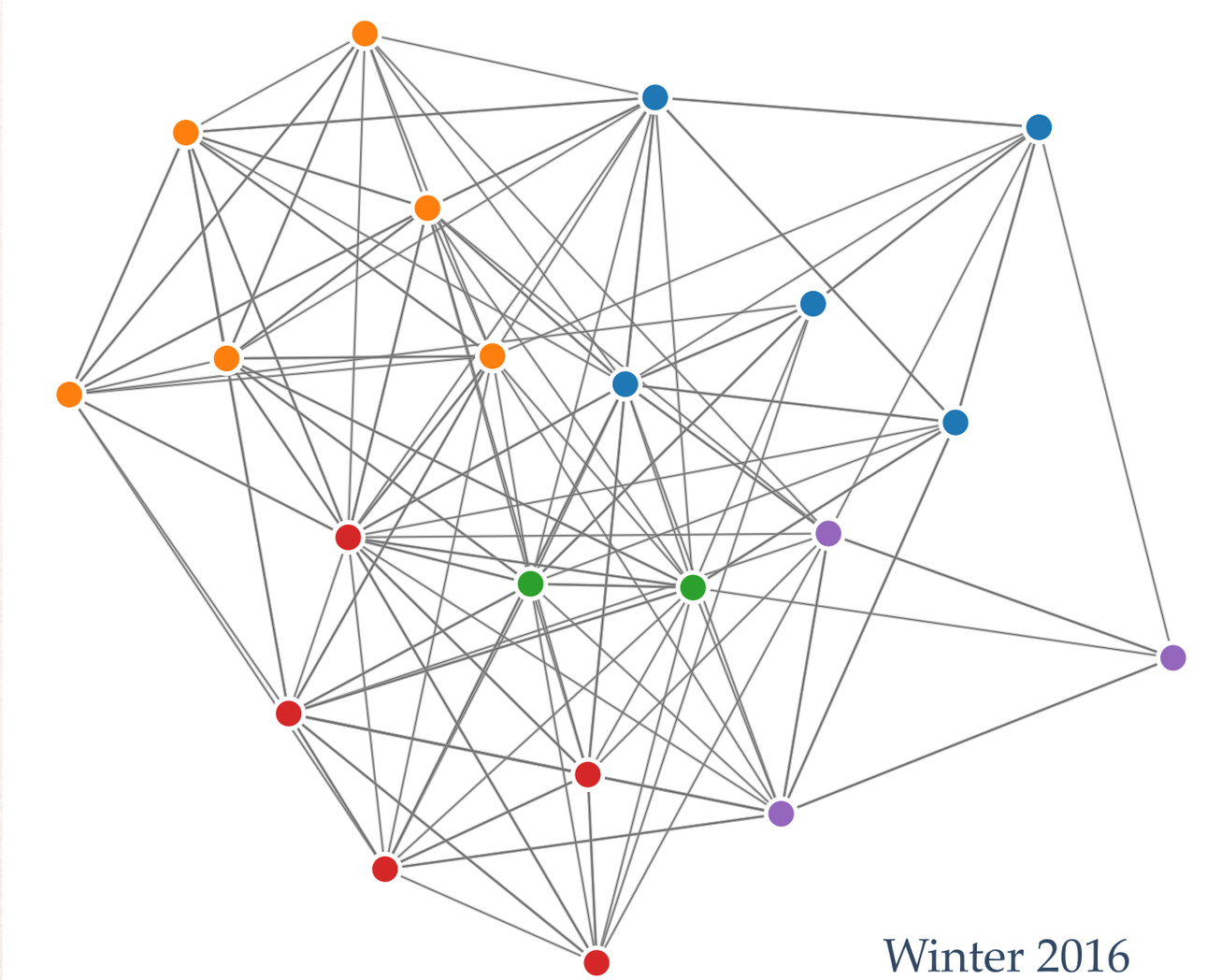


Planning Strategies

- assessing risks
- using effective representations for thinking about problems and solutions
- building at the appropriate fidelity
- prioritizing important features and research questions
- moving on despite uncertainty or imperfect knowledge.

Help & Help-seeking

- *"I can ask for help and that everyone asks for help and it doesn't make them stupid to need help."*



Thanks so much for

teaching me how to

advocate for myself &

my ideas, embrace failure &

inexperience & search for

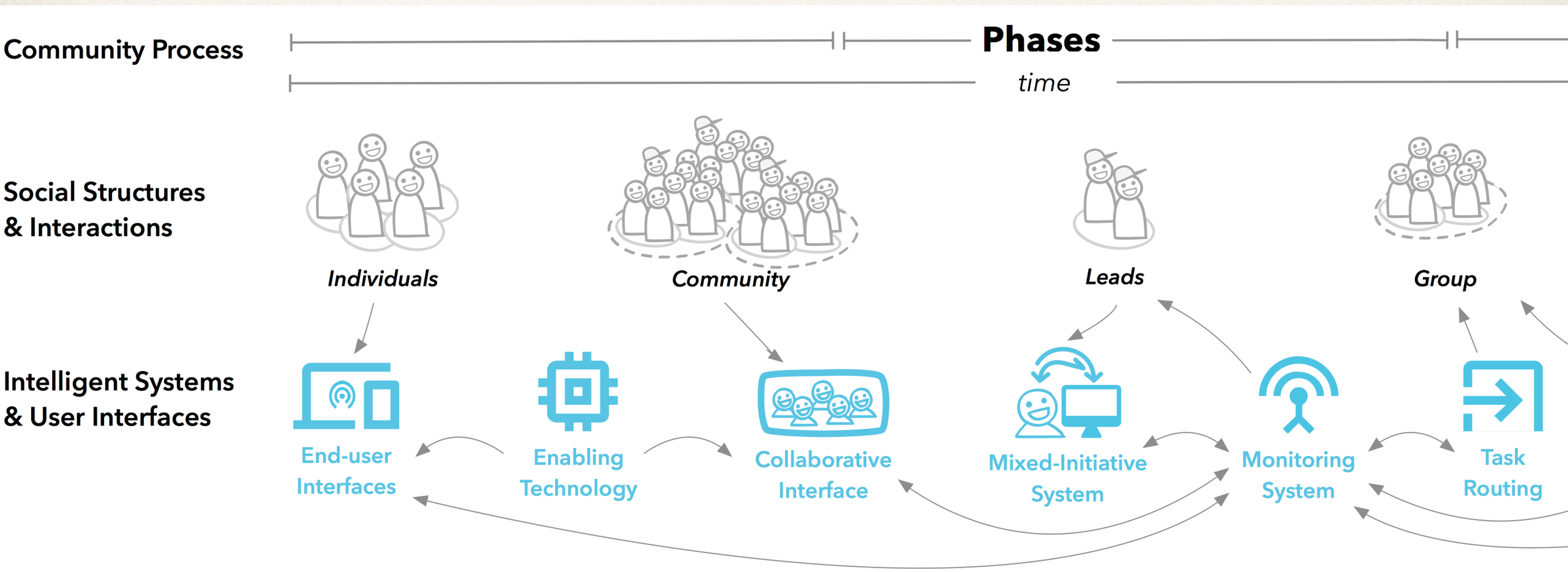
truth rather than bullshit.

Computational Ecosystem: Agile Research Studios

- Develop regulation skills for research planning and help-seeking across ecosystem interactions

- Extends the scale and capacity of a community to produce and learn, and to engage more deeply with ourselves and with research

Our recent work: moving beyond ecosystem design



1: Developing regulation skills for building a self-directed (research) practice

Cognitive skills

- representing problem and solution spaces
- assessing risks
- critical thinking and argumentation
- core design, research, and STEM methods

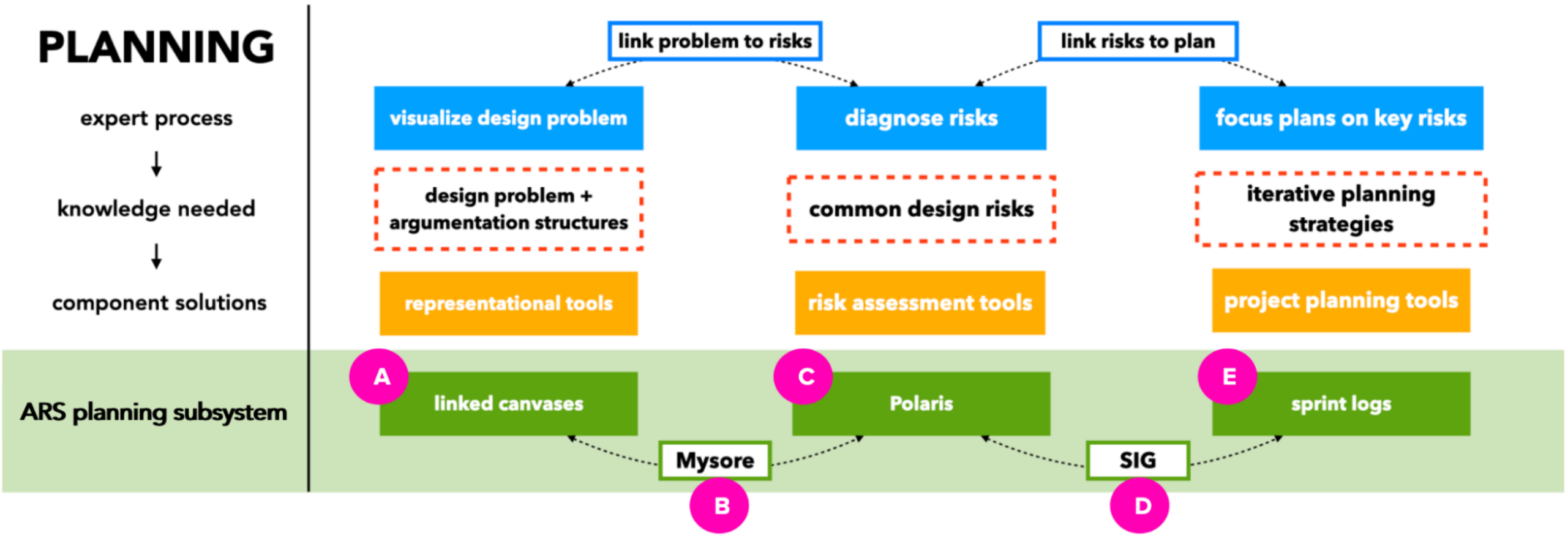
Metacognitive skills and dispositions

- planning: forming feasible plans and planning effective iterations
- help-seeking: leveraging resources; seeking help; communication skills
- reflection: awareness of one's own skills, abilities, and metacognitive blockers

Emotional regulation and disposition toward self and learning

- emotional regulation: understanding one's fears and anxieties
- disposition: dealing with failure, embracing challenges, embracing self-direction

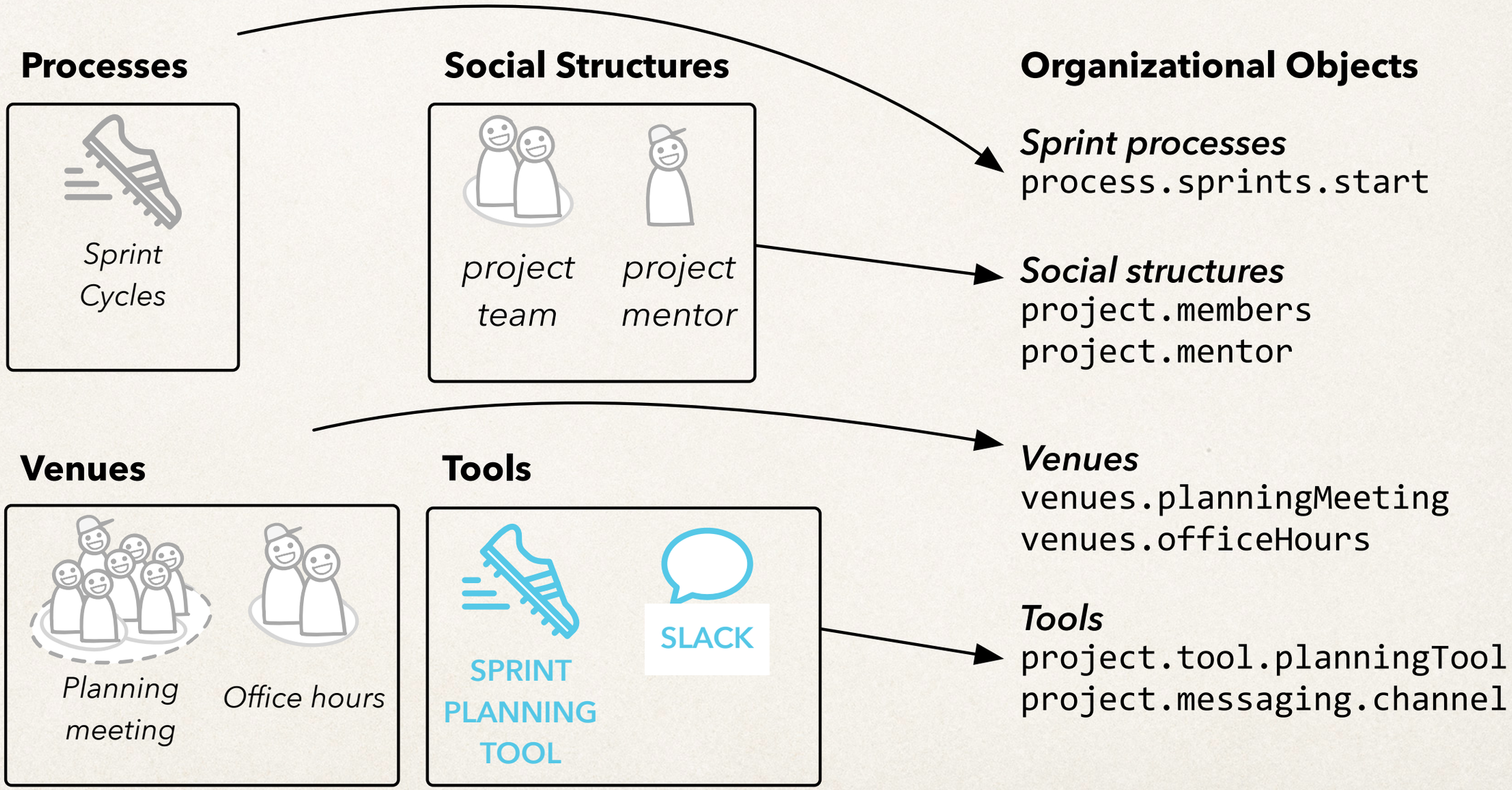
Building a planning practice in the ARS computational ecosystem [Maliakal et al., 2023]



In-action cues for replanning

[Maliakal et al., 2023]

Organizational Objects for Workplaces [Garg, Gergle, Z., 2023]

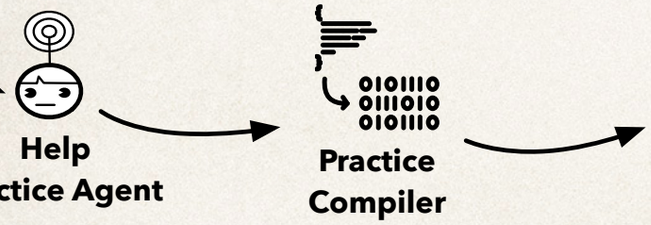


Practice Agents for facilitating practice [Garg, Gergle, Z., 2024]

A Coach Suggests Practice

```
[help] come to @OfficeHours
with your rep[synthesis tree]
and we can chat about the
implications for your design.
```

B Practice Agent Interprets Practice



C Practice Scripts are Generated to Facilitate Practice and Reflection

1. Summarize Practice

```
message @Stella
 practice.summary and
   library.synthesis_tree
```

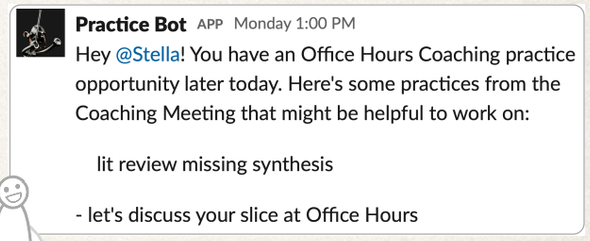
2. Promote practice and co-regulation

```
message @Stella the
morningOf(next(
   venue.OfficeHours))
```

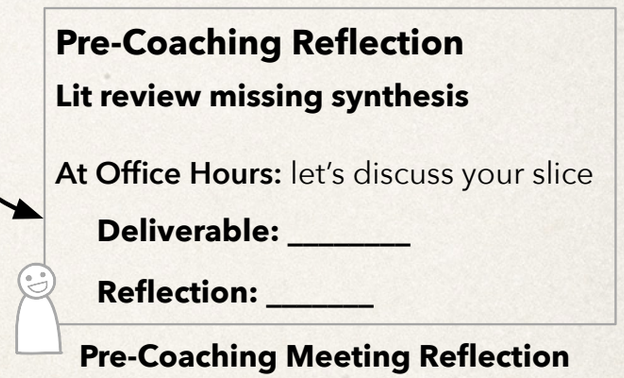
3. Support Reflection

```
message @Stella the
dayBefore(next(
   venue.CoachingSession))
with help.reflection and
append to practiceObject
```

D Execution Engine Engages Students in Activities at Opportune Moments

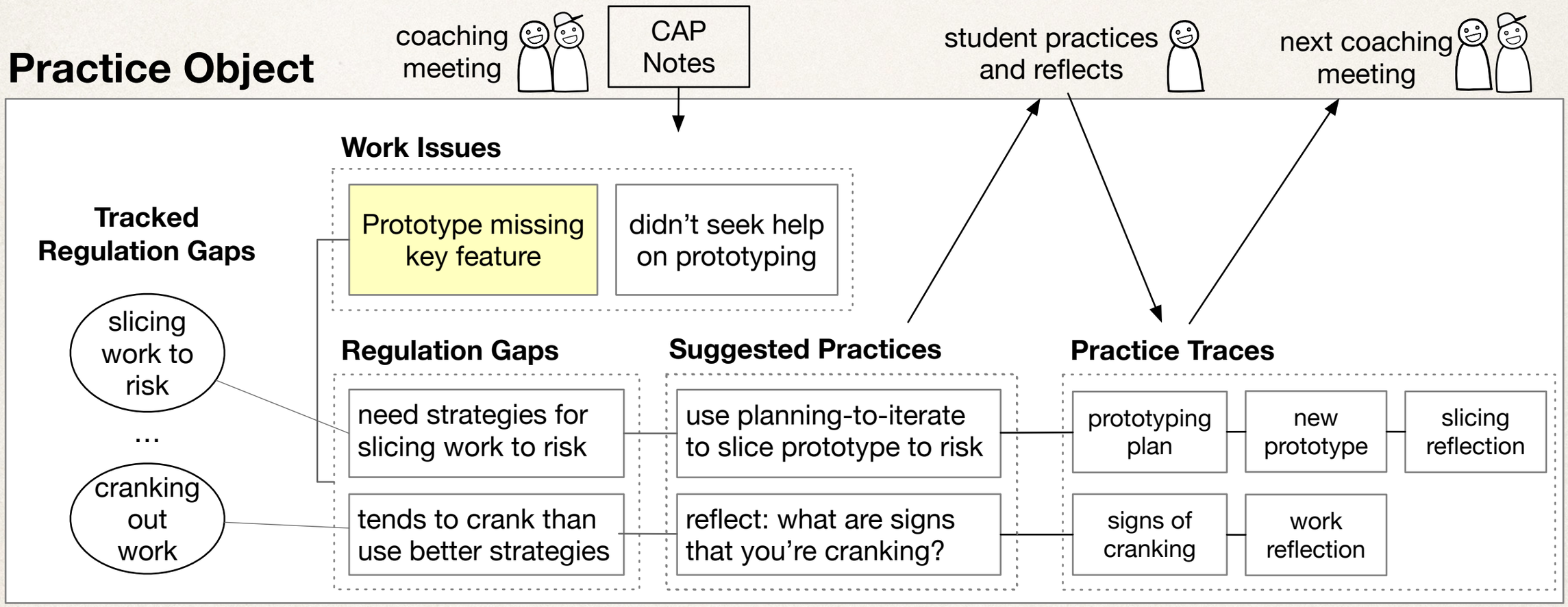


Pre-Office Hours Preparation



Pre-Coaching Meeting Reflection

Practice Objects for tracking practice [Garg, Gergle, Z., 2024]



Summary: Building a self-directed practice

- Computational supports for facilitating a practice across ecosystem interactions

- Ecosystem-level monitoring and orchestration to promote, coordinate, and restructure interactions *across* a computational ecosystem

2. Computational Understanding of Human Experiences

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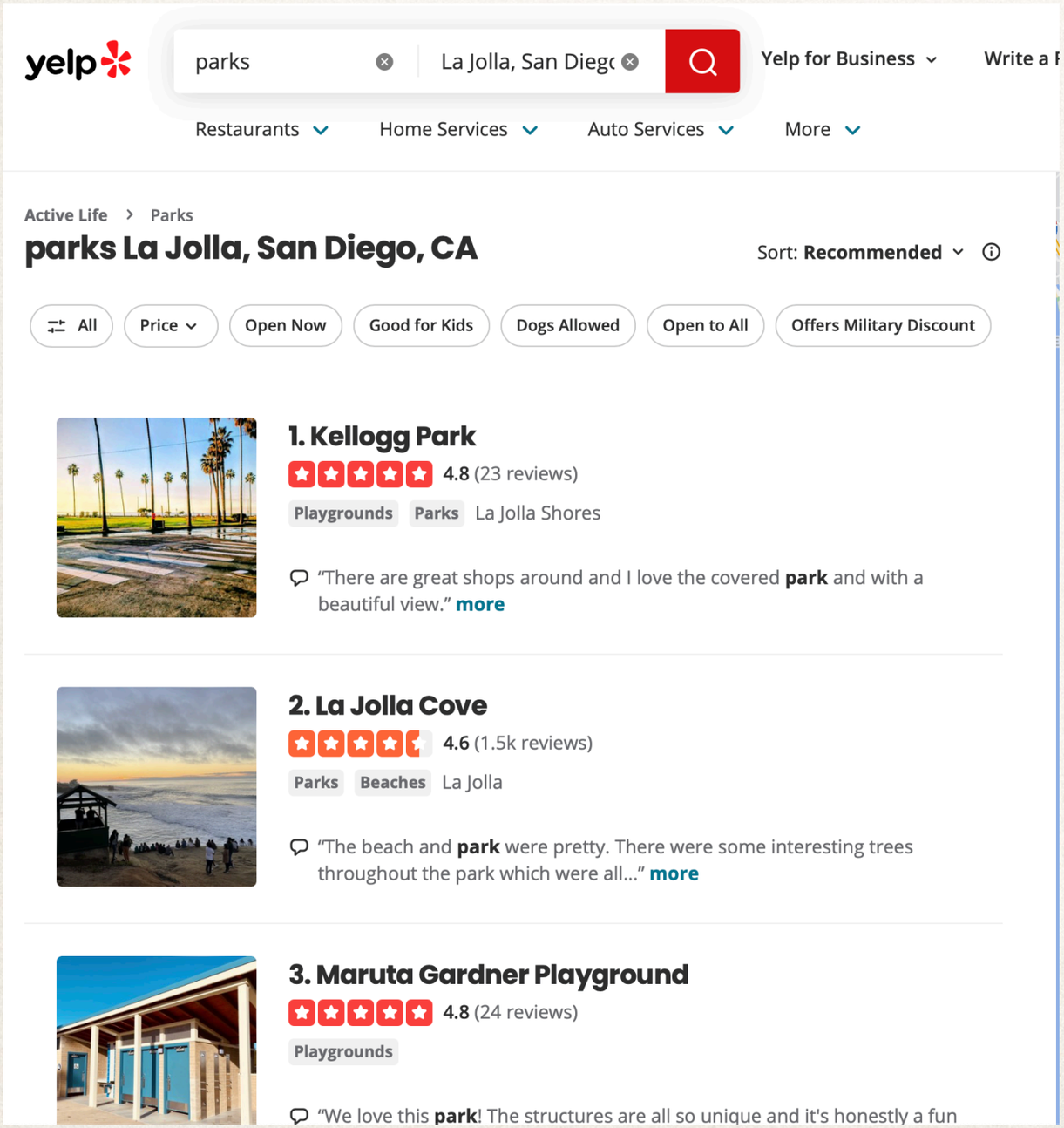

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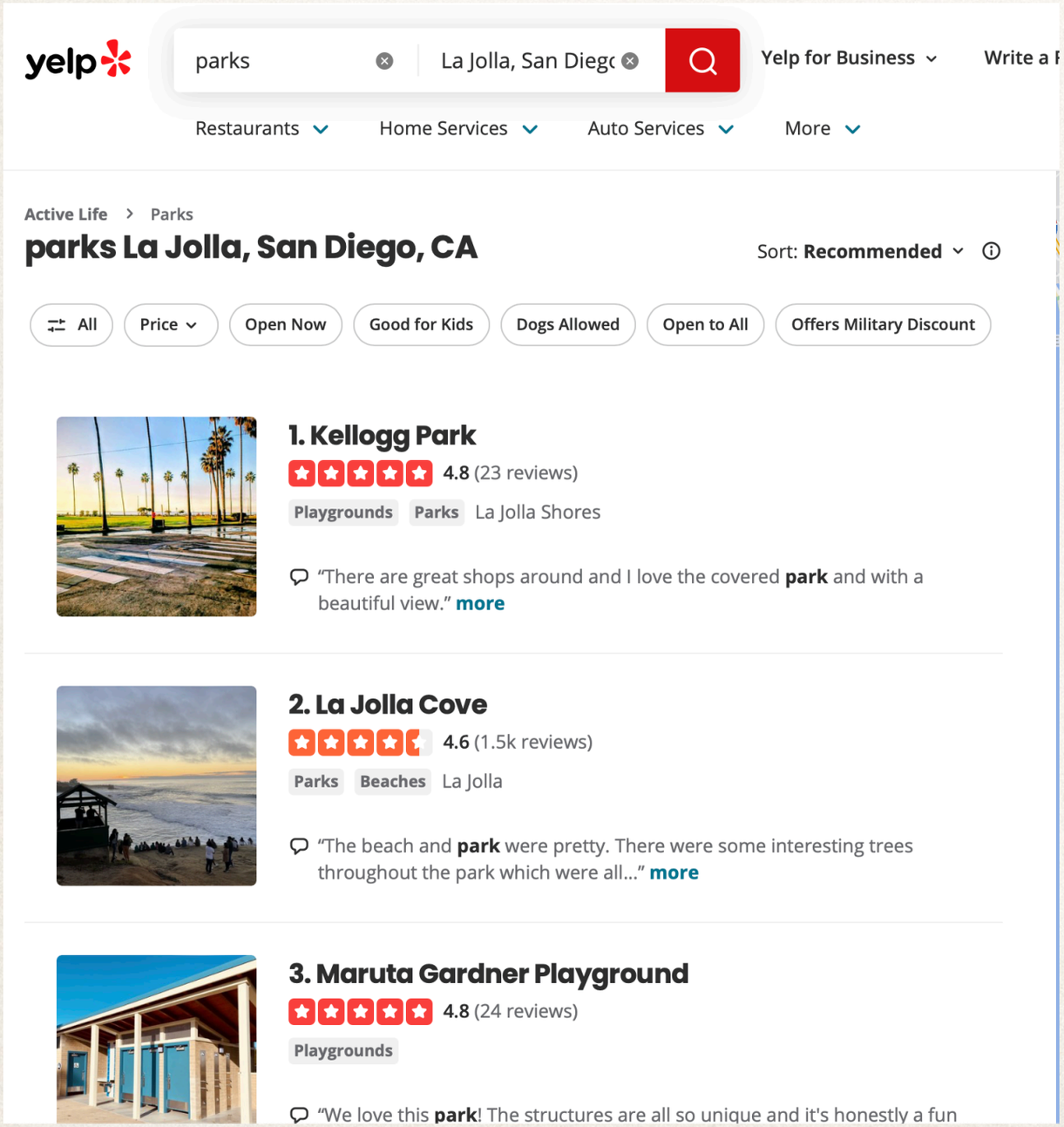
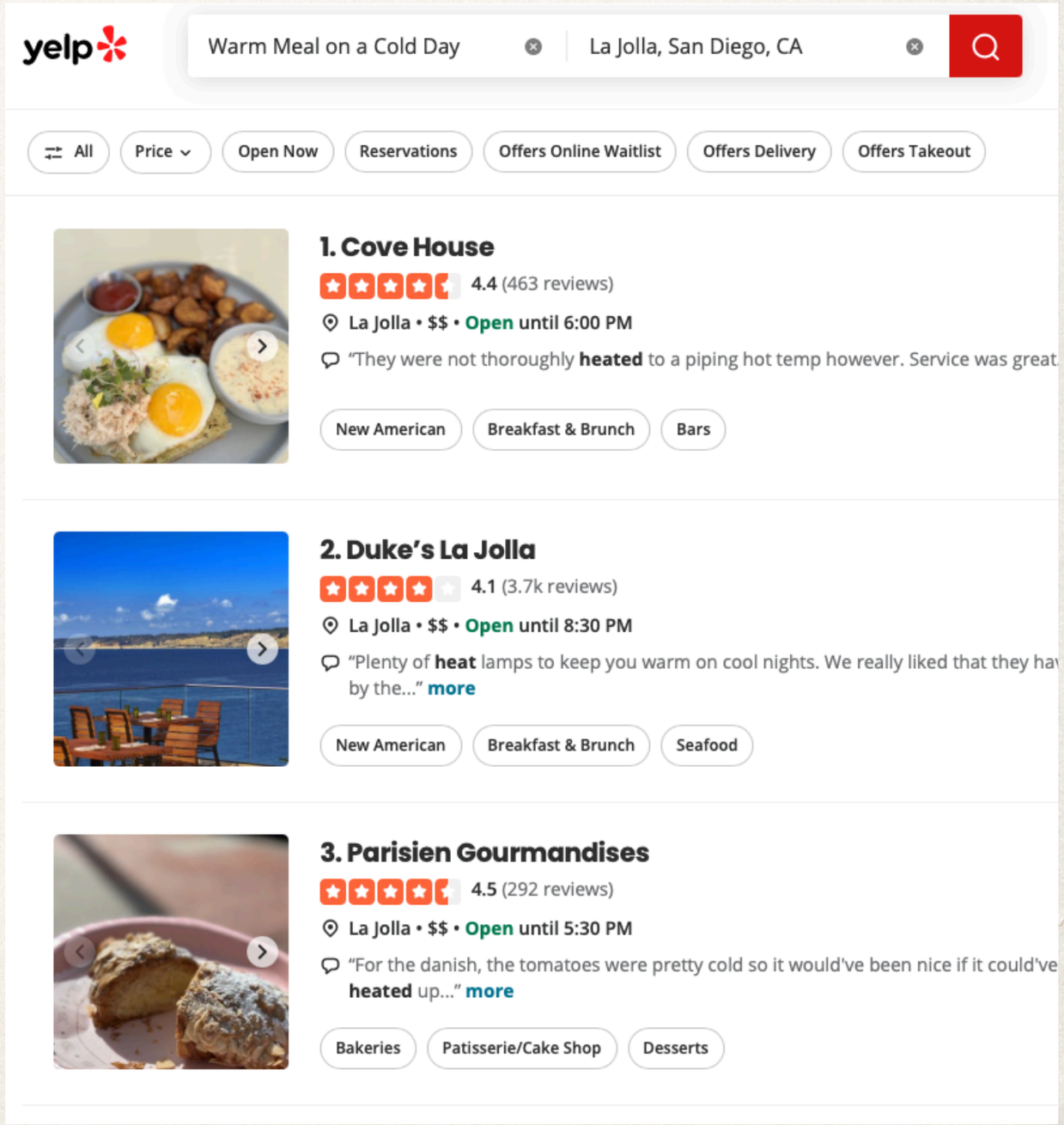


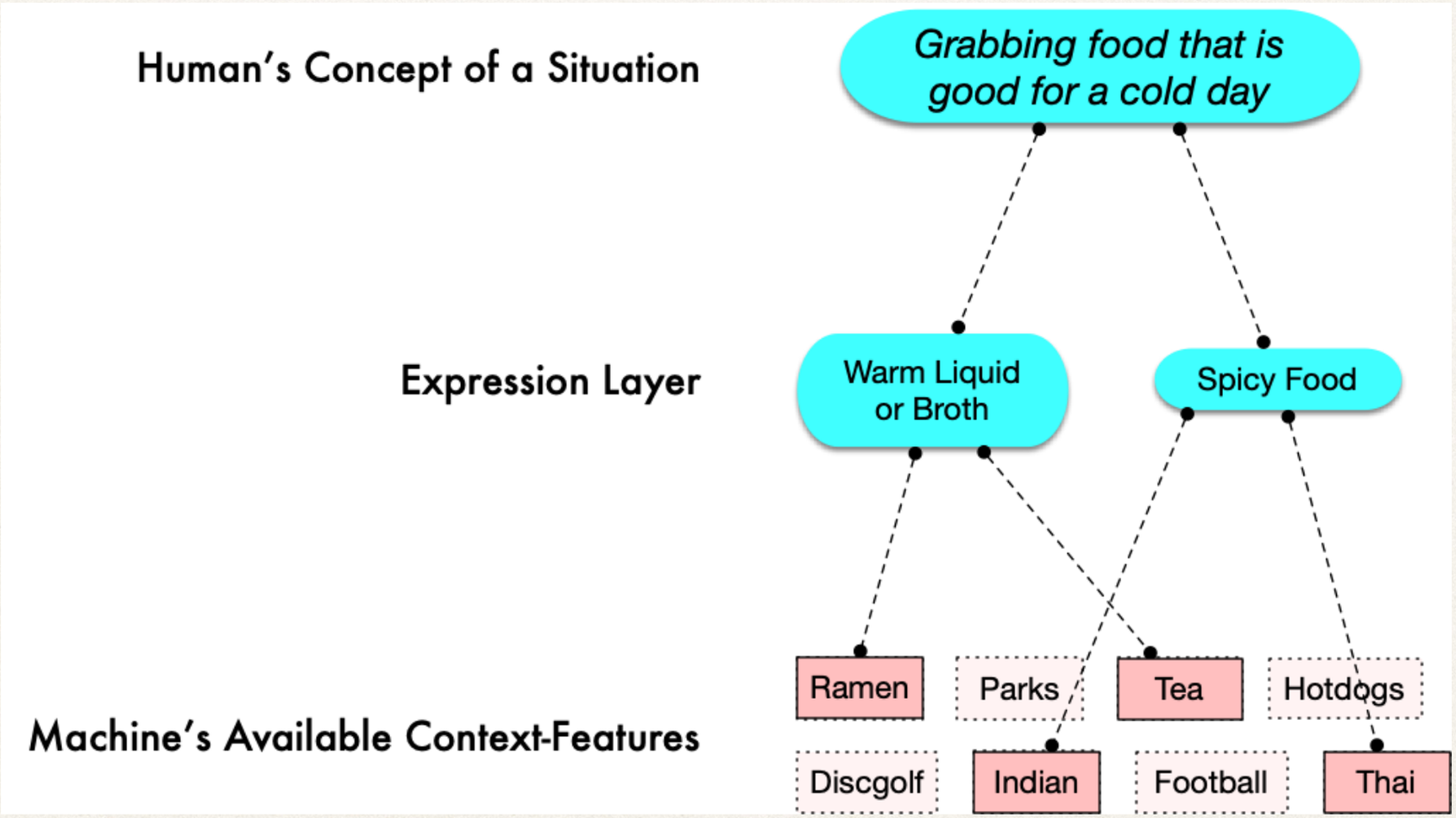


2. Computational Understanding of Human Experiences

"an increasing understanding on the part of system developers that human activities are enmeshed in a variety of [cultural and social] practices and relations that make them meaningful by setting a context within which they can be understood…"

Seeking a Foundation for Context-Aware Computing
Paul Dourish, **2001 (!!)**

Bridging Human-Machine Understanding of Human Experiences [Louie et al, 2022]



Fundamental challenge: understanding human experiences across contexts

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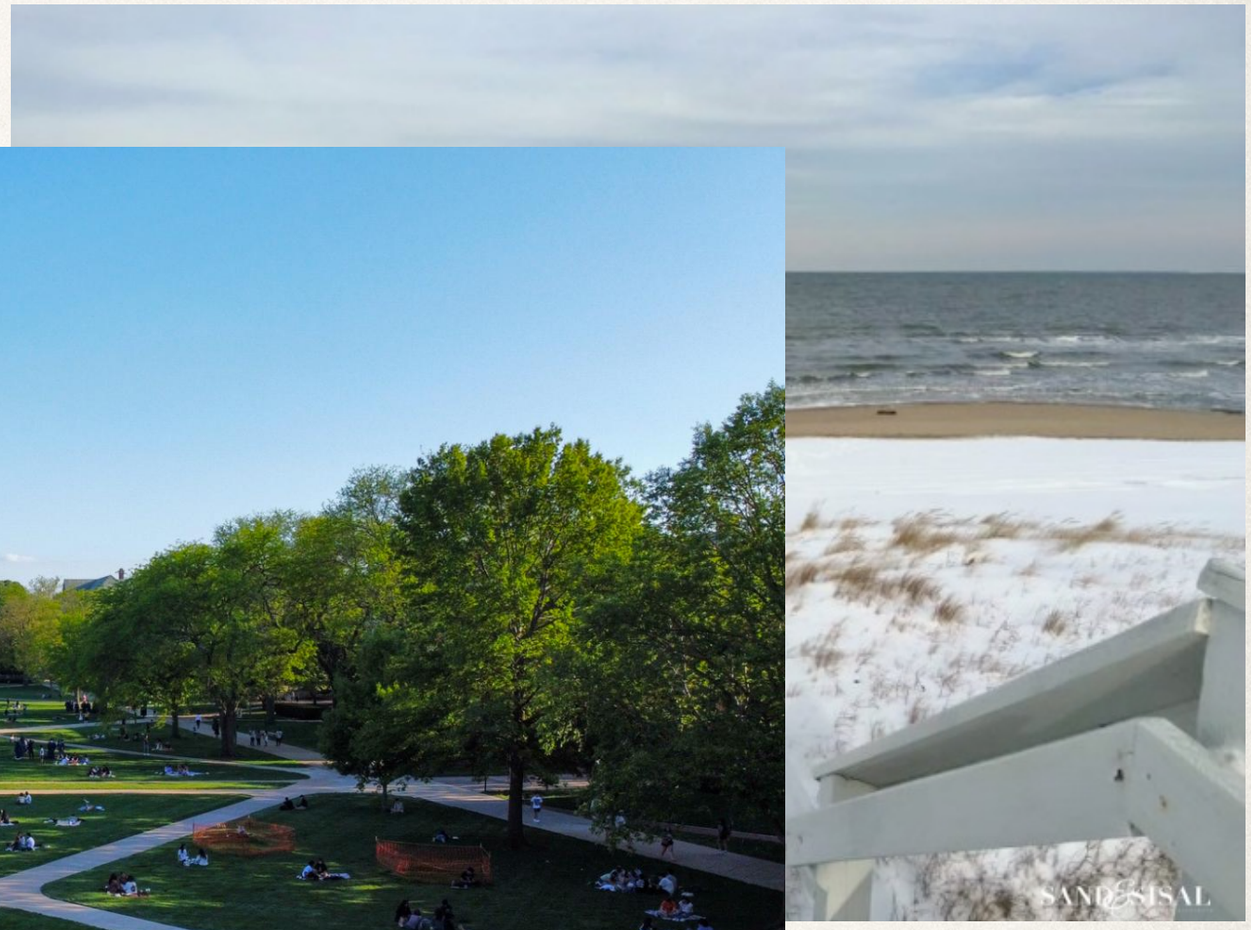
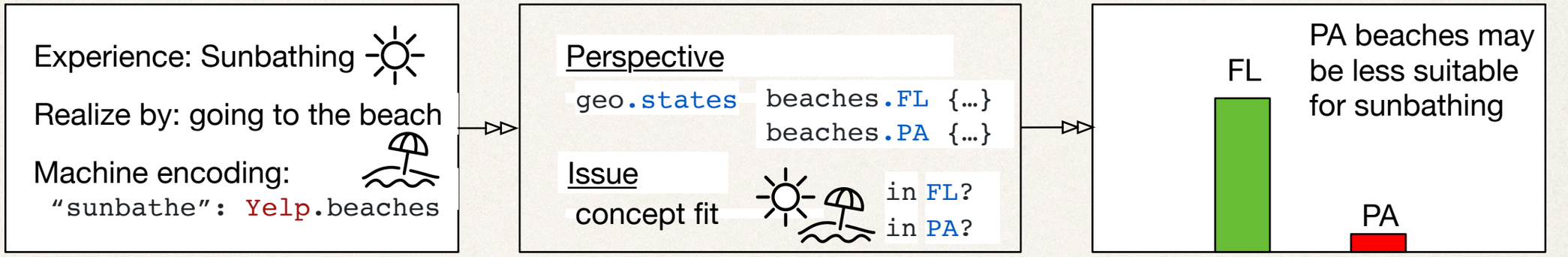


Differ: An Experiential Computing Platform [He, Zhang, Gergle, Z.]

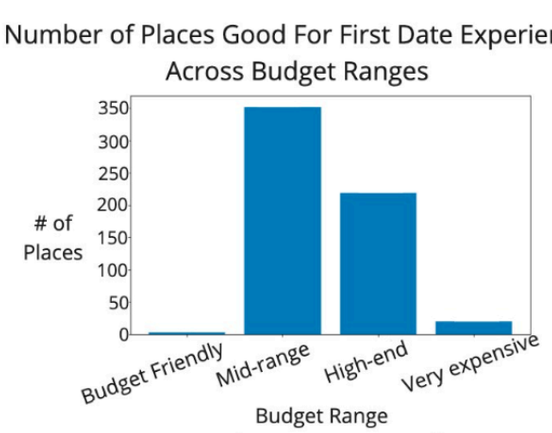


1. Define human experience and its computational encoding

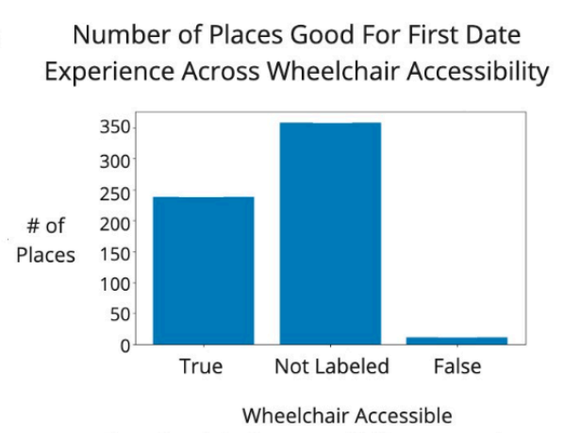
2. Define accountable perspectives and issues of concern

3. Automatically surface differences to designers via visualizations

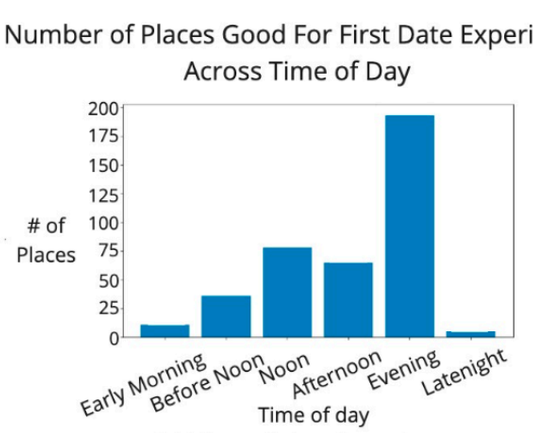
Example: Going on a first date



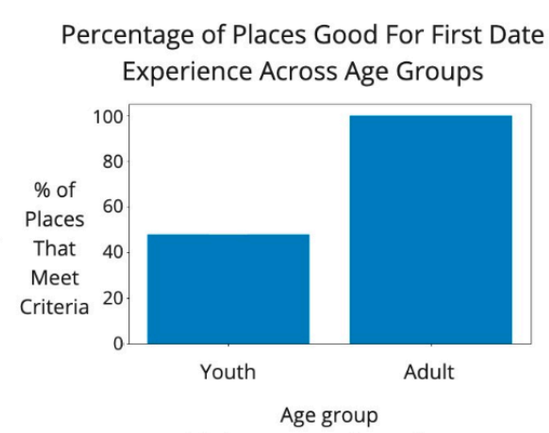
(a) Budget Range, Prevalence



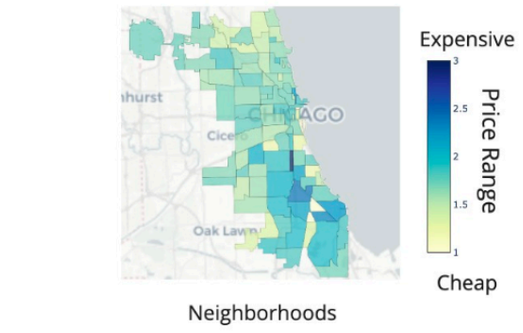
(b) Wheelchair Accessibility, Prevalence]



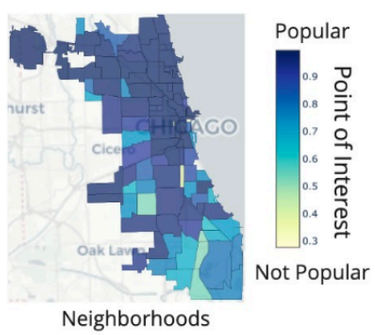
(c) Time of day, Prevalence



(d) Age group, Prevalence

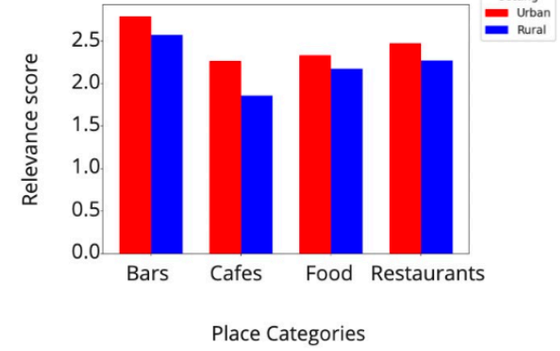


(e) Neighborhood, Affordability



(f) Neighborhood, Popularity

(g) City places x Time of day, Safety



(h) Urban/Rural, Conceptual fit

Summary: Computational Understanding of Human Experiences

- Computational understanding of human experiences is foundational for building richer computational ecosystem that support intrinsically valuable human activities

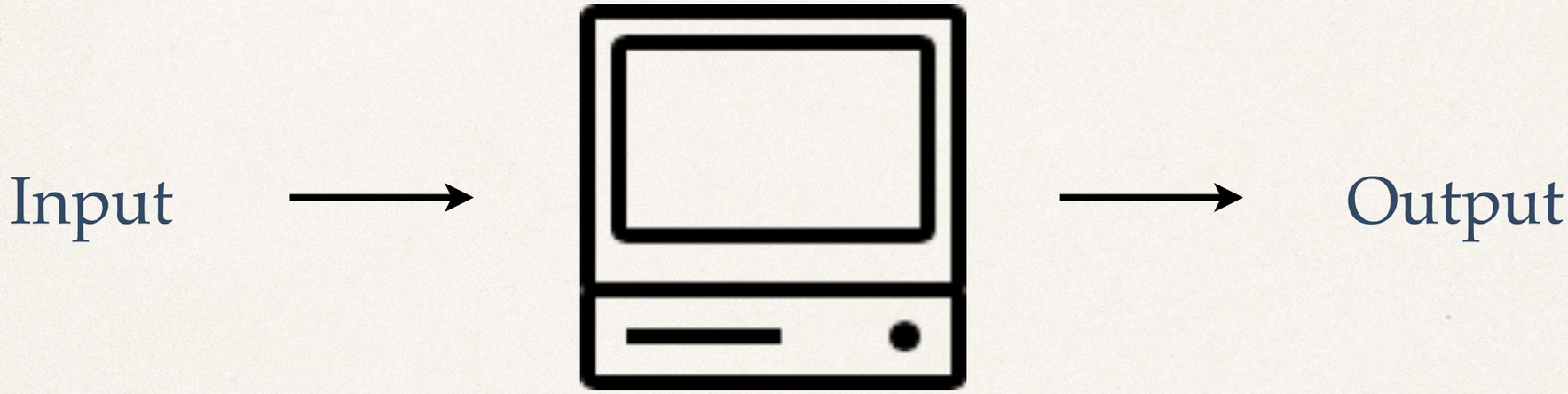
- Centering experiential understanding requires its own ecosystem of supports - which we can build as foundation for supporting other ecosystems!

(Limited) role of technology in advancing human values at scale

- Digital computers are insufficient for advancing human values

- We need computational ecosystems not just for consequential aims, but for advancing human values

Understand the limitations of the digital computers



Computers reliably produce
desired consequential outcomes

HCI is largely consequentialist

The role of designers is precisely to "produce novel integrations of HCI research [to make] a product that transforms the world from its current state to a preferred state."

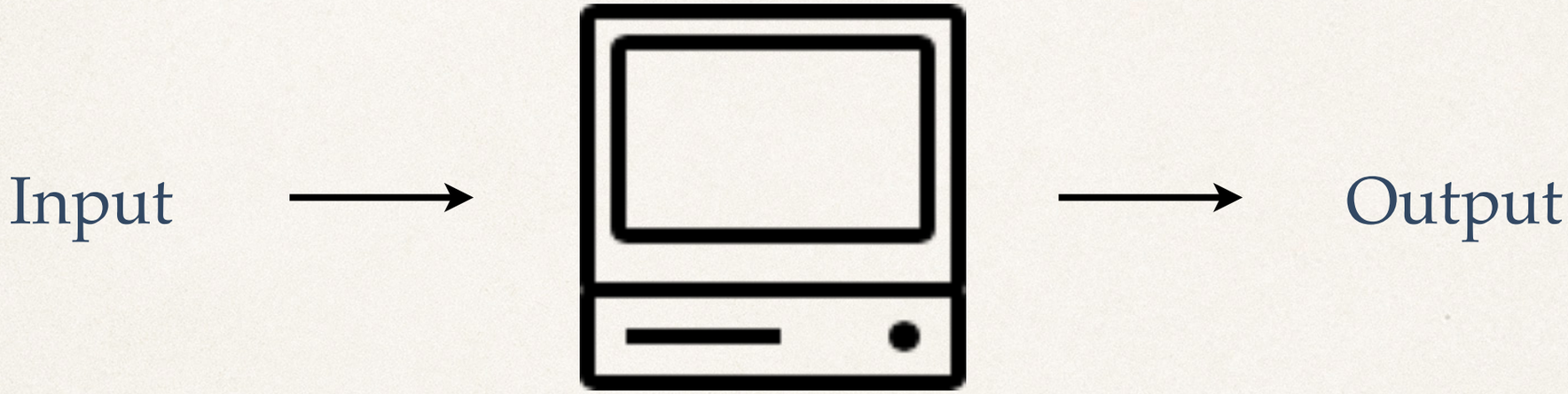
Zimmerman et al., CHI 2007

But there is more to advancing human value than achieving desired ends

"This suggests a certain diagnosis of the **modern mania** that perceives the point of a life's work in some set of **listable achievements**, the point of parenting in the **production of children with some desired set of characteristics and capacities**, and the point of intimate relationships in some **status** to whose production and stabilization the participants ought to commit themselves. This outlook is a formula for **indefinitely postponing the good life** by dint of a ceaseless, determined pursuit of its static simulacrum…"

Talbot Brewer
Retrieval of Ethics

Claim: computers can never be the be-all and end-all to promoting human values rooted in intrinsically valuable human activities [Z., 2024]



Computers encode consequentialist thinking

Claim: computers can never be the be-all and end-all to promoting human values rooted in intrinsically valuable human activities [Z., 2024]

Searching for the Non-Consequential: Dialectical Activities in HCI and the Limits of Computers

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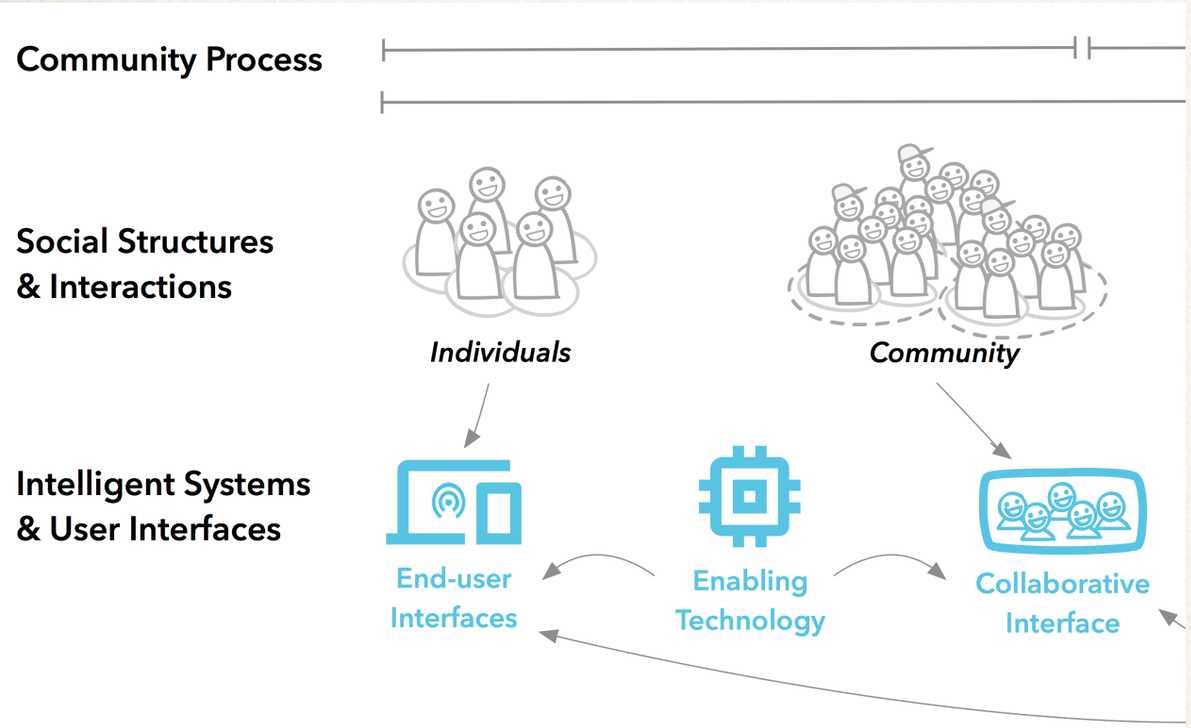
ABSTRACT

This paper examines the pervasiveness of consequentialist thinking in human-computer interaction (HCI), and forefronts the value of non-consequential, dialectical activities in human life. *Dialectical activities* are human endeavors in which the value of the activity is intrinsic to itself, including being a good friend or parent, engaging in art-making or music-making, conducting research, and so on. I argue that computers—the ultimate consequentialist machinery for reliably transforming inputs into outputs—cannot be the be-all and end-all for promoting human values rooted in dialectical activities. I examine how HCI as a field of study might reconcile the consequentialist machines we have with the dialectical activities we value, and propose *computational ecosystems* as a vision for HCI that makes proper space for dialectical activities.

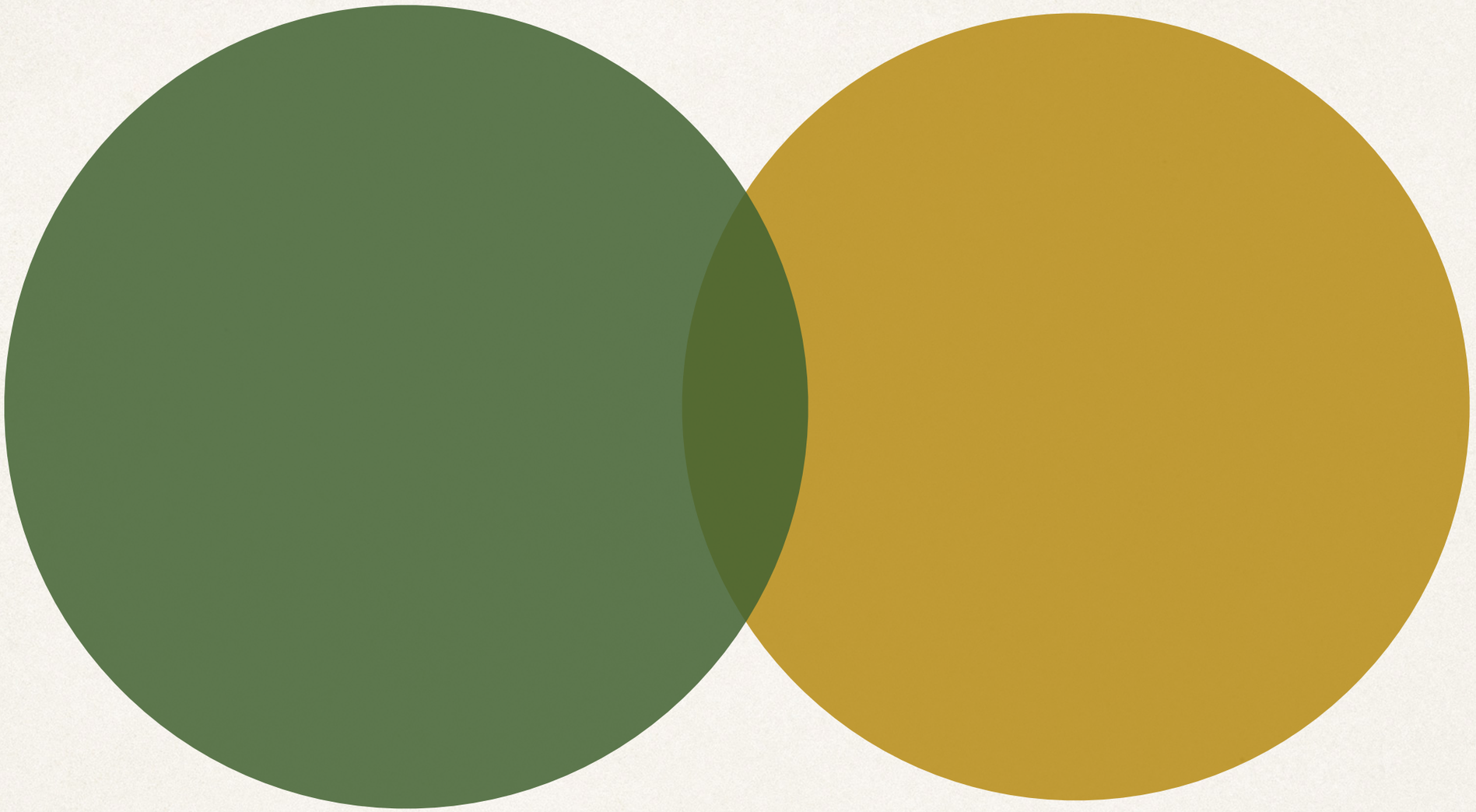
But while the HCI mission of using computational technologies to shape the world to meet our needs and desires rolls on full steam, questions to the very idea of focusing on the production of desired ends remain largely unanswered. As is the case in our culture, much of HCI research and practice is rooted in *consequentialist thinking*: reasoning about actions as means for achieving desired outcomes and ends. But as philosophers have contested across millennia, certain quintessential human values, activities, and ways of being cannot be easily reconciled nor understood through the consequentialist lens. For instance, *dialectical activities* [25], or activities whose values are rooted in the intrinsic nature of the activity itself and that are revealed only through repeated engagement with the activity—such as parenting, being a good friend, engaging in art-making and other creative pursuits, conducting research—do not easily reduce to producing certain desired outcomes. Continued

The real value of computational ecosystems is not “merely"consequential



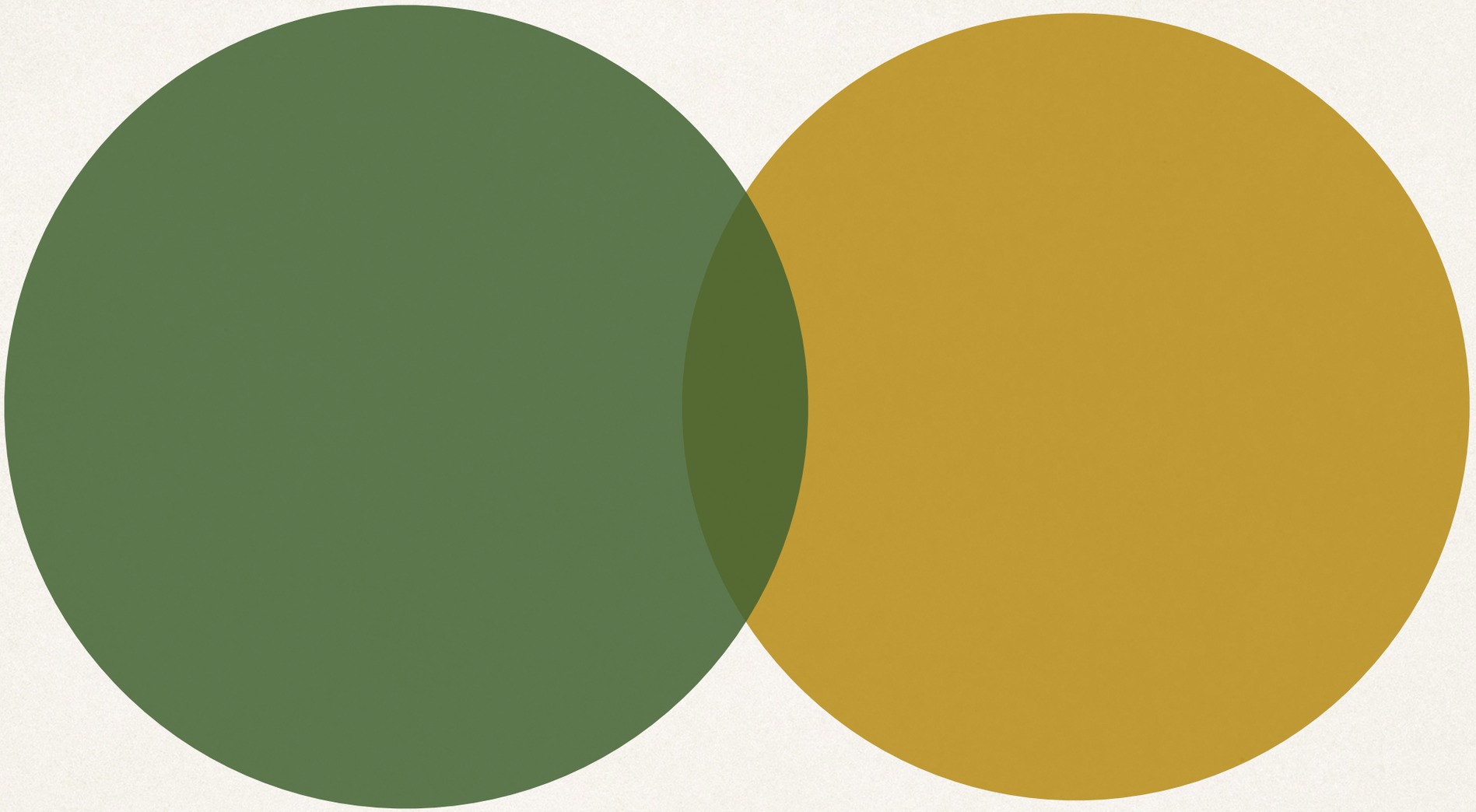
- Computational Ecosystems produce desired goods and services; they solve consequential problems

- Computational Ecosystems promote engagement in intrinsically valuable human activities

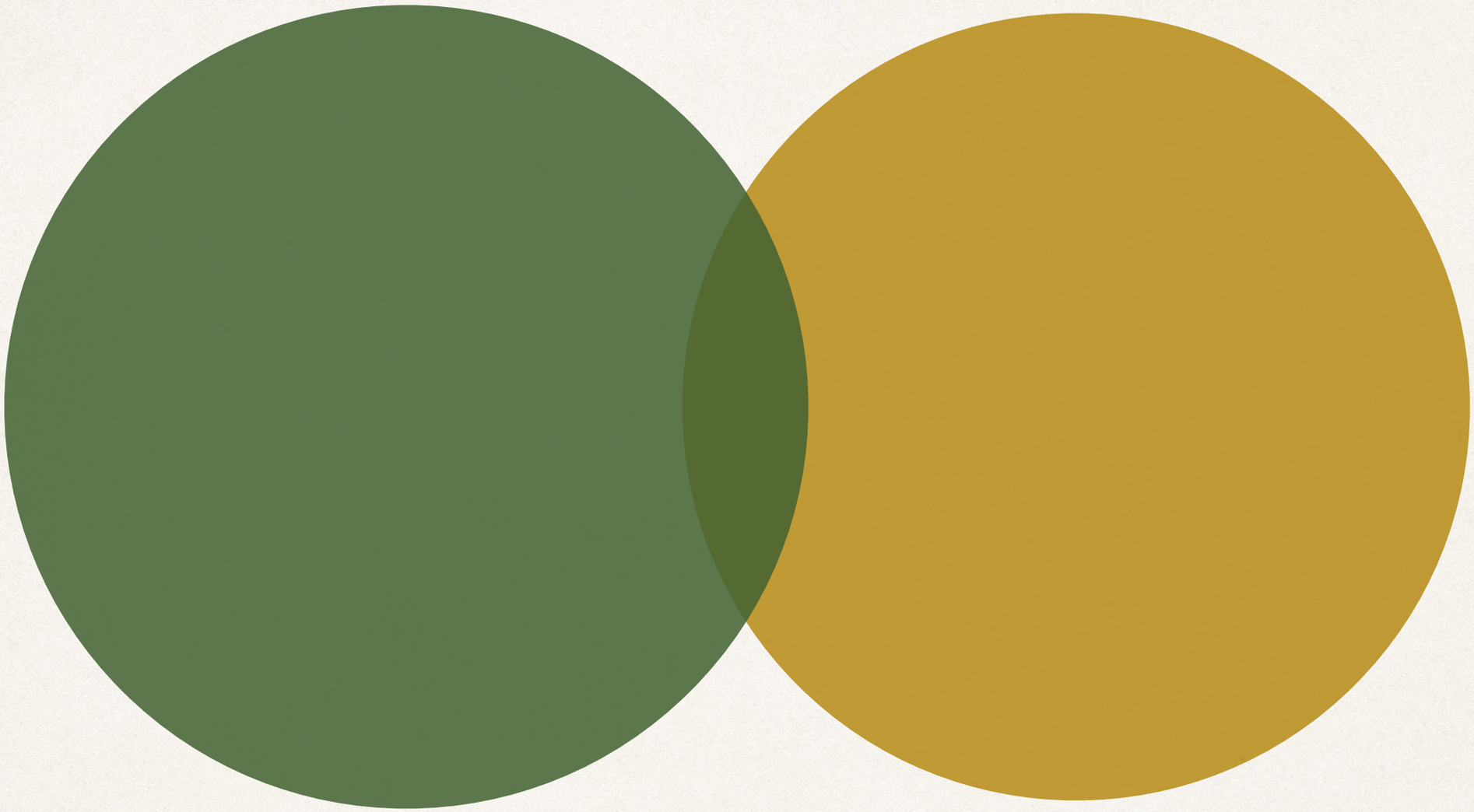


Values you wish to scale

Technological solutions

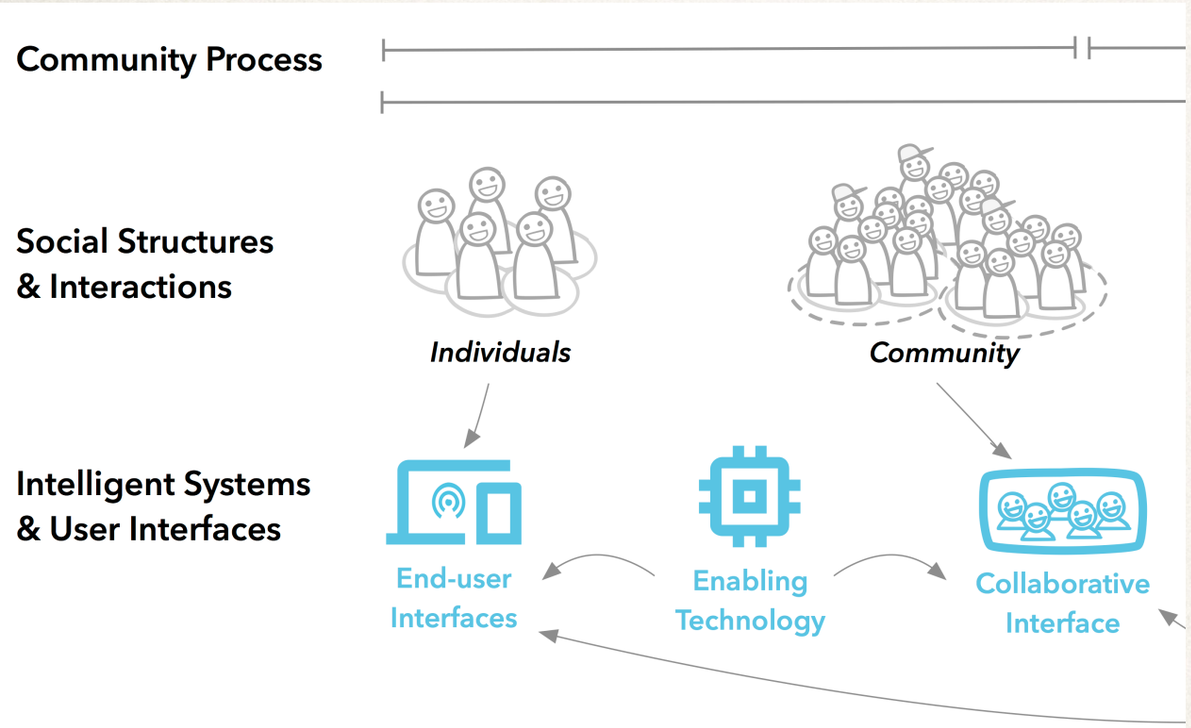


“Technological values”



Values you wish to scale

Mindful of values.
Accept the limits of technology.
Learn to scale.

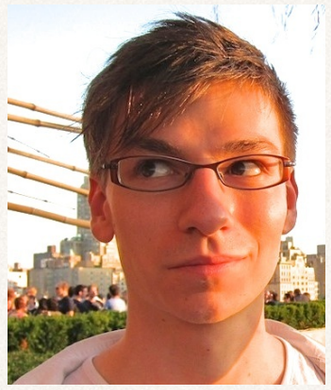


- **Ecological thinking**: create sustainable processes and interactions that foreground the intrinsic value of human engagement

- **Computational thinking**: decompose and distribute problem solving to diverse people or machines

Cobi

Community Informed Planning



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thank you

agileresearch.io
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slides+readings: haoqizhang.com

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