CS122 Class 22: Visions (of better technology)

Dynabook prototype

Agenda

- ZC
- Lecture: HCI’s cycle of visions
- Seminar
- Project work time (~ 20 min)

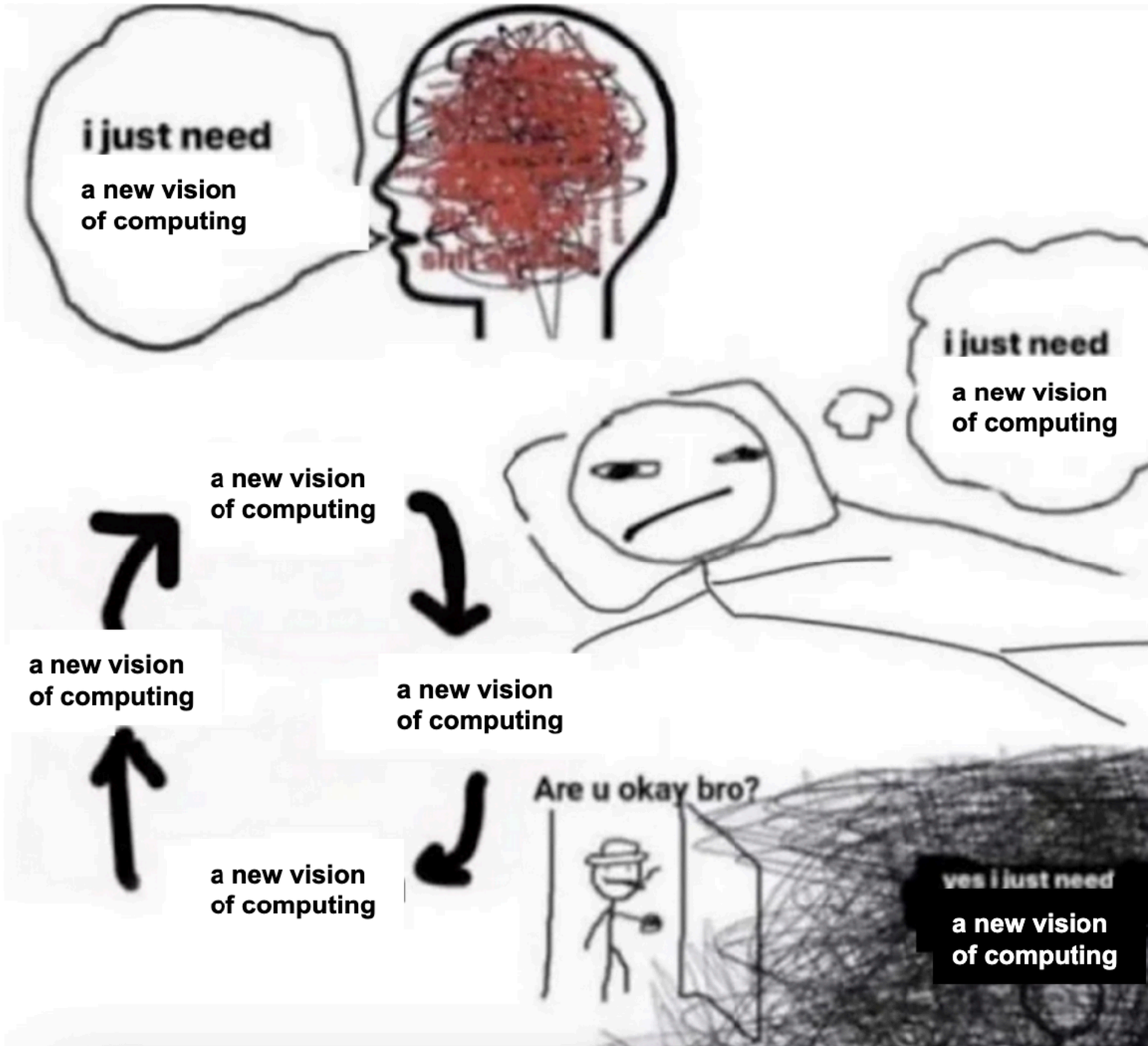
What's your ideal future?

What world do you want to live in?

How would you get people to get there with you?

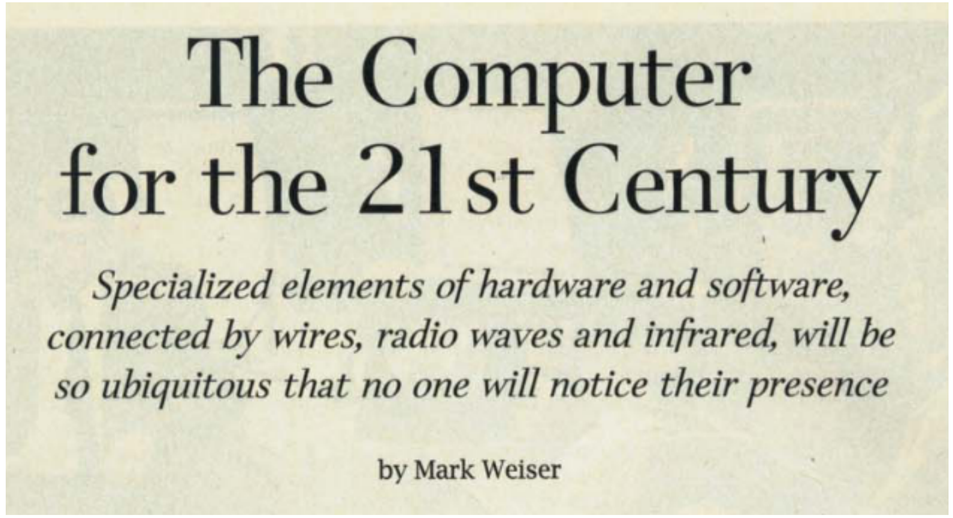
The Swan No. 9, Hilma af Klint (1913)

We do a lot of visioning in computer science, especially HCI.



Two epistemologies of HCI

- **Systems building:**
  Designing and evaluating new ways of interacting with computer technology

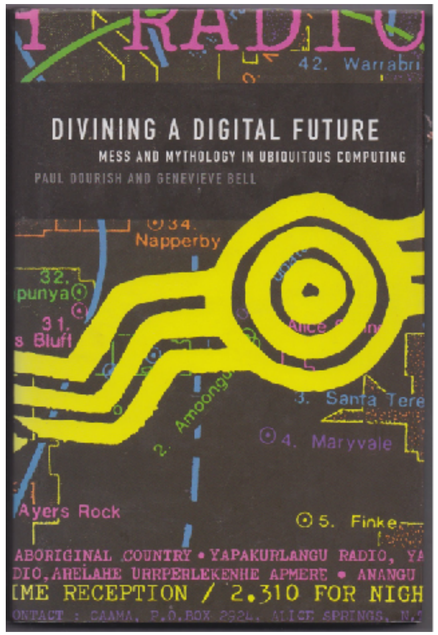

The Computer for the 21st Century

Specialized elements of hardware and software, connected by wires, radio waves and infrared, will be so ubiquitous that no one will notice their presence

by Mark Weiser

Mark Weiser. The Computer For the 21st Century. Scientific American. 1991

- **Descriptive/design methods:**
  Observing the use of computer technology in the real world



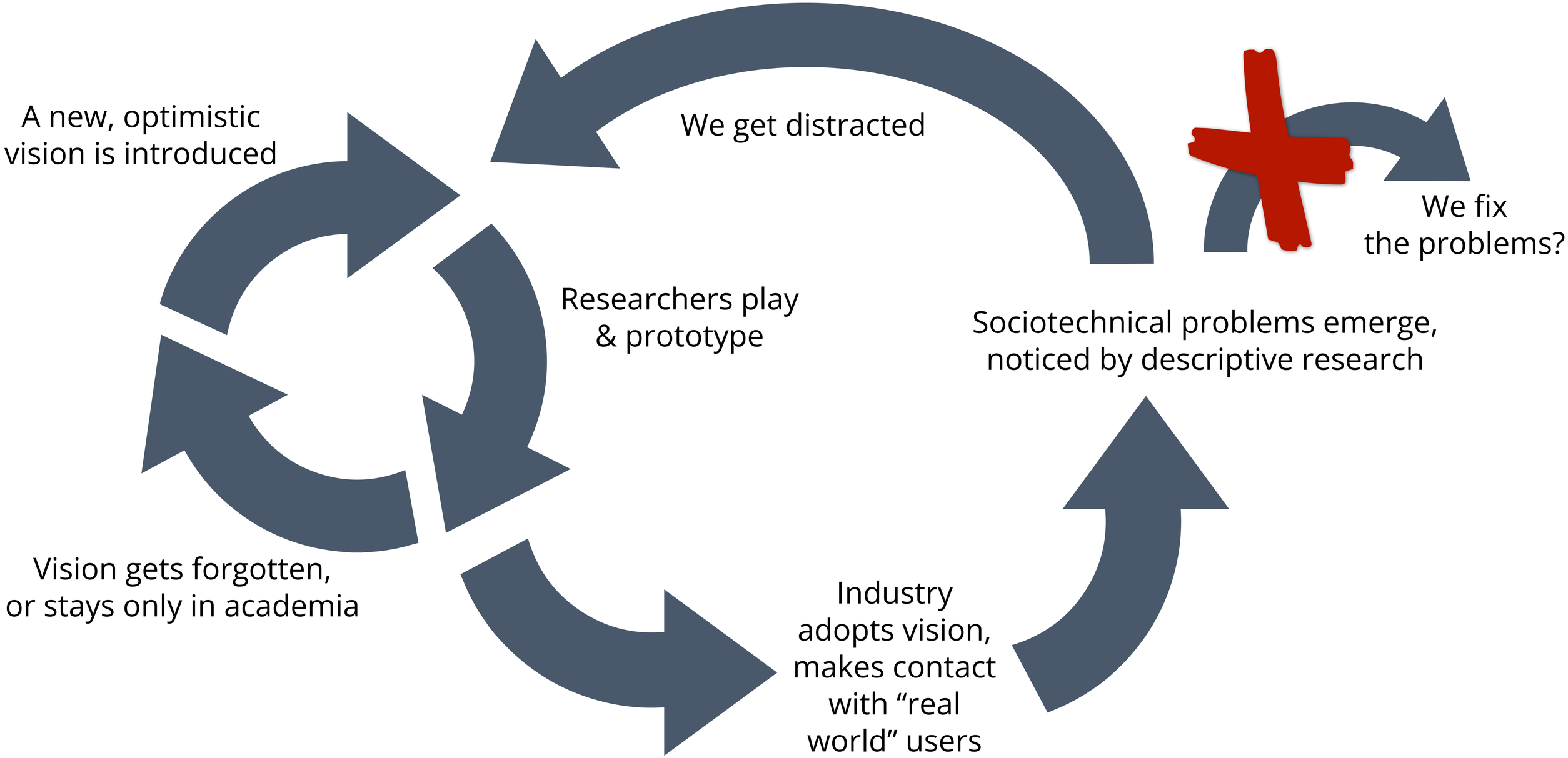
Paul Dourish and Genevieve Bell. Divining a Digital Future: Mess and Mythology in Ubiquitous Computing. MIT Press. 2011 (https://dl.acm.org/doi/10.5555/2018772)

HCI incentivizes visioning

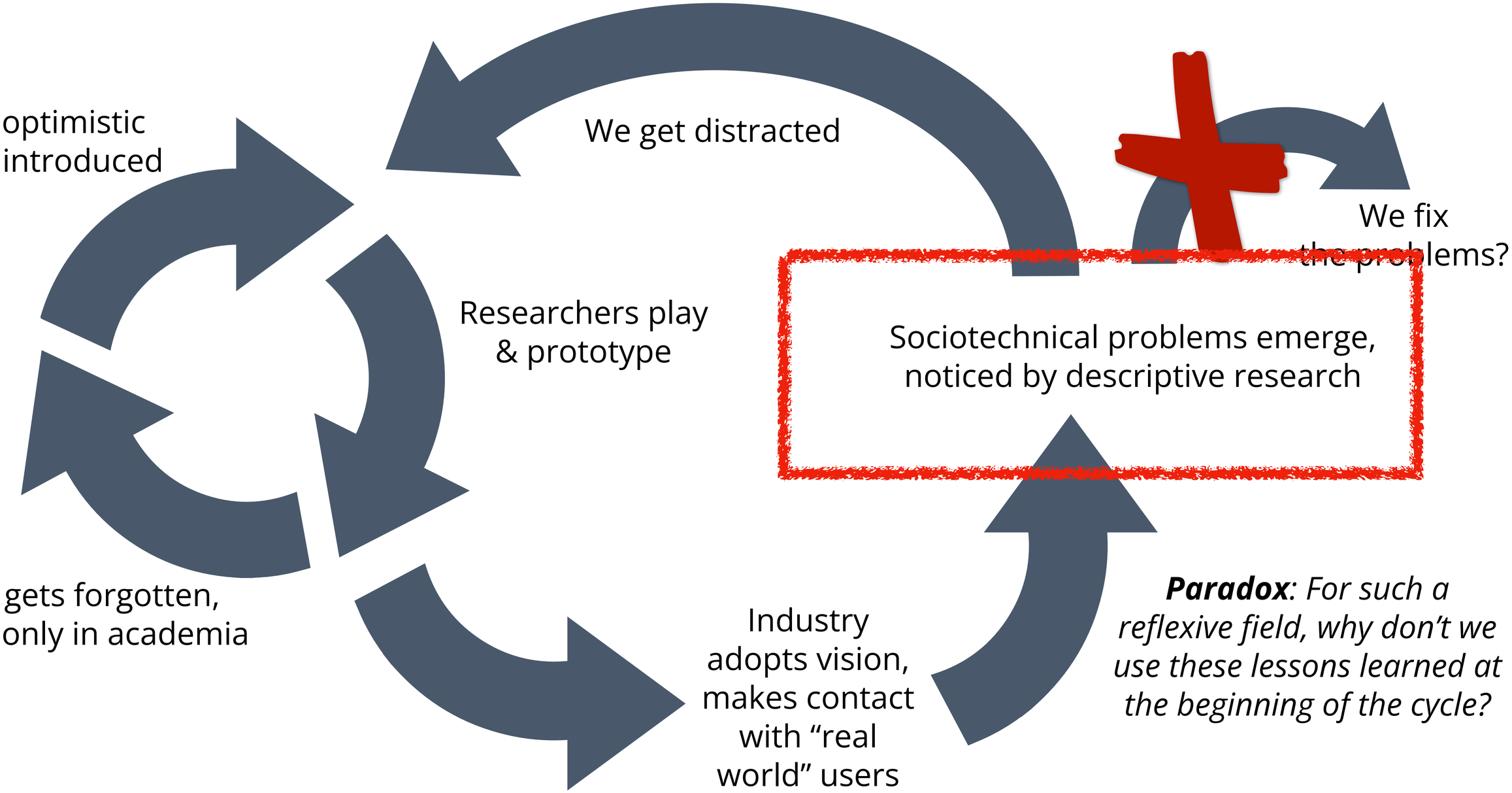
- In technical HCI, creativity and unconstrained ideation are often valued over practicality
- Influential visions are celebrated contributions to the research community
- This creates a **bias against the present**, where it's (1) easier and (2) more rewarded to create or expand visions than it is to address current-day problems

Isabelle Stegners. Another Science is Possible: A Manifesto for Slow Science. Polity. 2017

Technical HCI's cycle of visions

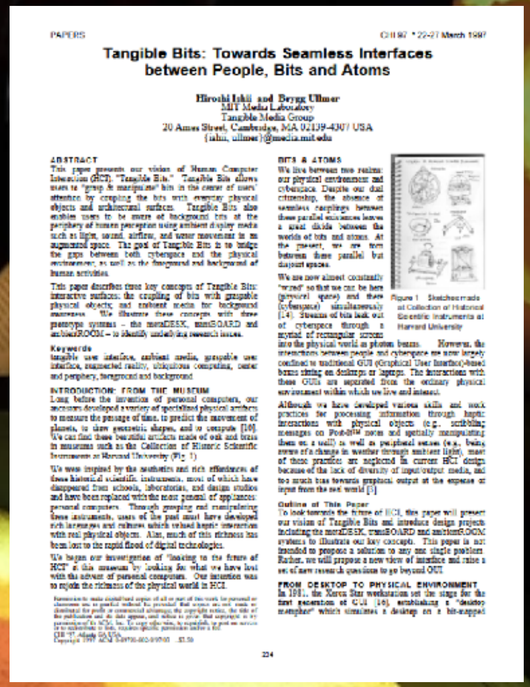


Technical HCI's cycle of visions



Example vision: Tangible Bits

Hiroshi Ishii and Brygg Ulmer. Tangible bits: towards seamless interfaces between people, bits and atoms. CHI 1997 (https://doi.org/10.1145/258549.258715)



PAPERS CHI 97 • 22-27 March 1997

Tangible Bits: Towards Seamless Interfaces between People, Bits and Atoms

Hiroshi Ishii and Brygg Ulmer
MIT Media Laboratory
Tangible Media Group
20 Ames Street, Cambridge, MA 02139-4307 USA
{ishii, ullmer}@media.mit.edu

ABSTRACT
This paper presents our vision of Human Computer Interaction (HCI): "Tangible Bits." Tangible Bits allows users to "grasp & manipulate" bits in the center of users' attention by coupling the bits with everyday physical objects and architectural surfaces. Tangible Bits also enables users to be aware of background bits at the periphery of human perception using ambient display media such as light, sound, airflow, and water movement in an augmented space. The goal of Tangible Bits is to bridge the gaps between both cyberspace and the physical environment, as well as the foreground and background of human activities.

This paper describes three key concepts of Tangible Bits: interactive surfaces; the coupling of bits with graspable physical objects; and ambient media for background awareness. We illustrate these concepts with three prototype systems – the metaDESK, transBOARD and ambientROOM – to identify underlying research issues.

Keywords
tangible user interface, ambient media, graspable user interface, augmented reality, ubiquitous computing, center and periphery, foreground and background

INTRODUCTION: FROM THE MUSEUM
Long before the invention of personal computers, our ancestors developed a variety of specialized physical artifacts to measure the passage of time, to predict the movement of planets, to draw geometric shapes, and to compute [10]. We can find these beautiful artifacts made of oak and brass in museums such as the Cabinet of Historic Scientific Instruments at Harvard University (Fig. 1).

We were inspired by the aesthetics and rich affordances of these historical scientific instruments, most of which have disappeared from schools, laboratories, and design studios and have been replaced with the near ubiquity of appliance-like personal computers. Through grasping and manipulating these instruments, users of the past must have developed rich intimacies and richness which valued haptic interaction with real physical objects. Alas, much of this richness has been lost in the rapid flood of digital technologies.

We began our investigation of "leaving to the future of HCI" at this museum by looking for what we have lost with the advent of personal computers. Our intention was to reclaim the richness of the physical world in HCI.

BITS & ATOMS
We live between two realms: our physical environment and cyberspace. Despite our dual citizenship, the absence of seamless couplings between these parallel existences leaves a great divide between the worlds of bits and atoms. At the present, we are torn between these parallel but disjoint spaces.

We are now almost constantly "wired" so that we can be here (physical space) and there (cyberspace) simultaneously [14]. Streams of bits leak out of cyberspace through a myriad of rectangular screens into the physical world as photon beams. However, the interactions between people and cyberspace are now largely confined to traditional GUI (Graphical User Interface)-based boxes sitting on desktops or laptops. The interactions with these GUIs are separated from the ordinary physical environment within which we live and interact.

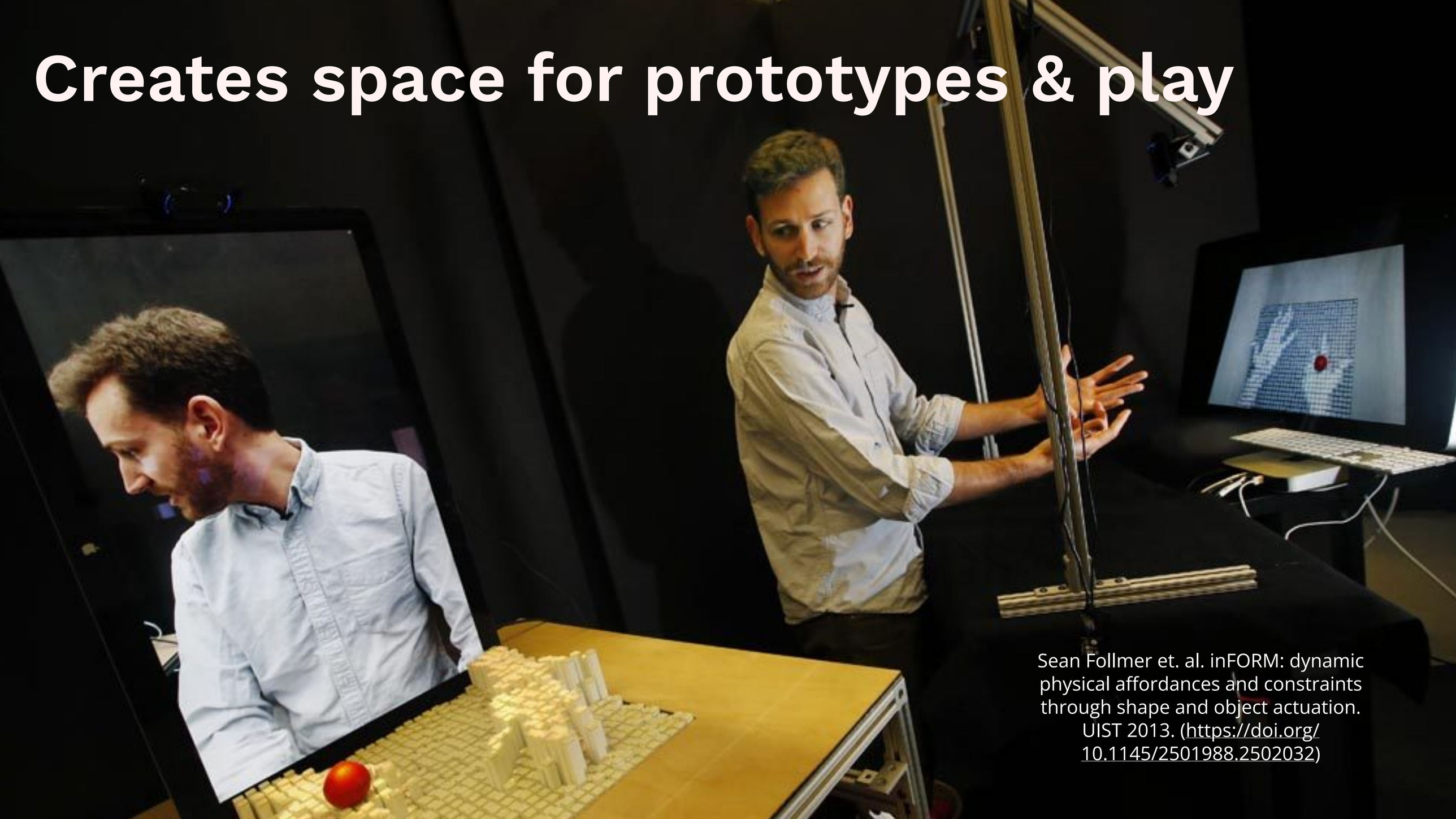
Figure 1. Sketches made at Collection of Historical Scientific Instruments at Harvard University

Although we have developed various skills and work practices for processing information through haptic interactions with physical objects (e.g., scribbling messages on Post-It™ notes and spatially manipulating them on a wall) as well as peripheral senses (e.g., being aware of a change in weather through ambient light), most of these practices are neglected in current HCI design because of the lack of diversity of input/output media, and too much bias towards graphical output at the expense of input from the real world [1].

Outline of This Paper
To look towards the future of HCI, this paper will present our vision of Tangible Bits and introduce design projects including the metaDESK, transBOARD and ambientROOM systems to illustrate our key concepts. This paper is not intended to propose a solution to any one single problem. Rather, we will propose a new view of interface and raise a set of new research questions to go beyond GUI.

FROM DESKTOP TO PHYSICAL ENVIRONMENT
In 1991, the Xerox Star workstation set the stage for the next generation of GUI [18], establishing a "desktop metaphor" which simulates a desktop on a bit-mapped

Creates space for prototypes & play



Sean Follmer et. al. inFORM: dynamic physical affordances and constraints through shape and object actuation. UIST 2013. (https://doi.org/10.1145/2501988.2502032)

A few other visions in HCI

Radical Atoms

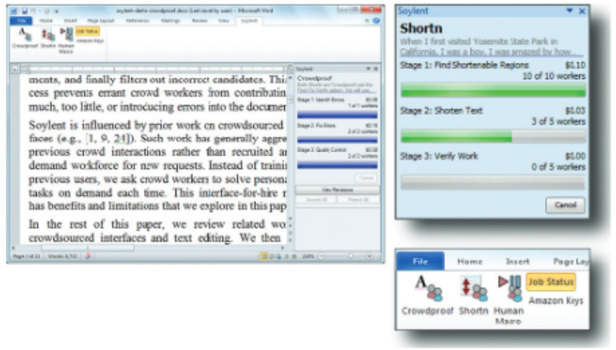
Hiroshi Ishii et. al. Radical atoms: beyond tangible bits, toward transformable materials. ACM Interactions. 2012. (https://doi.org/10.1145/2065327.2065337)

Olfactory interfaces

Jas Brooks et. al. Augmented Breathing via Thermal Feedback in the Nose. UIST 2024. (https://doi.org/10.1145/3654777.3676438).

Mixed reality & head mounted displays

Steve Mann. Personal Imaging. PhD Thesis, 1997 (http://hdl.handle.net/1721.1/45496)



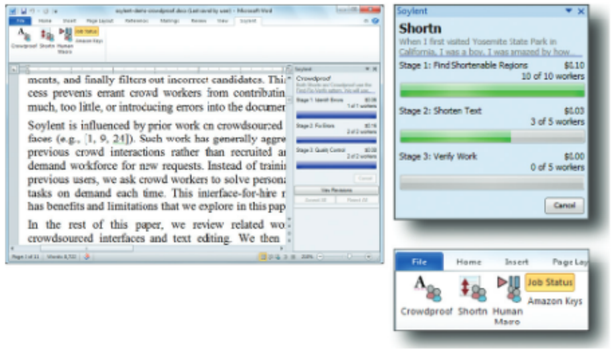
Crowdsourcing

Michael Bernstein et. al. Soylent: a word processor with a crowd inside. UIST 2010. (https://dl.acm.org/doi/10.1145/2791285).

A few other visions in HCI that have escaped to the real world

Mixed reality & head mounted displays

Steve Mann. Personal Imaging. PhD Thesis, 1997 (http://hdl.handle.net/1721.1/45496)



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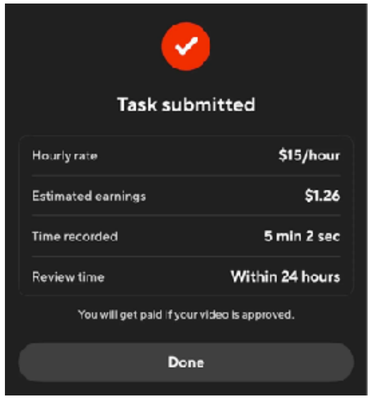
Michael Bernstein et. al. Soylent: a word processor with a crowd inside. UIST 2010. (https://dl.acm.org/doi/10.1145/2791285).



Industry partners are critical to real-world vision adoption

CHI 2026 Sponsors

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Mohamed bin Zayed University of Artificial Intelligence

Contributing Sponsors

AUTODESK

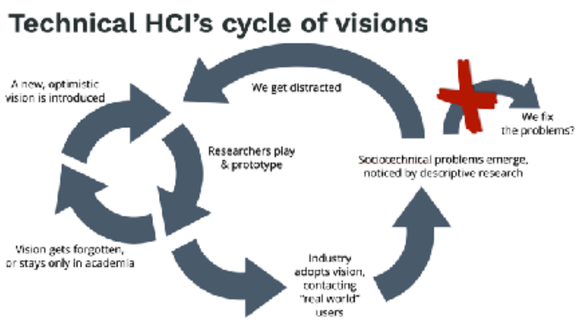
Bill Buxton. A multi-touch three dimensional touch-sensitive tablet. CHI 1985. https://www.billbuxton.com/leebuxtonsmith.pdf

Steve Jobs introducing iPhone multi-touch capabilities during Macworld keynote, 2007.

But because researchers don't control the **afterlives** of their visions, gaps between vision and reality can emerge.

HCI’s cyclical visions: Talk outline

Introduction



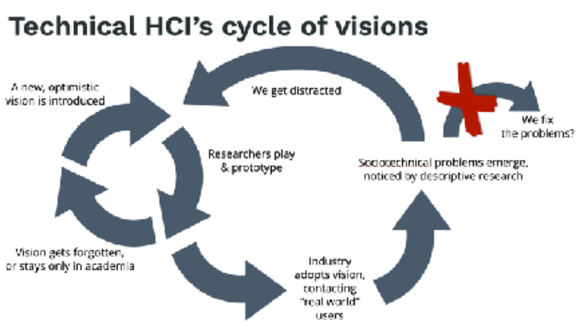
Case study #1: Ubicomp

Case study #2: Malleable Software

What now?

HCI’s cyclical visions: Talk outline

Introduction



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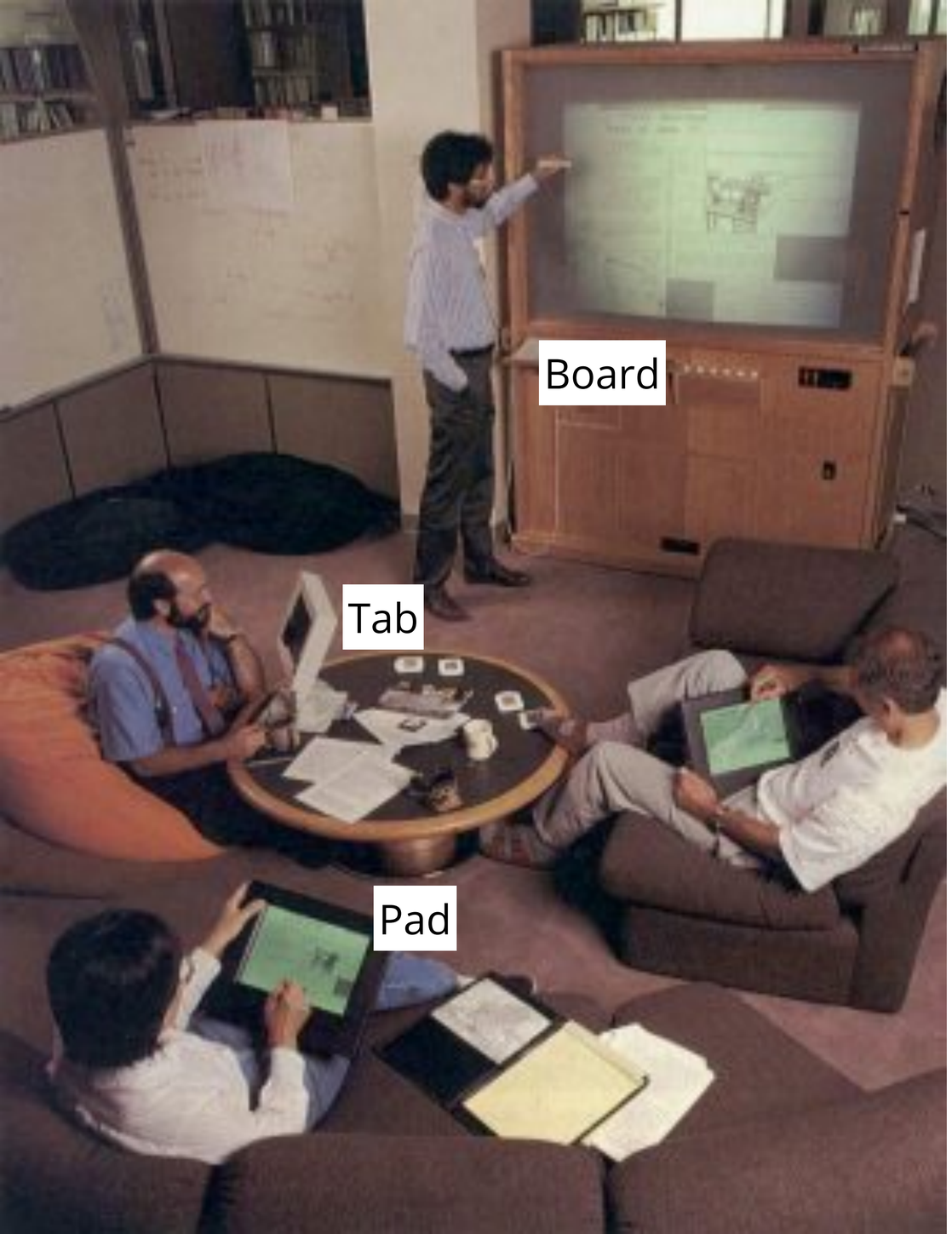


Ubiquitous computing

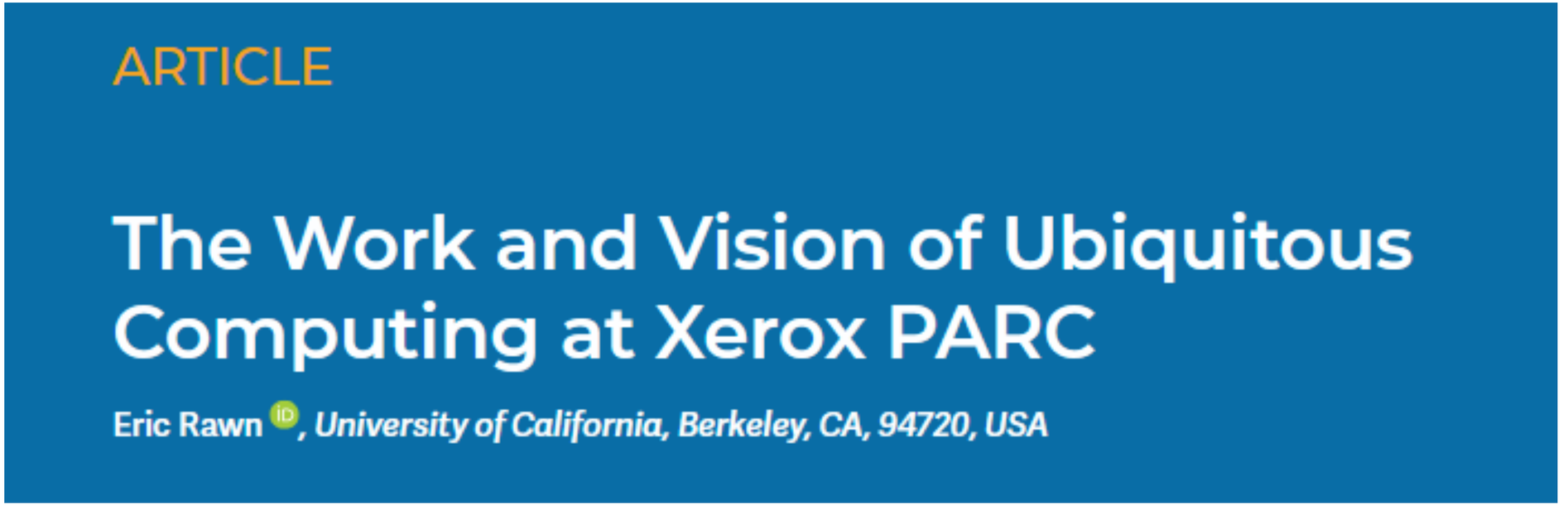
The Computer for the 21st Century

Specialized elements of hardware and software, connected by wires, radio waves and infrared, will be so ubiquitous that no one will notice their presence

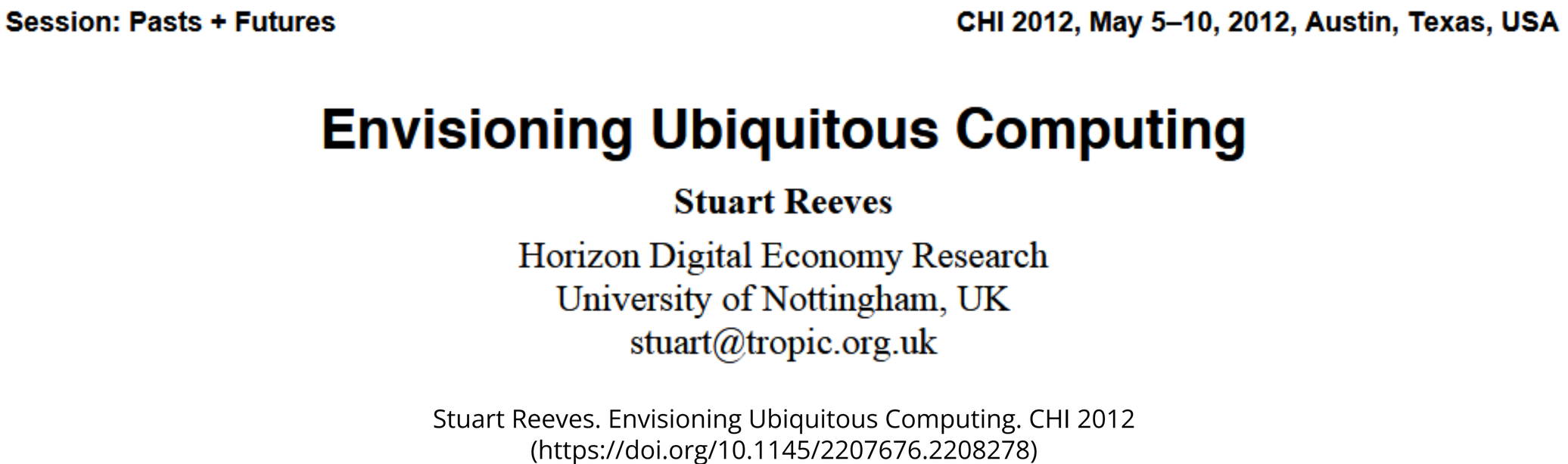
by Mark Weiser

- Developed by Mark Weiser at Xerox PARC in the late 1980s
- Computers will “fade into the fabric of every day life”

Mark Weiser. The Computer For the 21st Century. Scientific American. 1991



Eric Rawn. The Work and Vision of Ubiquitous Computing at Xerox PARC. IEEE Annals of the History of Computing. 2026. (https://doi.org/10.1109/MAHC.2024.3371908)



Stuart Reeves. Envisioning Ubiquitous Computing. CHI 2012 (https://doi.org/10.1145/2207676.2208278)

As a vision expands, it gains supporting infrastructure

Home > What we do > Browse our areas of investment and support > Pervasive and ubiquitous computing

Area of investment and support

UK Research and Innovation

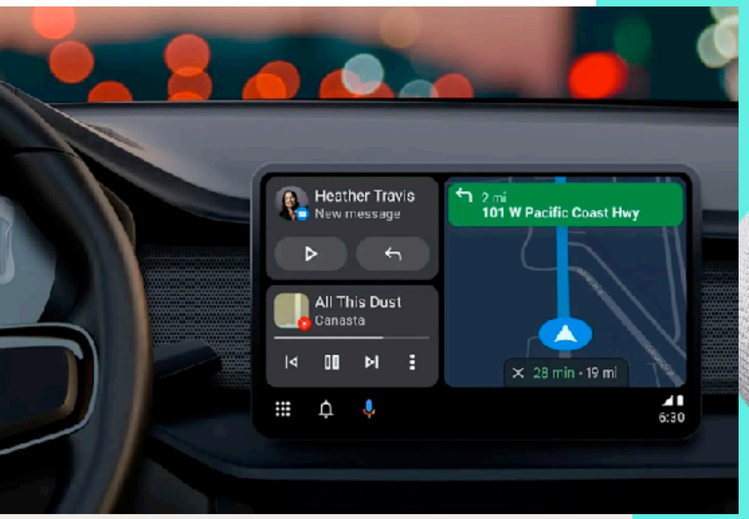
Pervasive and ubiquitous computing

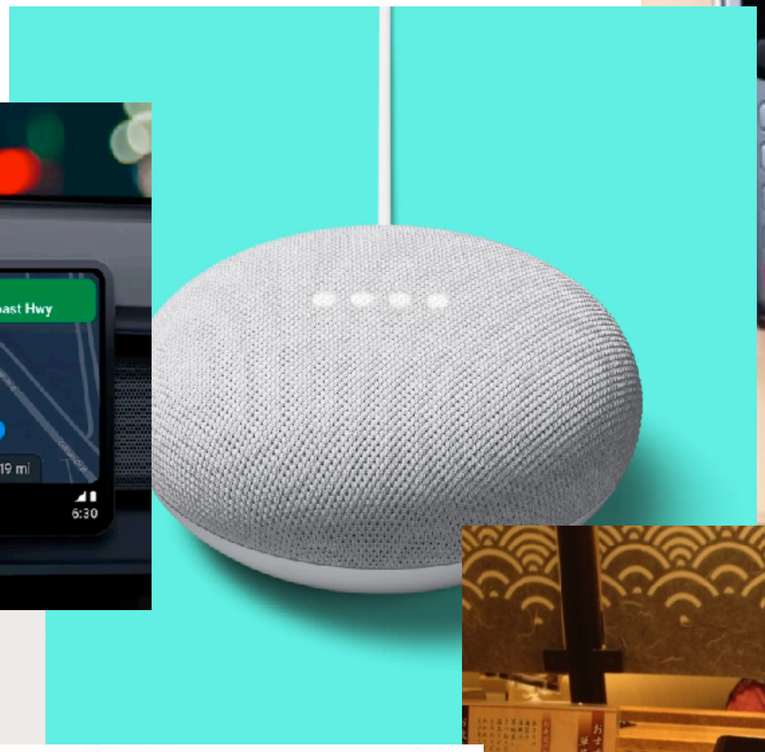
intel labs

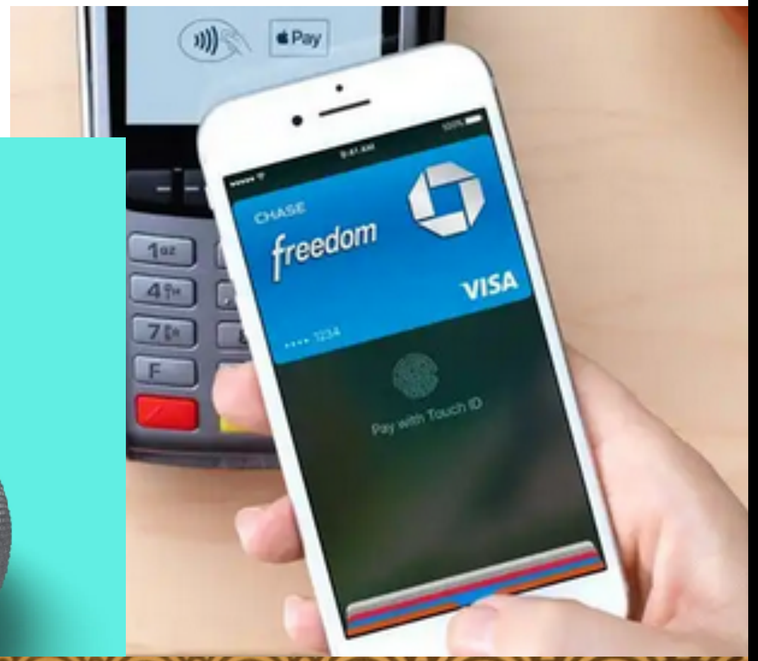
Proceedings of the ACM on *Interactive, Mobile, Wearable and Ubiquitous Technologies*

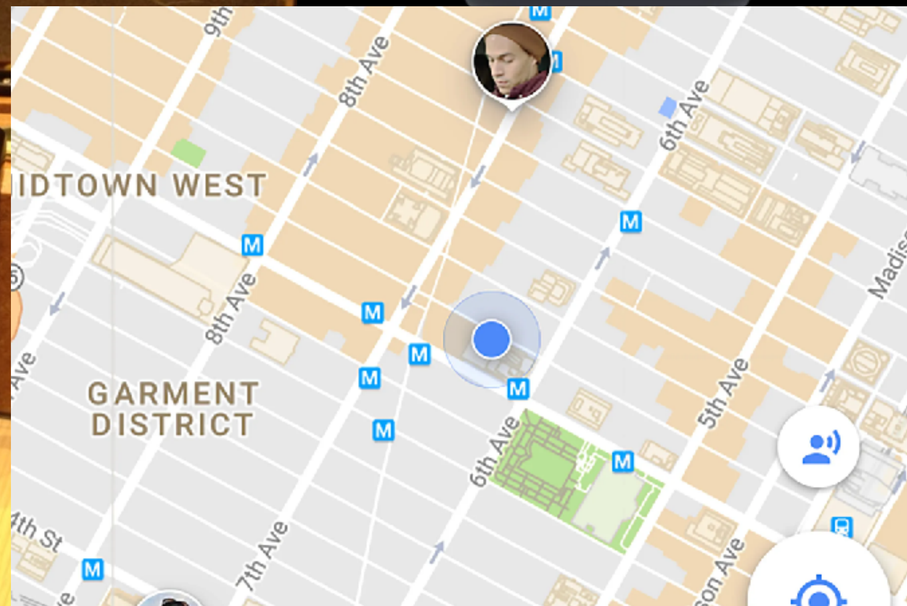
UbiComp ISWC 2026

Ubicomp came true

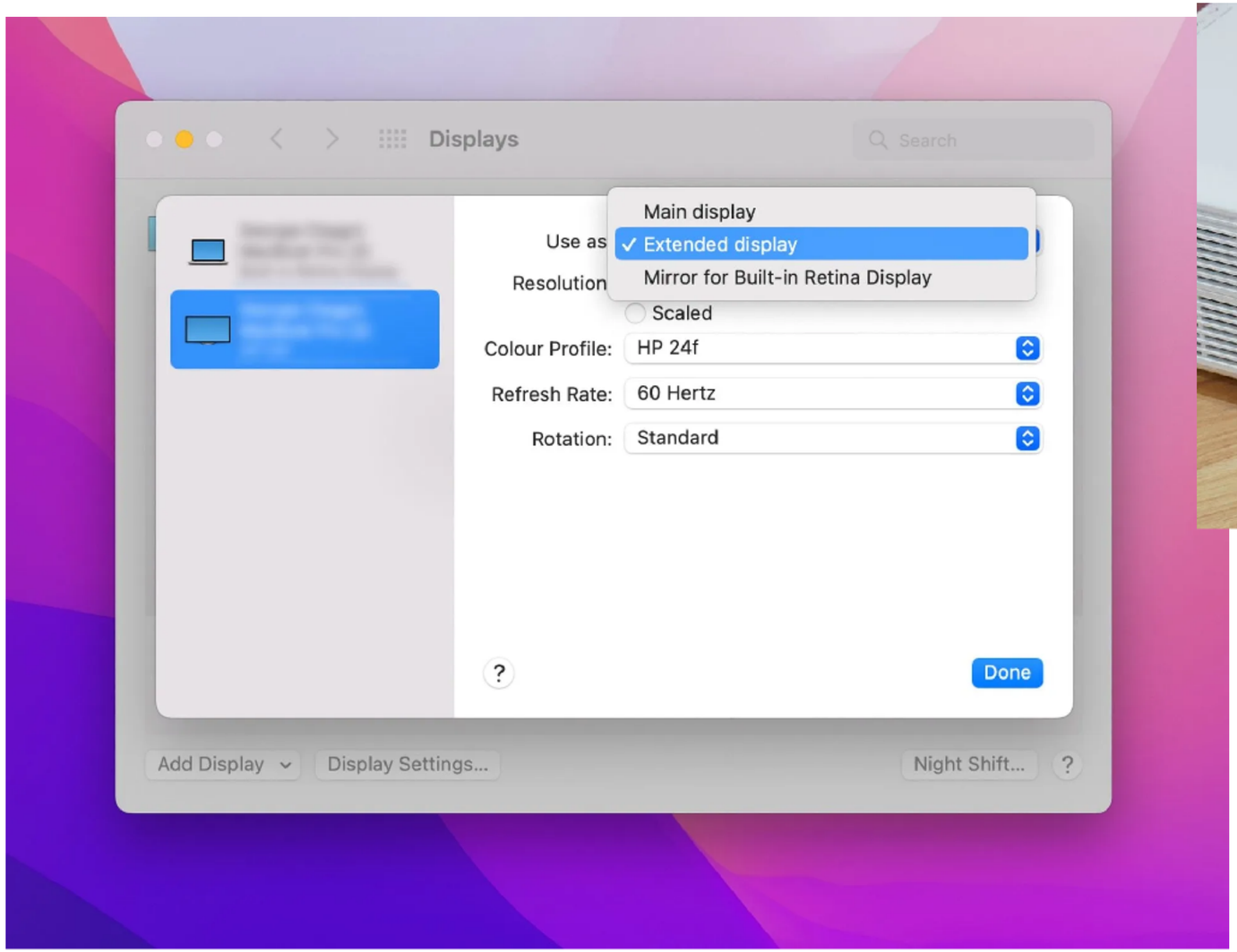








Ubicomp came true…except when entering a new environment

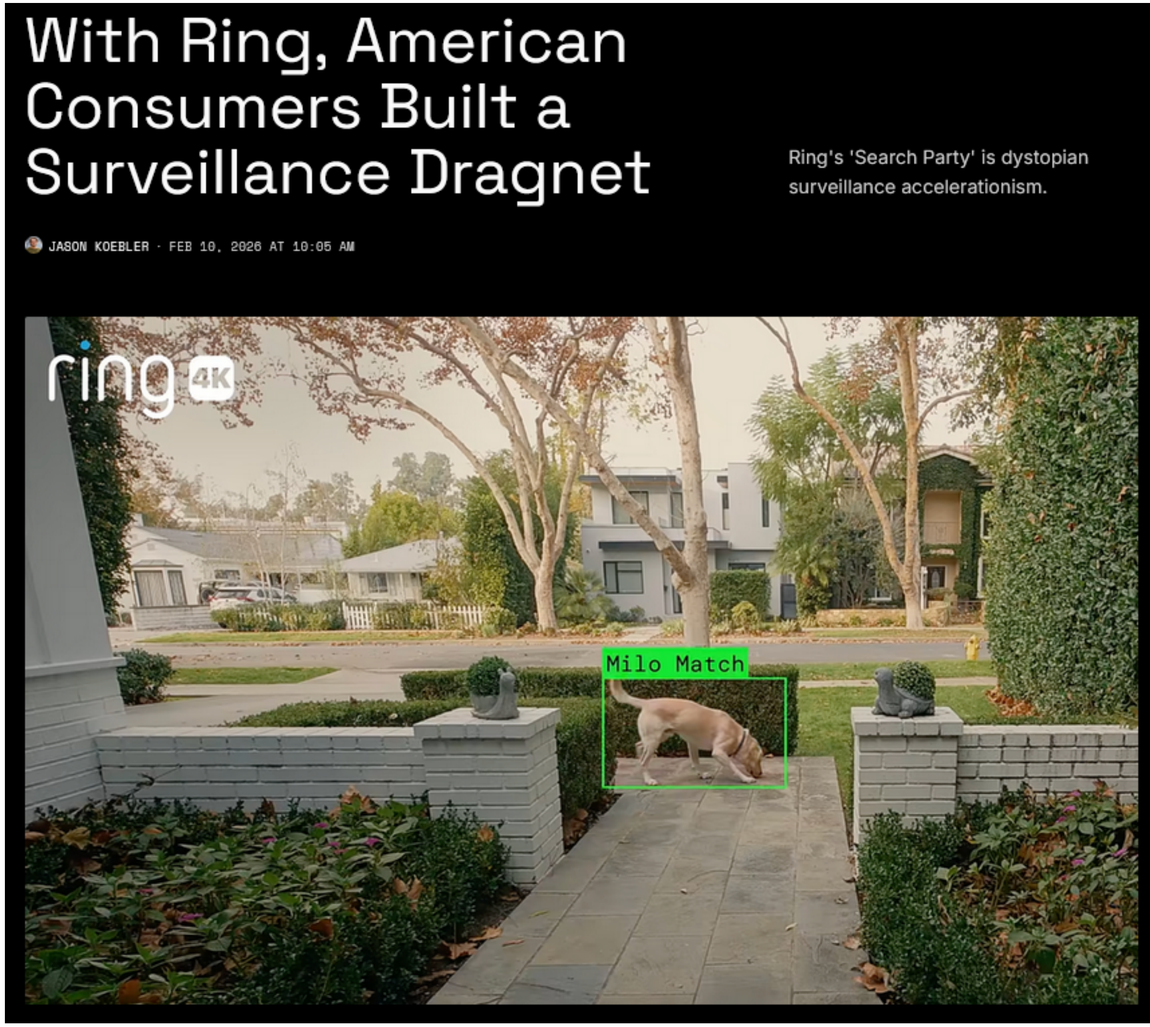


Ubicomp came true...with walled gardens instead of seamlessness

Apple device ecosystem

Google device ecosystem

Ubicomp came true…to enable the surveillance state



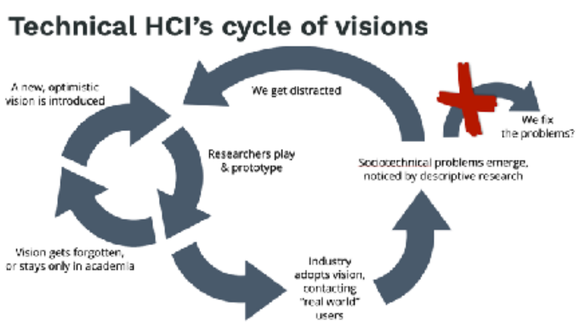
Vision	Reality	Sociotechnical difficulty
Technology fades into the background	Frequent breakdown / usability challenges (projector)	Lack of incentive to work on “boring” UX problems
Seamless interoperation between devices	Friction at boundaries of vendors / ecosystems (Airpods with Android)	Limited cooperation incentives for corporate actors
Positive impact - beneficial, enabling technology	Allows unprecedented extension of surveillance (Ring camera)	Ease of capture & control of technology by corporate/ government actors

Once we've recognized these sociotechnical problems in one domain...

- Why don't researchers or industry actors dedicate more resources to fixing the problems?
- Why don't we recognize—or choose to not ignore—when the same embedded, predictable sociotechnical gaps exist in our new visions, so we can intervene before the technological infrastructure becomes entrenched?

HCI’s cyclical visions: Talk outline

Introduction



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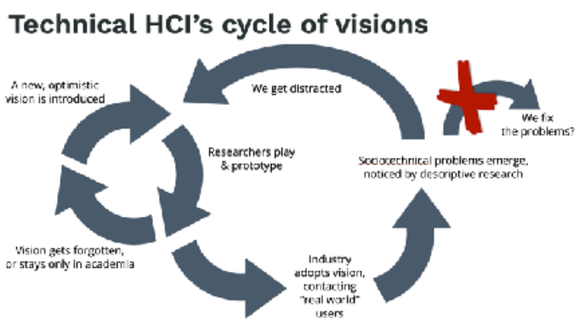
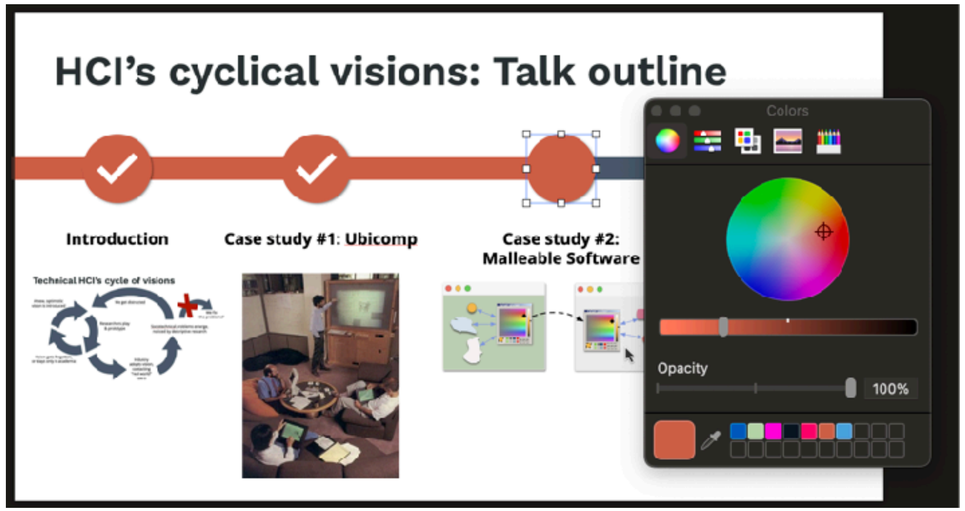


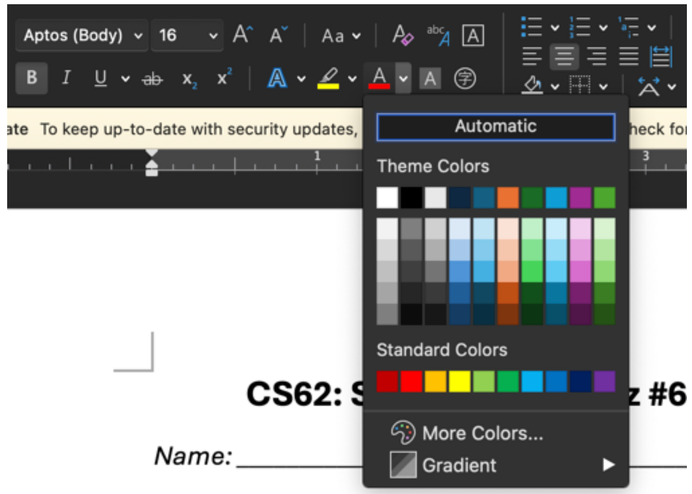
Case study #1: Ubicomp

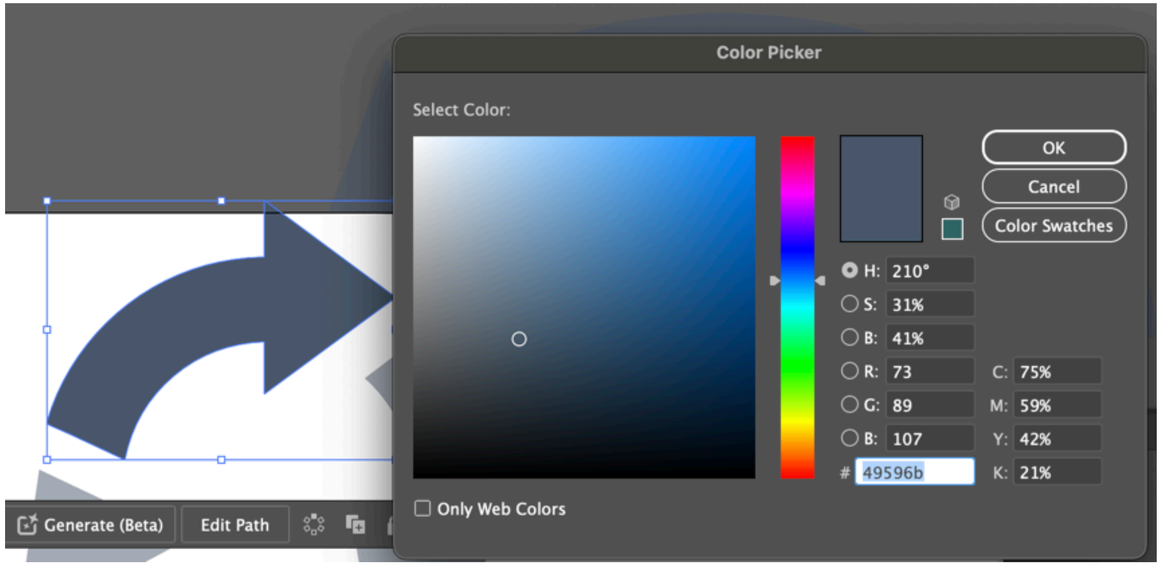
Case study #2: Malleable Software

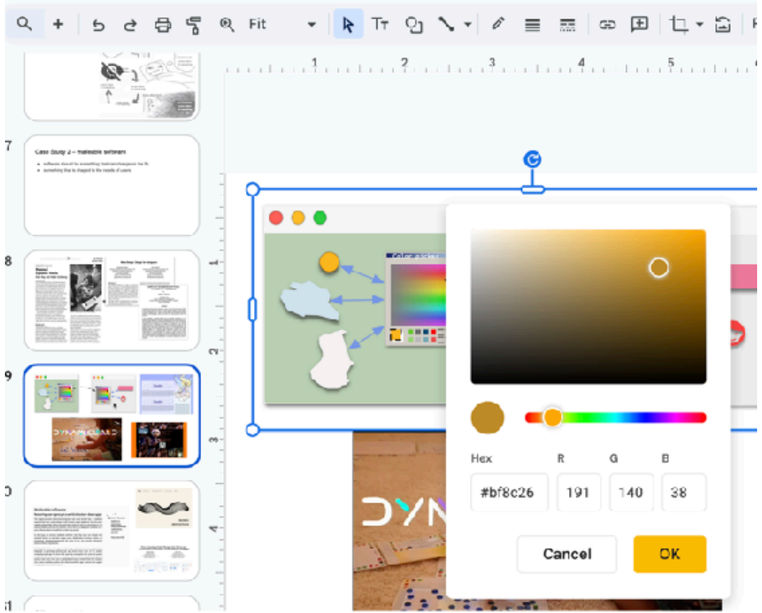
What now?

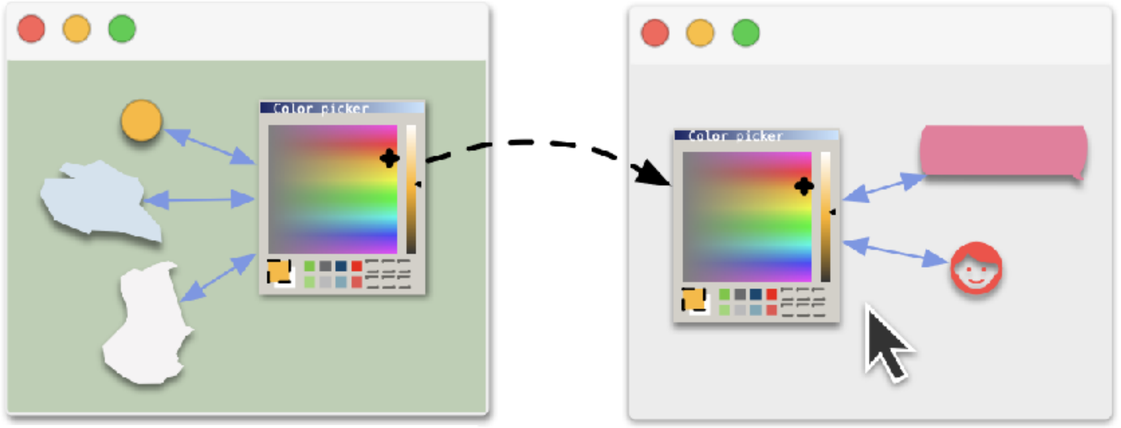
Why does each app have its own color picker?











Memphis Chernotá. Designing and Programming Malleable Software. PhD thesis 2020.

Template from Jelly Neo

***Webstrates*: Shareable Dynamic Media**

Clemens N. Klokmose[1], James R. Eagan[2,3], Siemen Baader[1], Wendy Mackay[4,5,3] & Michel Beaudouin-Lafon[5,3,4]
[1]Aarhus University, [2]Télécom ParisTech, [3]CNRS, [4]INRIA, [5]Université Paris-Sud
clemens@cs.au.dk, james.eagan@telecom-paristech.fr, sb@cs.au.dk, {mackay, mbl}@lri.fr

Figure 1: Sample uses of *Webstrates*: (a) Collaborative document authoring with different editors personalized at run-time; (b) Multiple devices used to sketch a figure (tablet 1), see it in a print preview (tablet 2), and adjust it in a graphics editor (laptop). (c) Distributed talk controlled remotely by a speaker with a separate interface for audience participation.

Clemens Klokmose et al. Webstrates: Shareable Dynamic Media. UIST 2015. (https://dl.acm.org/doi/epdf/10.1145/2807442.2807446)

Brett Victor. Dynamicland. https://dynamicland.org

Myspace

Original Publication
Computer 10(3):31–41. March 1977.

Personal Dynamic Media

Alan Kay and Adele Goldberg

Introduction

The Learning Research Group at Xerox Palo Alto Research Center is concerned with all aspects of the communication and manipulation of knowledge. We design, build, and use dynamic media which can be used by human beings of all ages. Several years ago, we crystallized our dreams into a design idea for a personal dynamic medium the size of a notebook (the *Dynabook*) which could be owned by everyone and could have the power to handle virtually all of its owner's information-related needs. Towards this goal we have designed and built a communications system: the Smalltalk language, implemented on small computers we refer to as "interim Dynabooks." We are exploring the use of this system as a programming and problem solving tool; as an interactive memory for the storage and manipulation of data; as a text editor; and as a medium for expression through drawing, painting, animating pictures, and composing and generating music. (Figure 26.1 is a view of this interim Dynabook.)

We offer this paper as a perspective on our goals and activities during the past years. In it, we explain the Dynabook idea, and describe a variety of systems we have already written in the Smalltalk language in order to give broad images of the kinds of information-related tools that might represent the kernel of a personal computing medium.

Background

Humans and Media

"Devices" which variously store, retrieve, or manipulate information in the form of messages embedded in a medium have been in existence for thousands of years. People use them to communicate ideas and feelings both to others and back to themselves. Although thinking goes on in one's head, external media serve to materialize thoughts and, through feedback, to augment the actual paths the thinking follows. Methods discovered in one medium provide metaphors which contribute new ways to think about notions in other media.

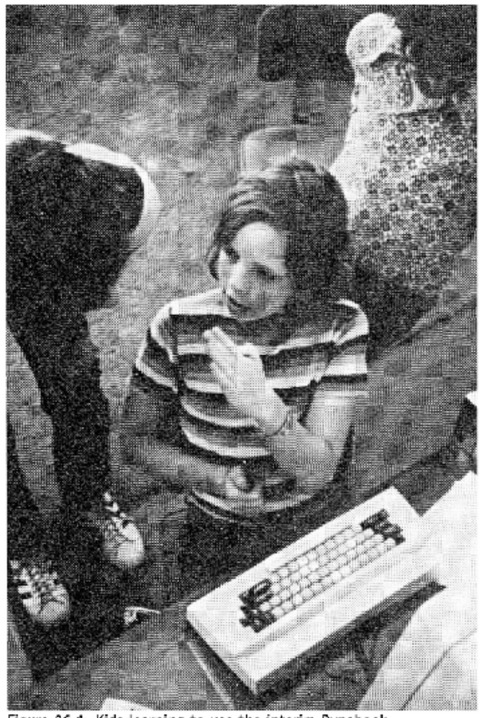


Figure 26.1. Kids learning to use the interim Dynabook.

For most of recorded history, the interactions of humans with their media have been primarily nonconversational and passive in the sense that marks on paper, paint on walls, even "motion" pictures and television, do not change in response to the viewer's wishes. A mathematical formulation—which may symbolize the essence of an entire universe—once put down on paper, remains static and requires the reader to expand its possibilities.

Every message is, in one sense or another, a *simulation* of some idea. It may be representational or abstract. The essence of a medium is very much dependent on the way messages are embedded, changed, and viewed. Although digital computers were originally designed to do arithmetic computation, the ability to simulate the details of any descriptive model means that the computer, viewed as a medium itself, can be *all other media* if the embedding and

Alan Kay and Adele Goldberg. Personal Dynamic Media. Computer. 1977 (https://doi.org/10.1109/C-M.1977.217672)

Meta-Design: Design for Designers

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ABSTRACT

One fundamental challenge for the design of the interactive systems of the future is to invent and design environments and cultures in which humans can express themselves and engage in personally meaningful activities. Unfortunately, a large number of new media are designed from a perspective of viewing and treating humans primarily as consumers. The possibility for humans to be and act as designers (in cases in which they desire to do so) should be accessible not only to a small group of "high-tech scribes," but rather to all interested individuals and groups. Meta-design characterizes activities, processes, and objectives to create new media and environments that allow users to act as designers and be creative.

In this paper we discuss problems addressed by our research on meta-design, provide a conceptual framework for meta-design, and illustrate our developments in the context of a particular system, the Envisionment and Discovery Collaboratory.

consumers, which creates a mindset of consumerism for the rest of their lives [15, 23]. Citizens often feel left out of decisions by

Gerhard Fischer and Eric Scharff. Meta-design: design for designers. DIS 2000. (https://doi.org/10.1145/347642.347798)

USERS AND CUSTOMIZABLE SOFTWARE: A CO-ADAPTIVE PHENOMENON

by

WENDY E. MACKAY

Submitted to the
Alfred P. Sloan School of Management
in partial fulfillment of the requirements for the degree of
Doctor of Philosophy.

Abstract

Co-adaptive phenomena are defined as those in which the environment affects human behavior and at the same time, human behavior affects the environment. Such phenomena pose theoretical and methodological challenges and are difficult to study in traditional ways. However, some aspects of the interaction between people and technology only make sense when such phenomena are taken into account.

In this dissertation, I postulate that the use of information technology is a co-adaptive phenomenon. I also argue that customizable software provides a particularly good testbed for studying co-adaptation because individual patterns of use are encoded and continue to influence user behavior over time. The possible customizations are constrained by the design of the software but may also be modified by users in unanticipated ways, as they appropriate the software for their own purposes. Because customization patterns are recorded in files that can be shared among users, these customizations may act to informally establish and perpetuate group norms of behavior. They also provide a mechanism by which individual behavior can influence global institutional properties and future implementations of the technology. The presence of these sharable artifacts makes it easier to study customization than related co-adaptive phenomena such as learning and user innovation. Because some mechanisms may be the same for all co-adaptive phenomena, findings about use of customizable software may also shed light on user's choices about when to learn new software and when to innovate.

Wendy Mackay. Users and Customizable Software: A Co-Adaptive Phenomenon. PhD Thesis, 1990. (http://hdl.handle.net/1721.1/14087)

Malleable software

Restoring user agency in a world of locked-down apps

The original promise of personal computing was a new kind of clay—a malleable material that users could reshape at will. Instead, we got appliances: built far away, sealed, unchangeable. When your tools don't work the way you need them to, you submit feedback and hope for the best. You're forced to adapt your workflow to fit your software, when it should be the other way around.

In this essay, we envision malleable software: tools that users can reshape with minimal friction to suit their unique needs. Modification becomes routine, not exceptional. Adaptation happens at the point of use, not through engineering teams at distant corporations.

Realizing this vision will require confronting many barriers. From programming languages to operating systems and app stores, every layer of the modern computing landscape has been built upon the assumption that users are passive recipients rather than active co-creators. What we need instead are computing systems that invite every user to gradually become a creator. Tools that compose into custom workflows, rather than siloed monolithic apps. Systems that support local groups in communal creation.

Ink & Switch

Geoffrey Litt
Josh Horowitz
Peter van Hardenberg
Todd Matthews

June 2025

Print / View as PDF

Geoffrey Litt et. al. Malleable Software: Restoring User Agency in a World of Locked Down Apps. Blog Post, 2025. (https://www.inkandswitch.com/essay/malleable-software/)

Sangho Suh et. al. Dynamic Abstractions: Building the Next Generation of Cognitive Tools and Interfaces. UIST 2024. (https://doi.org/10.1145/3672539.368670)

Peiling Jiang and Hiajun Xia. Orca: Browsing at Scale Through User-Driven and AI-Facilitated Orchestration Across Malleable Webpages. CHI 2026. (https://doi.org/10.1145/3772318.3790335)

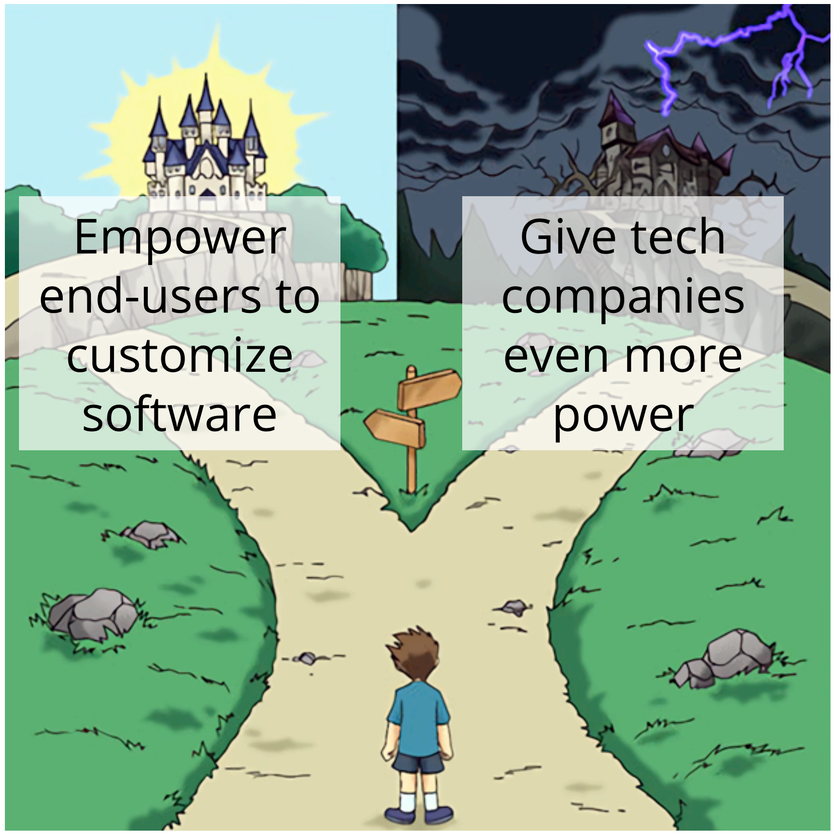
Malleable software's fork in the road

A new, optimistic vision is introduced

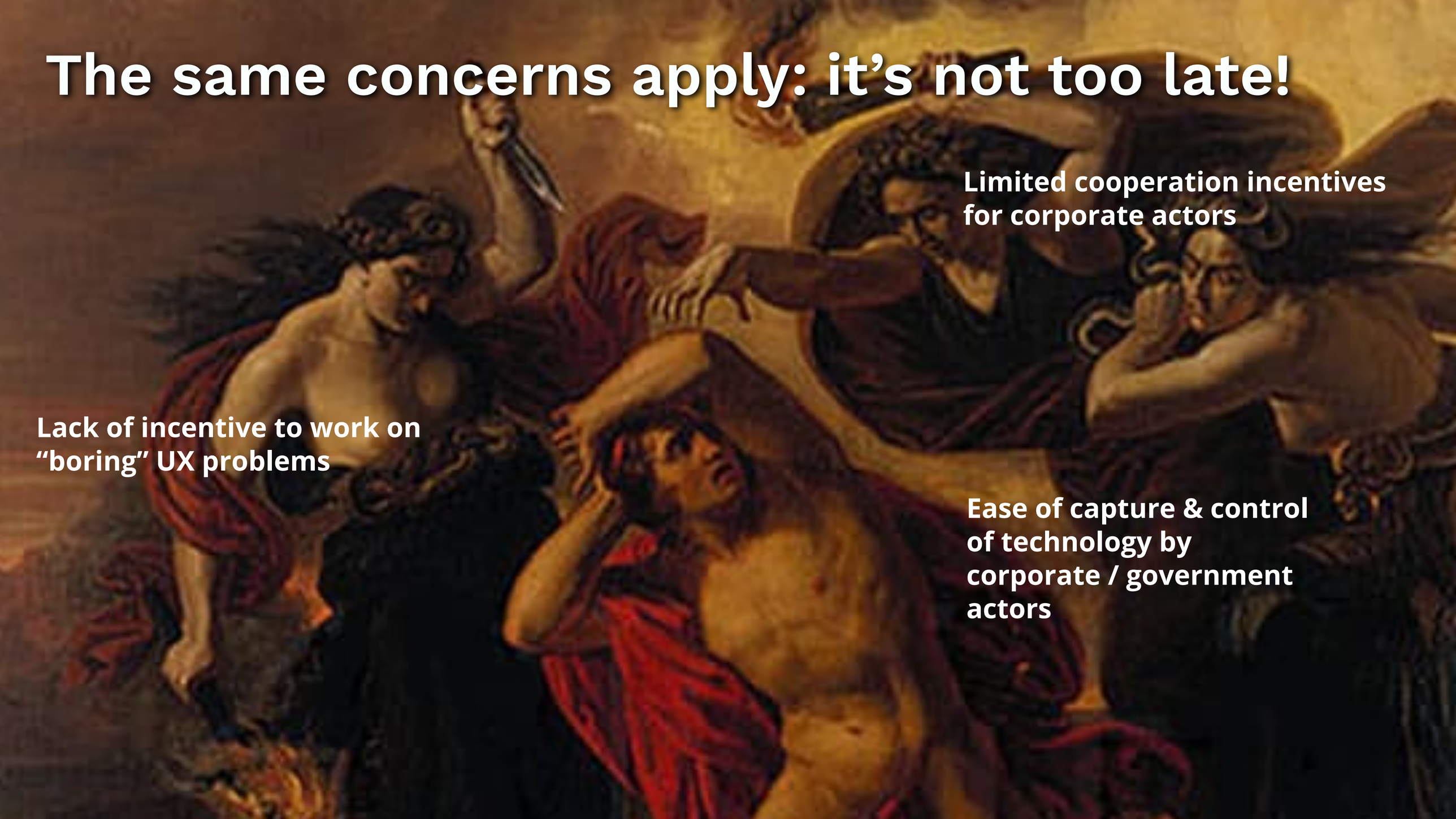
Researchers play & prototype

Industry adopts vision, contacting "real world" users

Vision gets forgotten, or stays only in academia



The same concerns apply: it’s not too late!



Limited cooperation incentives for corporate actors

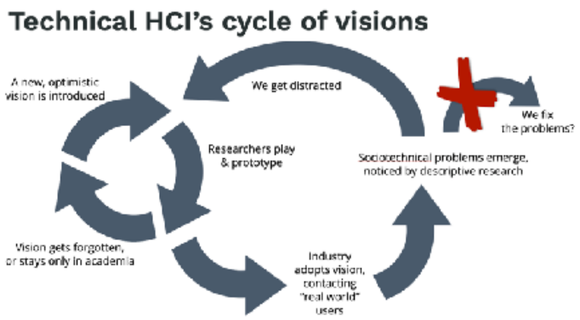
Lack of incentive to work on “boring” UX problems

Ease of capture & control of technology by corporate / government actors

Vision	Reality	Sociotechnical difficulty
Users have a specialized UI adapted to their specific needs	Users cannot understand black box software or recover from errors with their customized setup	Lack of incentive to work on “boring” UX problems
No more apps, everything is interoperable	Vendors are incentivized to financially trap users in their interoperable ecosystems (subscription models)	Limited cooperation incentives for corporate actors
Sharing personal data with LLM-powered tools allows even non-programmers to have malleable software	Sharing data with OpenAI creates unprecedented privacy problems & increased attack surface for surveillance	Ease of capture & control of technology by corporate / government actors

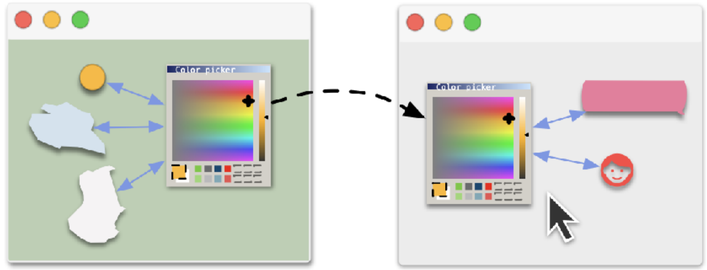
HCI’s cyclical visions: Talk outline

Introduction



Case study #1: Ubicomp

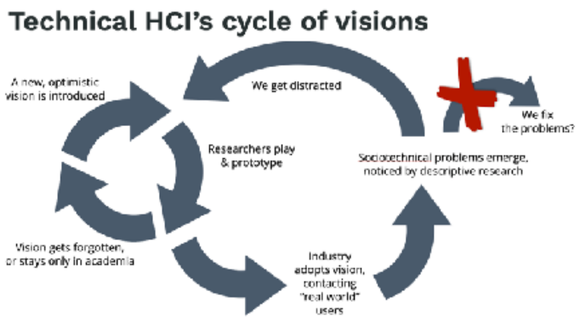
Case study #2: Malleable Software



What now?

HCI’s cyclical visions: Talk outline

Introduction



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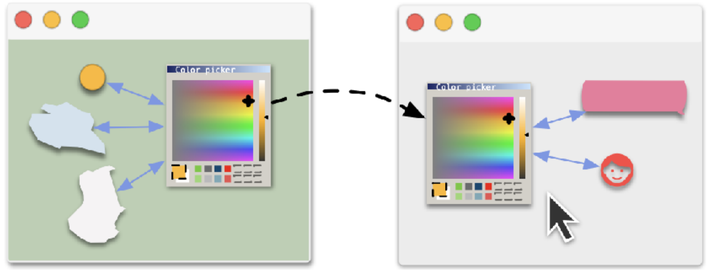
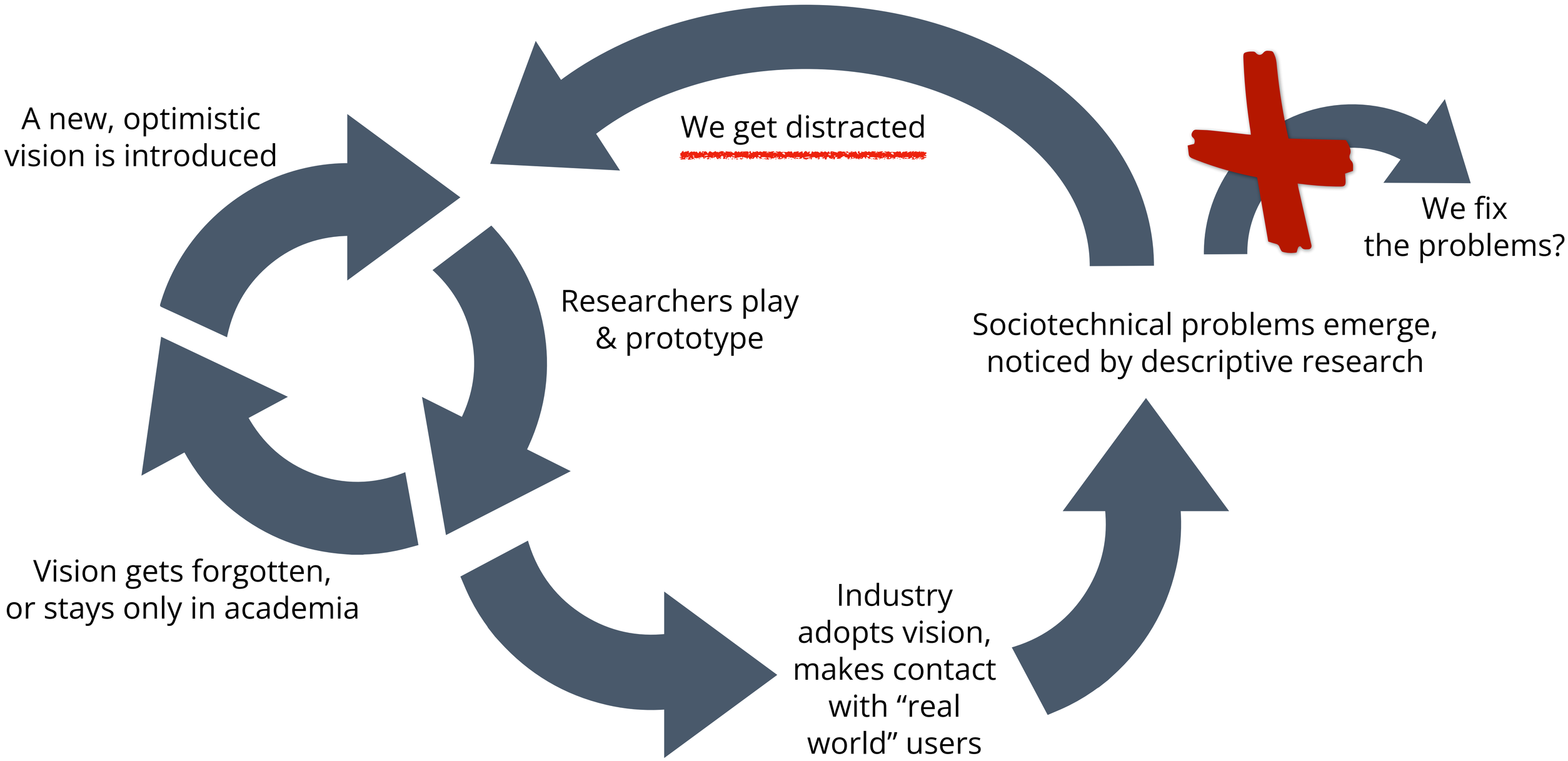


What now?

Why are we stuck here?



There is a rift between systems builders and qualitative researchers.

Do systems builders not know, or not care, about critical perspectives?

Cultural norms of unconstrained ideation

- Just as criticism is banned during brainstorming, critical perspectives can be sidelined to facilitate visioning
- Problems can always be dealt with at a *future* date…
- Specifying software at a high level of abstraction during the visioning phase obfuscates sociotechnical implementation realities

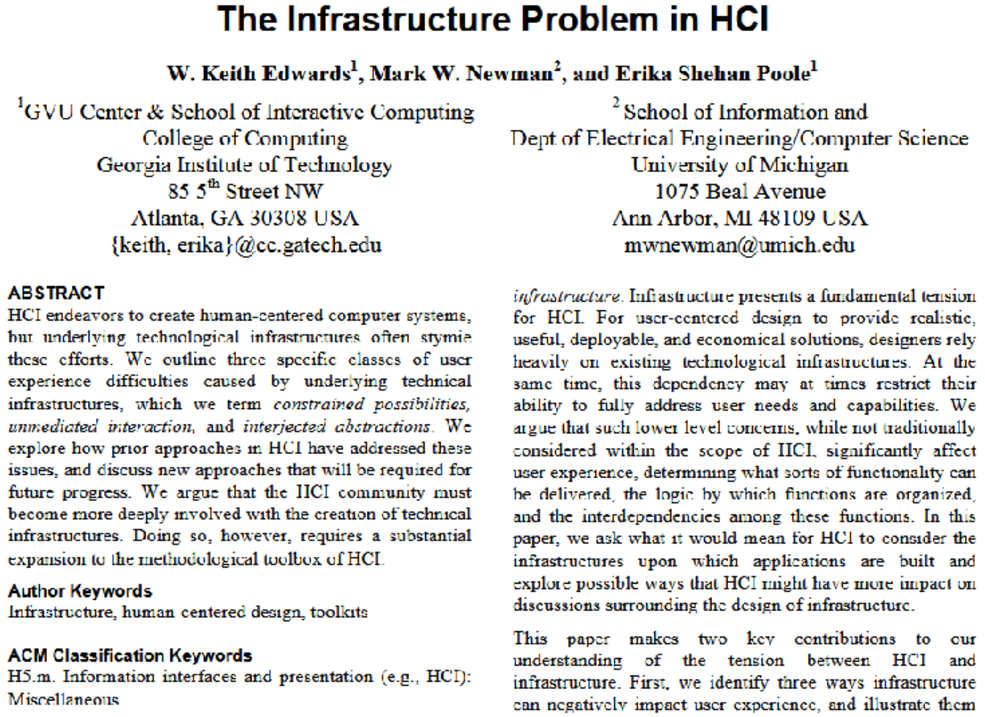
Lily Irani. Chasing Innovation: Making Entrepreneurial Citizens in Modern India. Princeton University Press. 2019. (https://doi.org/10.2307/j.ctv941vd8)

Corporate actors lack incentives for change

- The tech industry has limited incentives to fix problems of the kind that we have outlined
- User experience improvements can make customers happier, but “transformative technology” (aka generative AI) promises the chance of higher returns
- Changes that empower users (e.g., fixing interoperability problems) may not be aligned with the profit margins of those running the product ecosystems

And researchers lack capacity

- It’s often easier to make a new prototype than to influence real world technology use in a calcified ecosystem
- Visioning brings in corporate funding for research agendas, but only for work that is aligned with that company’s goals
- If researchers try “going it alone”, often they lack access to black box system internals that would allow them to make progress



The Infrastructure Problem in HCI

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ABSTRACT
HCI endeavors to create human-centered computer systems, but underlying technological infrastructures often stymie these efforts. We outline three specific classes of user experience difficulties caused by underlying technical infrastructures, which we term *constrained possibilities, unmediated interaction,* and *interjected abstractions*. We explore how prior approaches in HCI have addressed these issues, and discuss new approaches that will be required for future progress. We argue that the HCI community must become more deeply involved with the creation of technical infrastructures. Doing so, however, requires a substantial expansion to the methodological toolbox of HCI.

Author Keywords
Infrastructure, human centered design, toolkits

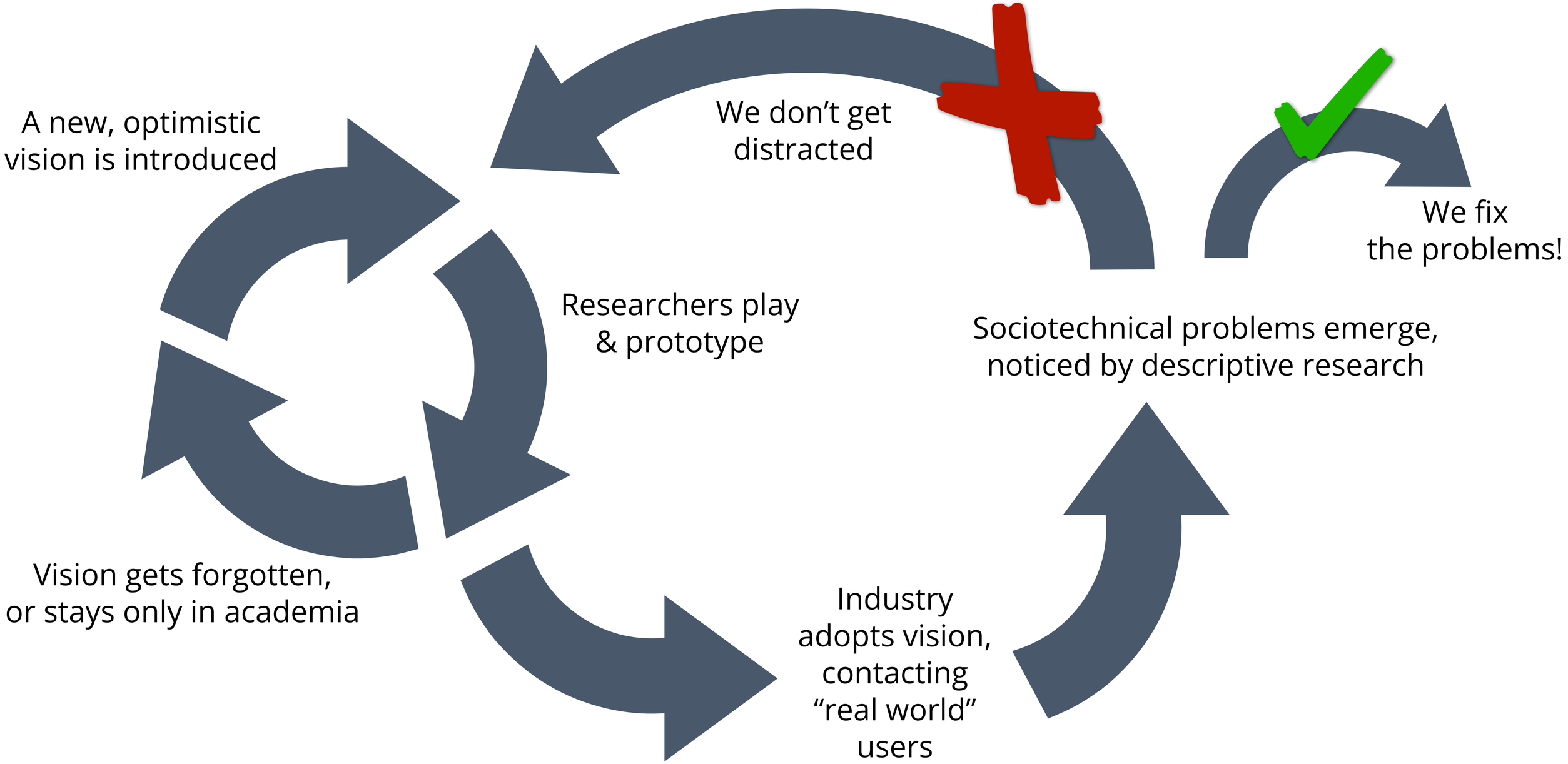
ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous

infrastructure. Infrastructure presents a fundamental tension for HCI. For user-centered design to provide realistic, useful, deployable, and economical solutions, designers rely heavily on existing technological infrastructures. At the same time, this dependency may at times restrict their ability to fully address user needs and capabilities. We argue that such lower level concerns, while not traditionally considered within the scope of HCI, significantly affect user experience, determining what sorts of functionality can be delivered, the logic by which functions are organized, and the interdependencies among these functions. In this paper, we ask what it would mean for HCI to consider the infrastructures upon which applications are built and explore possible ways that HCI might have more impact on discussions surrounding the design of infrastructure.

This paper makes two key contributions to our understanding of the tension between HCI and infrastructure. First, we identify three ways infrastructure can negatively impact user experience, and illustrate them

W. Keith Edwards et. al. The infrastructure problem in HCI. CHI 2010. (https://doi.org/10.1145/1753326.1753390)

Where do we go from here?

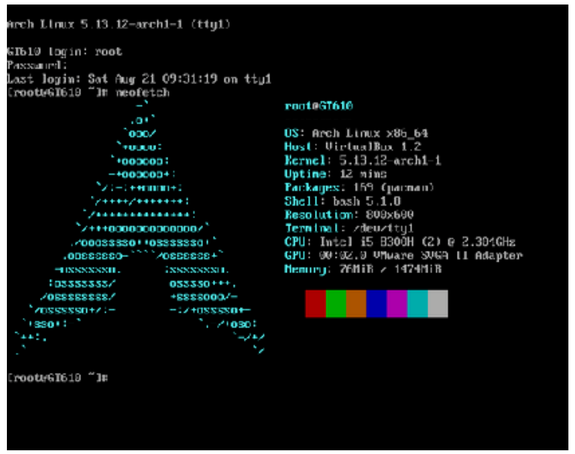


Building capacity

- Can researchers shift from building prototypes to changing everyday computer use? How can we build alternative sources of power and ecosystems to affect the real world other than via corporate partnerships?

Co-design and participatory design with those most impacted by technology

Pelle Ehn and Morten Kyng. Cardboard Computers: Mocking-it-up or Hands-on the Future. Design at work: cooperative design of computer systems. 1992. (https://dl.acm.org/doi/10.5555/125470.125488)



FOSS

Arch Linux.

Worker solidarity

Lily Irani and Six Silberman. Turkopticon: Interrupting worker invisibility in Amazon Mechanical Turk. CHI 2013 (https://doi.org/10.1145/2470654.2470742)

Self-reflexivity & history

- Look critically at the incentives of HCI researchers and how they are shaped by funding bodies and industry partners
- Commit to supporting and valuing research on the **history** and genealogy of ideas in HCI
  - If LLMs write related works sections, then we have a biased understanding of history, and continue to fall into cyclical visions

Shifting our values

- How can we push ourselves and our research communities to care less about flashy technological progress?
- How can we focus less on imagining our own versions of the future, and more about making change in our shared present?
- How can researchers work together to make progress on the hard stuff that has so far been left undone?

Discuss: In what ways does your tool try to make change in the present? In what ways is it flashy technological progress?

A bias against the present: Recurring sociotechnical oversights in HCI's cyclical visions of the future

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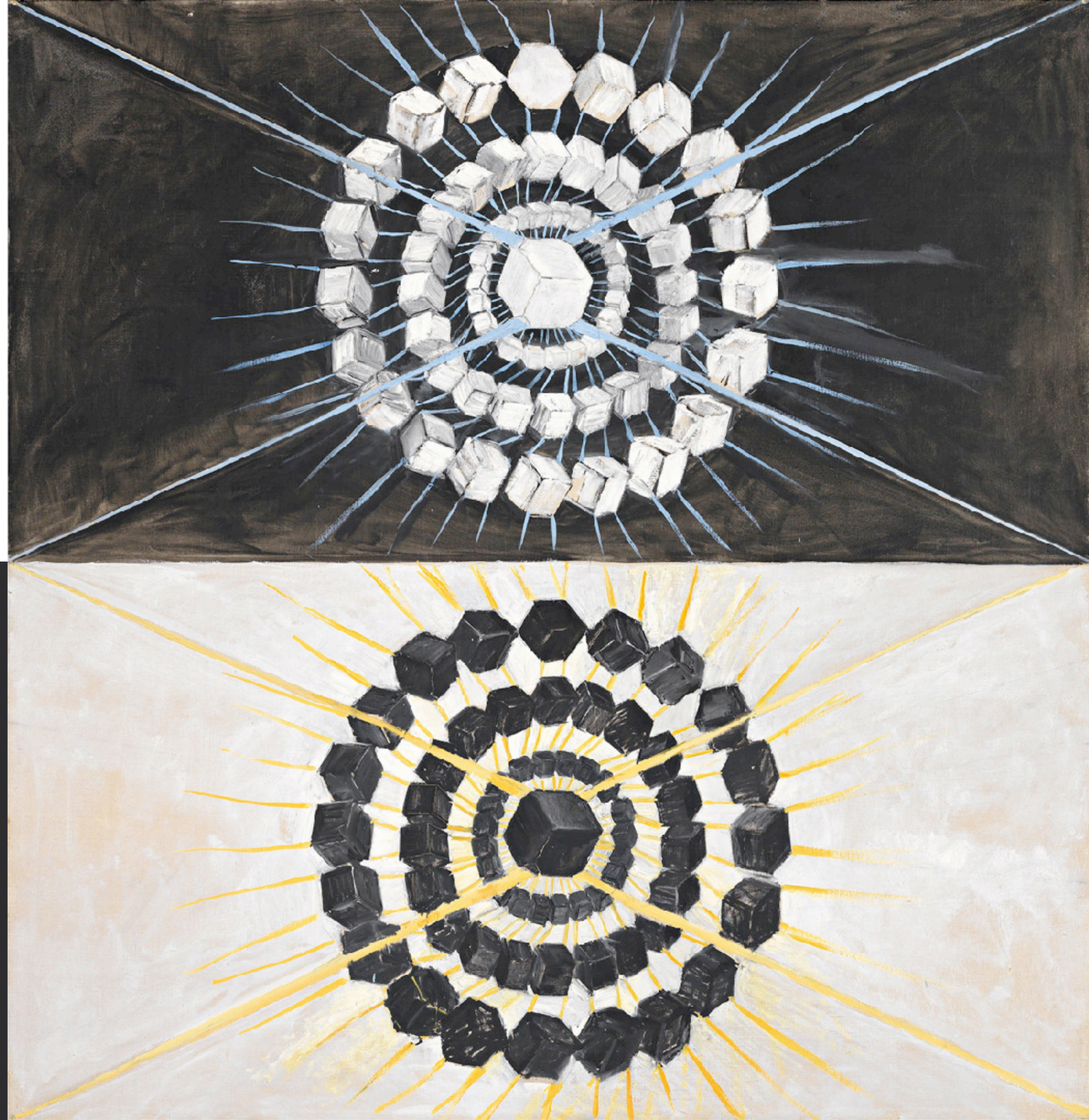
Image: The Swan No. 8, Hilma af Klint (1915)



Class 22 recap

- **TODO**
  - Next Mon: PM6 Materials (bring 5+ to class), RRs, seminar from Ishika & Jack C
  - Next Weds: Project MVP!
- Mentor sessions again this Sunday afternoon! Come code and co-work!

Seminar