29/Nov - 2011
Defense of PhD Dissertation

Using Infrastructure Awareness to Support the Recruitment of Volunteer Computing Participants

IT UNIVERSITY OF COPENHAGEN

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Using Infrastructure Awareness to Support the Recruitment of Volunteer Computing Participants

Using Infrastructure Awareness to Support the Recruitment of Volunteer Computing Participants

[Context]

Using Infrastructure Awareness to Support the Recruitment of Volunteer Computing Participants

Using

Infrastructure Awareness

to Support the Recruitment of Volunteer Computing Participants

[Conceptual Approach]

Using
Infrastructure Awareness to Support the Recruitment of Volunteer Computing Participants

[Design + Development + Evaluation]

Agenda

Part I – Introduction

- Volunteer Computing and Participative Computational Infrastructures
- Participant Recruitment
- Existing Research
- Infrastructures and Invisibility
- Infrastructure Awareness

Part II – Design

Part III – Evaluation

Part IV – Discussion

Agenda

Part I – Introduction

Part II – Design

- Fieldwork Studies
- Design Process
- GridOrbit Public Displays
- GridOrbit Notification System

Part III – Evaluation

Part IV – Discussion

Agenda

Part I – Introduction

Part II – Design

Part III – Evaluation

- Study Setup
- Quantitative Results
- Usage Patterns
- Adoption Impact
- GridOrbit Usage
- Motivations

Part IV – Discussion

Agenda

Part I – Introduction

Part II – Design

Part III – Evaluation

Part IV – Discussion

- Hypotheses
- Hypothesis Analysis
- Volunteer Computing Case
- A World of Infrastructures
- Conclusions

Introduction

Part I

Agenda

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- Participant Recruitment
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Part II – Design

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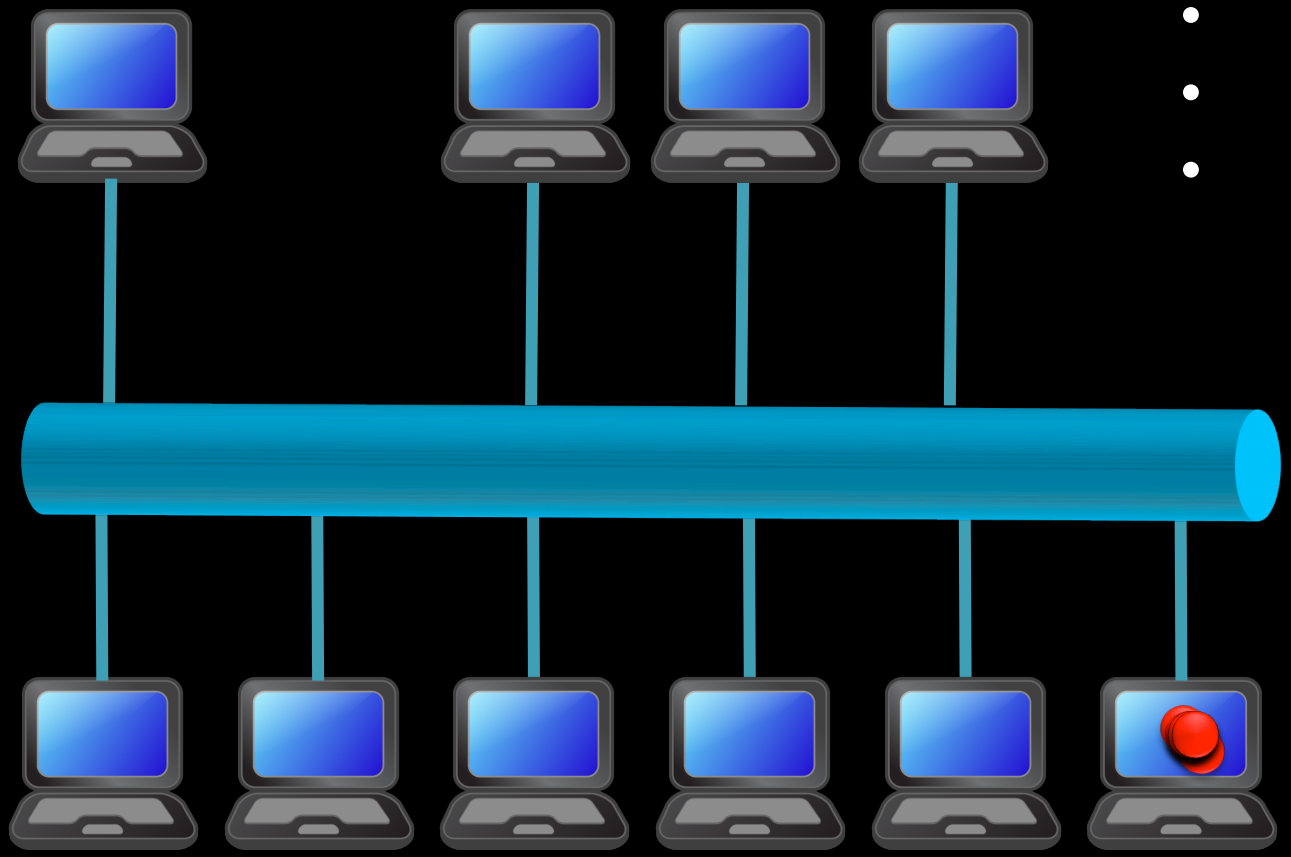
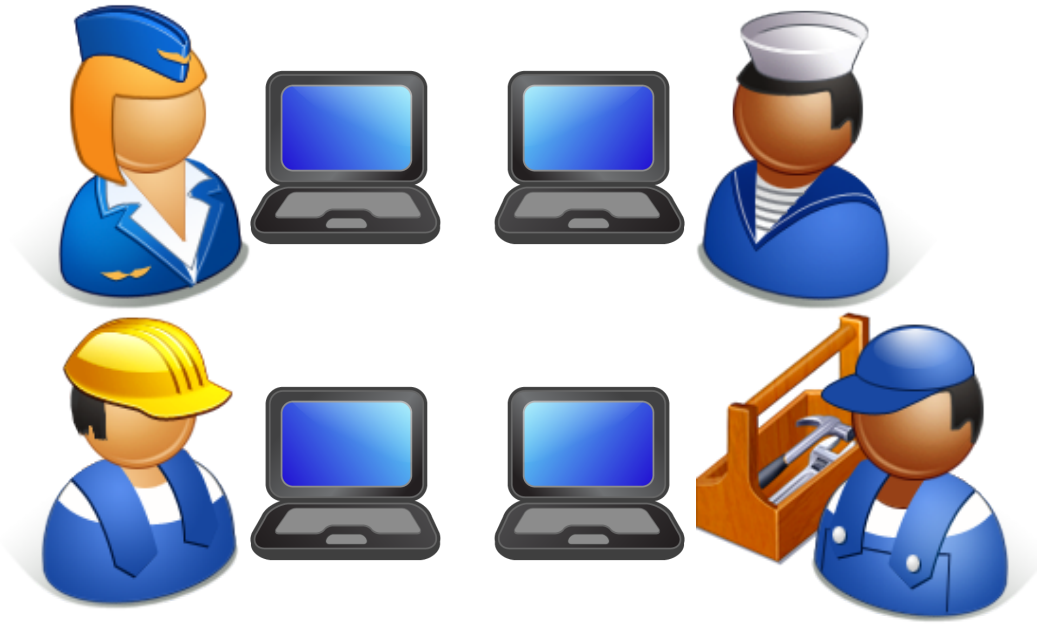
Part IV – Discussion



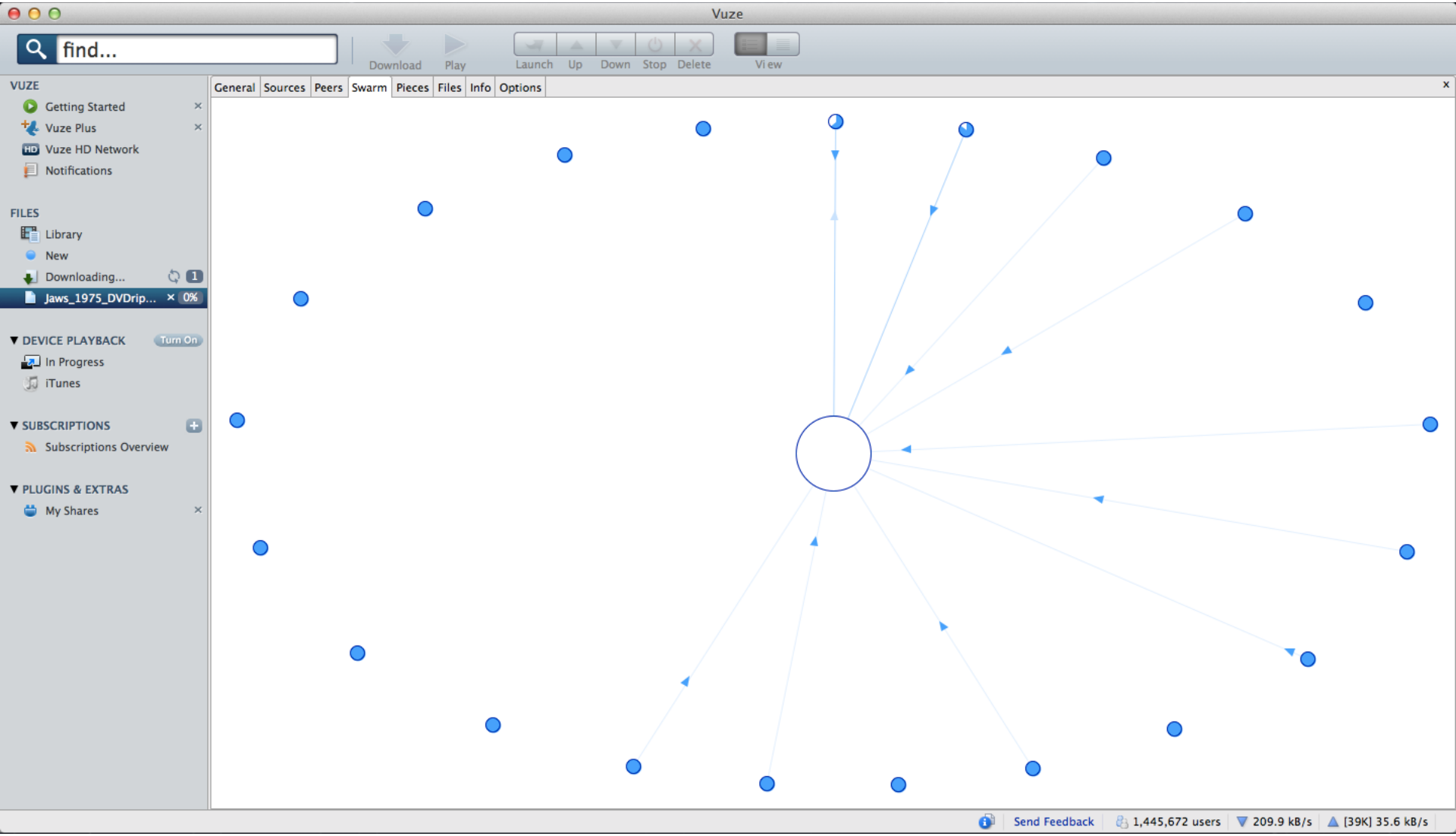
- BOINC
- Mini-Grid
- distributed.net
- OurGrid
- IBM’s WCG
- +12 more…

Participative Computational Infrastructures *are infrastructures that depend on their participants' use of a computational system to provide a service, with every instance of the system executing tasks of a similar nature, and collaborating with others.*

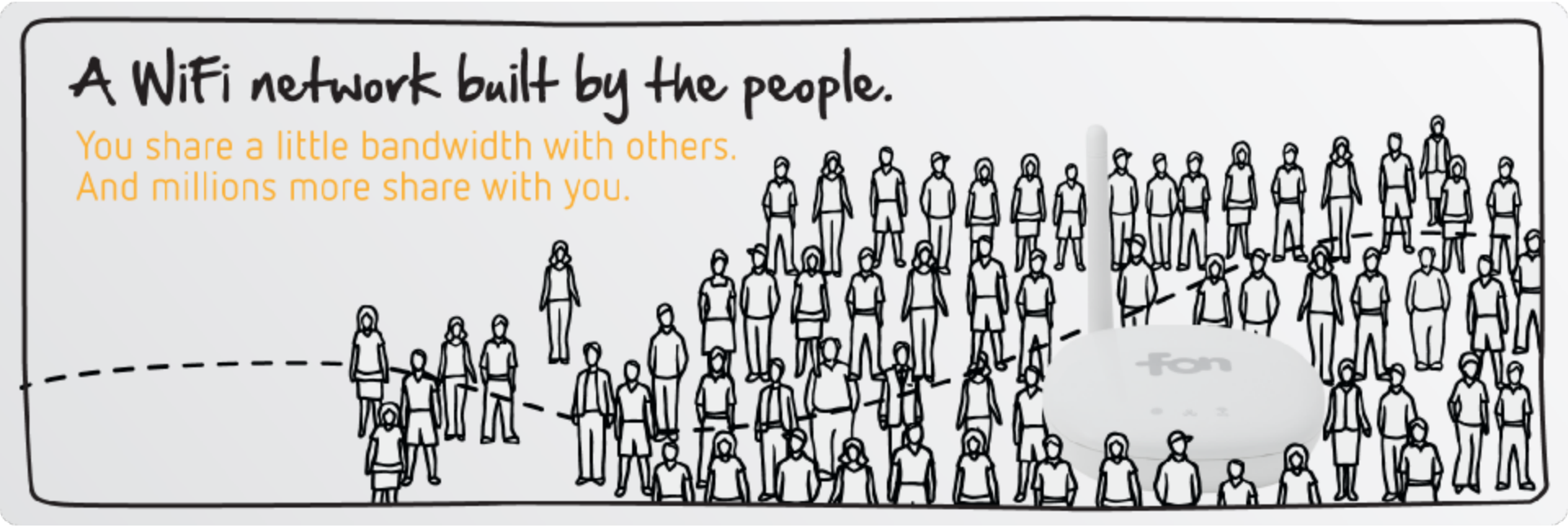


- Computing Power
- Storage
- Network
- Reasoning

[FoldIt – 57.000 participants Aug/10]



[BitTorrent – Vuze client's Swarm view]



[FON WiFi network – over 4 million FON spots May/11]

Regardless of how good, efficient or secure the computational aspect is, these infrastructures cannot provide the service they are designed for without a good number of participants [Butler'01 cited in page 17].

Related Work

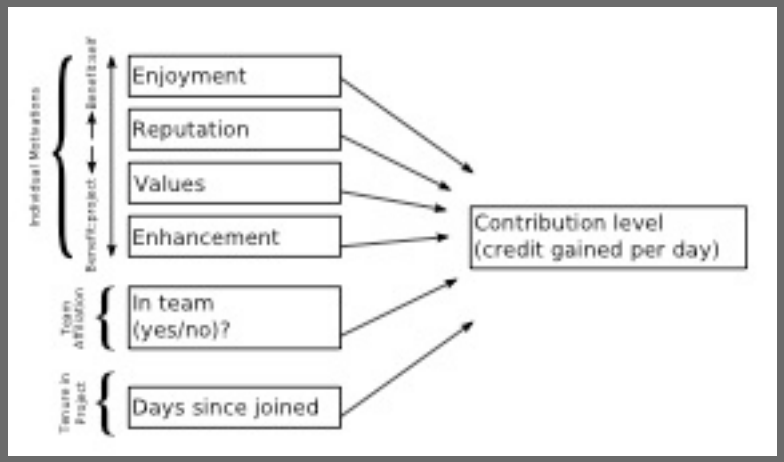
Technical Support

[Led by practitioners]

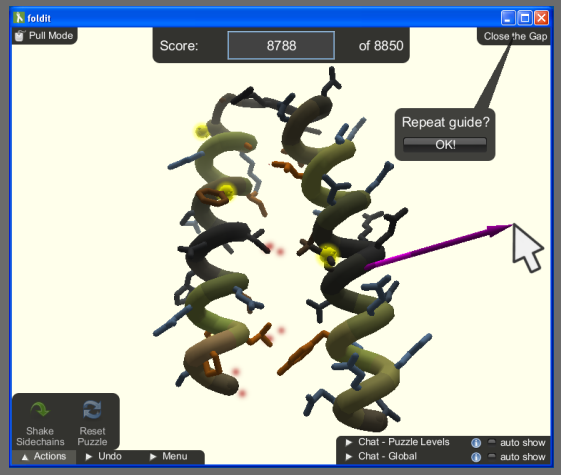
Motivational Factors

[Led by researchers]

Related Work

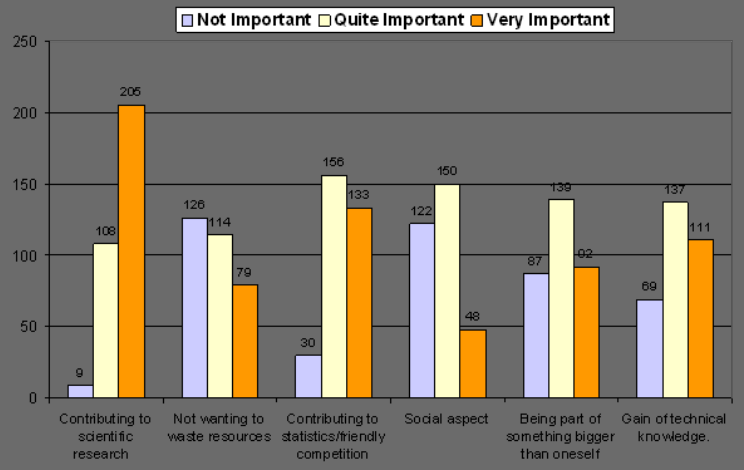


Motivational Models



Motivation Techniques
Persuasive Technologies

Motivational Factors



Survey Studies

Related Work

Motivational Factors

- Contributing to scientific research
- Friendly competition
- Prospective gain of technical knowledge
- Point systems and rewards
- Sense of community

[Hologan and Garg'05 – Motivational Models]

Related Work

Motivational Factors

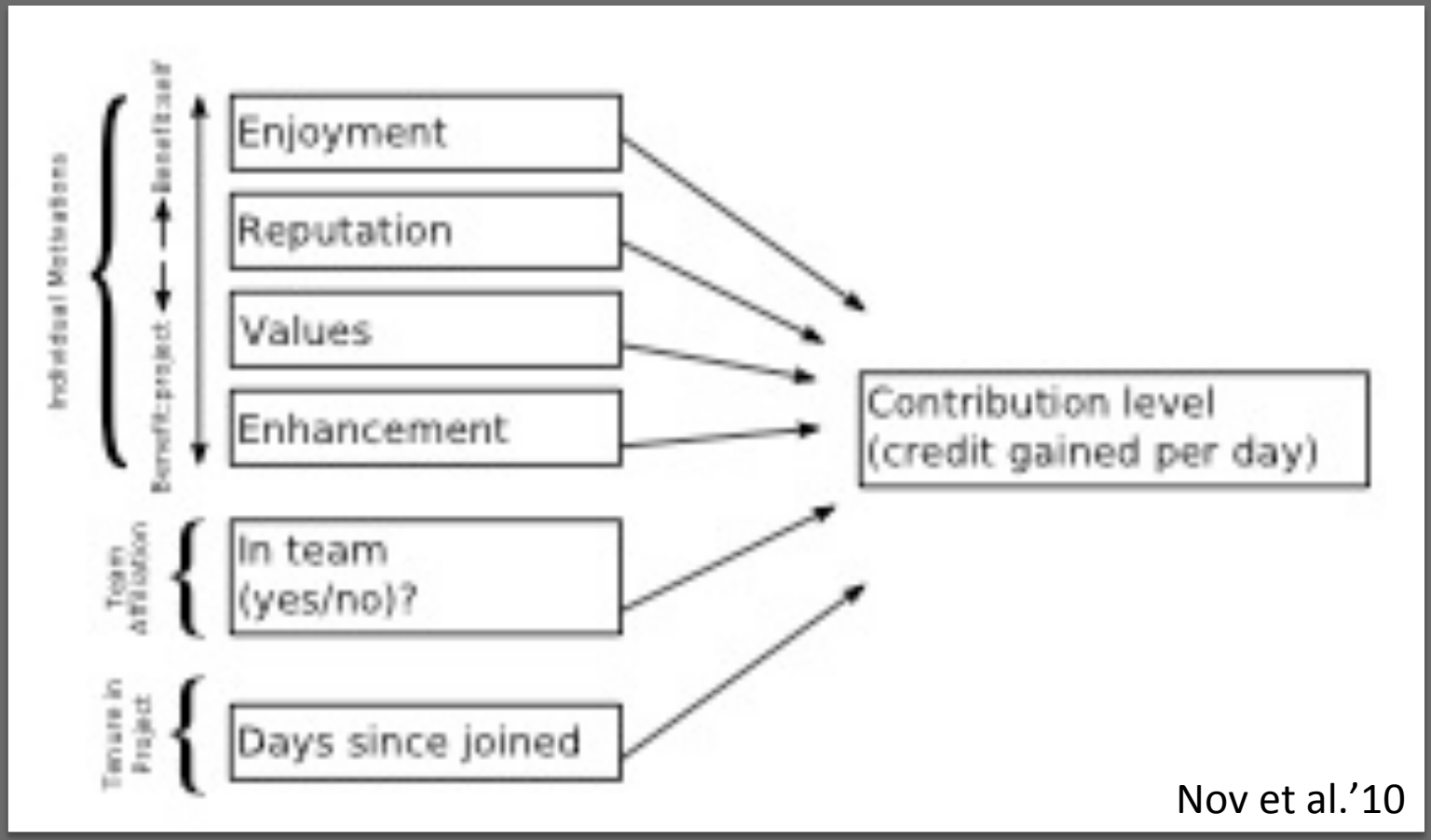
	Extrinsic Intrinsic	Motivation
1	E	To acquire professional experience.
2	E	To get to know people and build a personal network.
3	E	To learn and acquire new skills.
4	E	To share knowledge acquired over the years.
5	E	To keep involved: wanting to remain involved after retirement.
6	E	Credits: To obtain credits as a sign of contribution.
7	I	Solidarity: Wanting to give to a community and human beings in need.
8	I	Cause: Getting involved for a particular cause.
9	I	Personal reasons: Because of past experience, friends involved, personal satisfaction, enjoyment.
10	I	Self–expression and empowerment: To have an opportunity to interact, express ideas.

Krebs'10

[Motivational Models]

Related Work

Motivational Factors



Nov et al.'10

[Motivational Models]

Related Work

Motivational Factors

- Overview and statistics [Krebs'10]
- Improved communication about what's going on (results) [Krebs'10]
- Increased awareness [Krebs'10]

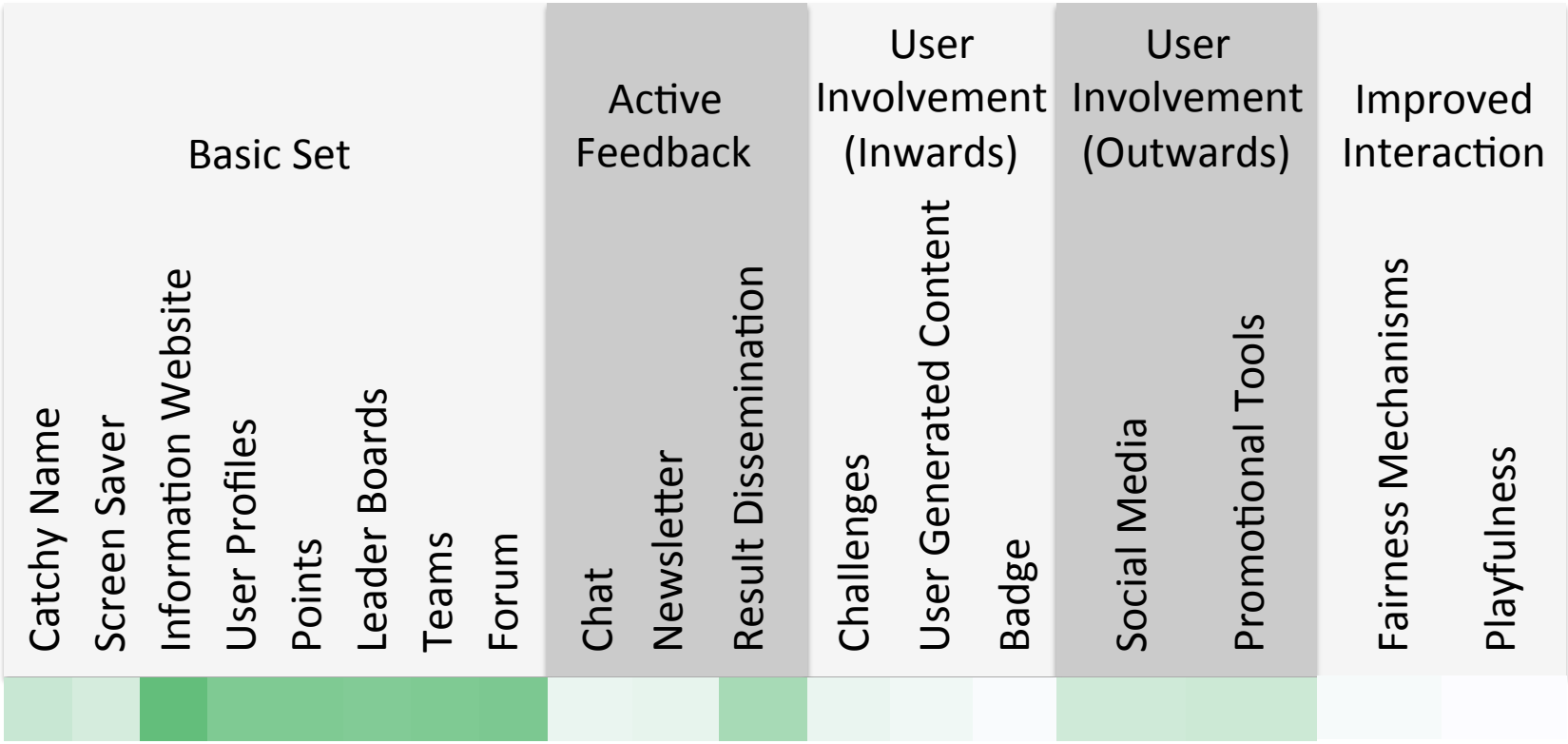
- Sense of community [Hologan and Garg'05]

- Up-to-date individual contributions [Nov et al.'10]
- Multiple feedback channels [Nov et al.'10]
- Contributions in relation to others [Nov et al.'10]
- Enjoyable user interface [Nov et al.'10]

[Motivational Techniques]

Related Work

Technical Support



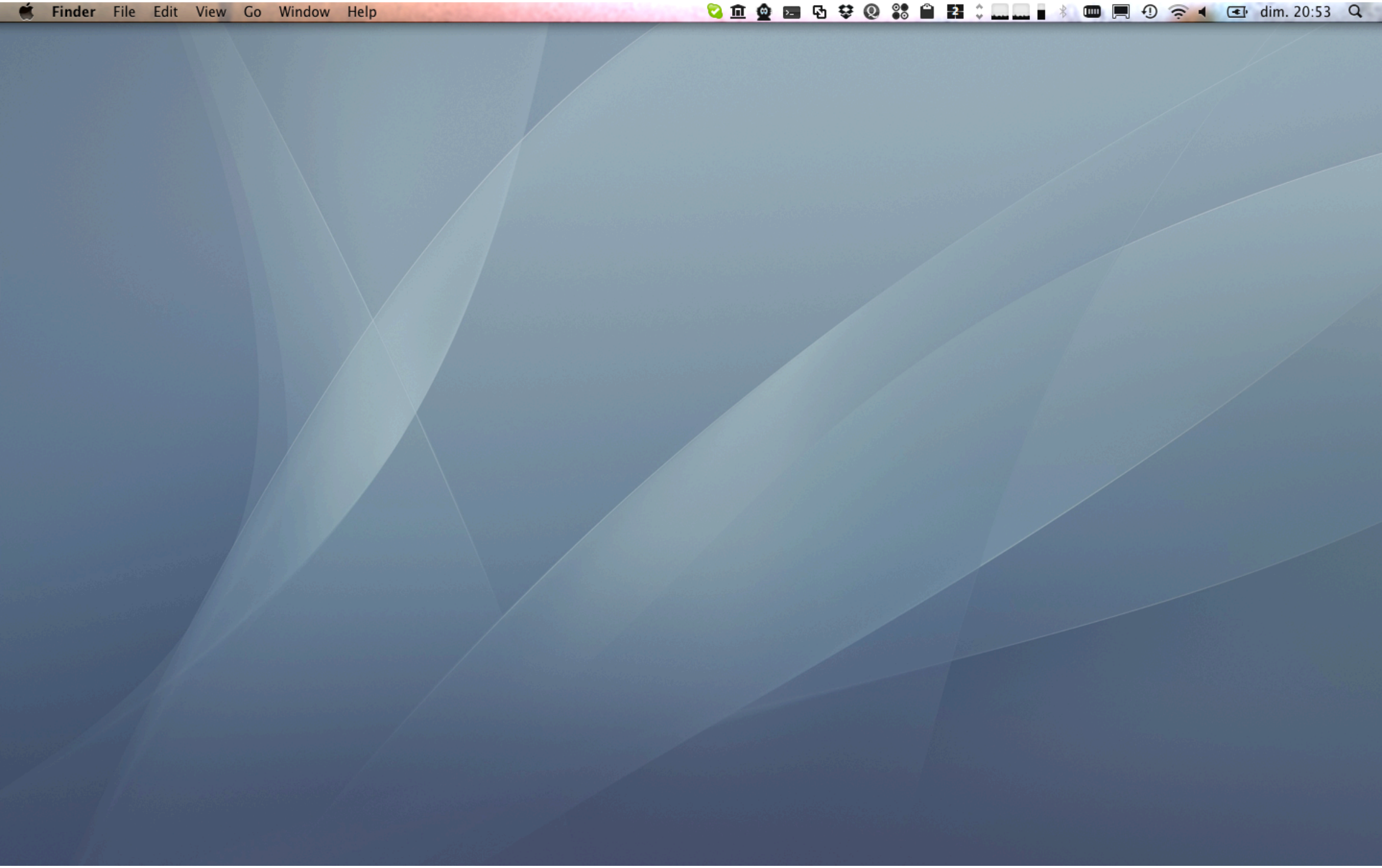
[Technological Support for Recruiting Participants – Page 27]

		Project Name	Opt		Basic Set						Active Feedback			User Involv. (inwards)			UserInv. (outwds)		Imprvd Interact.	
			Catchy Name	Screen Saver	Information Website	User Profiles	Points	Leader Board	Teams	Forum	Chat	Newsletter	Results Dissemination	Challenges	User Generated Content	Badge	Social Media	Promotional Tools	Fairness Mechanism	Playfulness
CPU	BOINC	Einstein@Home	●	●	●	●	●	●	●	●			●							
		LHC@Home	●		●	●	●	●	●	●										
		eOn	●		●	●	●	●	●	●										
		Cosmology@Home	●		●	●	●	●	●									●		
		uFluids@Home			●	●	●	●	●	●			●							
		Milkyway@Home	●		●	●	●	●	●	●			●							
		SETI@Home	●	●	●	●	●	●	●	●	●	●	●				●	●		
		Spinhenge@Home		●	●	●	●	●	●	●			●					●		
		Orbit@Home			●	●	●	●	●	●										
		QMC@Home		●	●	●	●	●	●	●										
		Leiden Classical			●	●	●	●	●	●								●		
		Virtual Prairie		●	●	●	●	●	●	●		●	●					●		
		Climateprediction.net	●	●	●	●	●	●	●	●		●	●					●		
		CAS@Home			●	●	●	●	●	●										
		Ibercivis			●	●	●	●	●	●			●	●			●	●		
		EDGeS@Home			●	●	●	●	●	●			●							
		World Community Grid	●	●	●	●	●	●	●	●		●	●	●		●	●	●		
		Yoyo@Home		●	●	●	●	●	●	●	●		●			●	●			
		Docking@Home		●	●	●	●	●	●	●		●	●							
		Malariacontrol.net	●	●	●	●	●	●	●	●										
		Rosetta@Home		●	●	●	●	●	●	●			●				●	●		

	Volunteriness (Resource Provision)		Scalability		Symmetry (Resource Utilization)		Engagement	
	Volunteer	*Non-volunteer*	*Global*	*Local*	*Symmetric*	*Asymmetric*	*Active*	*Passive*
BOINC	●	○	●	○	○	●	○	●
The Mini-Grid	●	○	○	●	●	○	○	●
BitTorrent	●	○	●	○	●	○	○	●
Peestripe	○	●	●	○	●	○	○	●
FoldIt	●	○	●	○	○	●	●	○
Startdust@HOME	●	○	●	○	○	●	●	○
FON	●	○	●	○	●	○	○	●
WeFi	●	○	●	○	○	●	○	●

[Technical properties derived from the ones identified by Venkataraman'11 and Benkler'06]

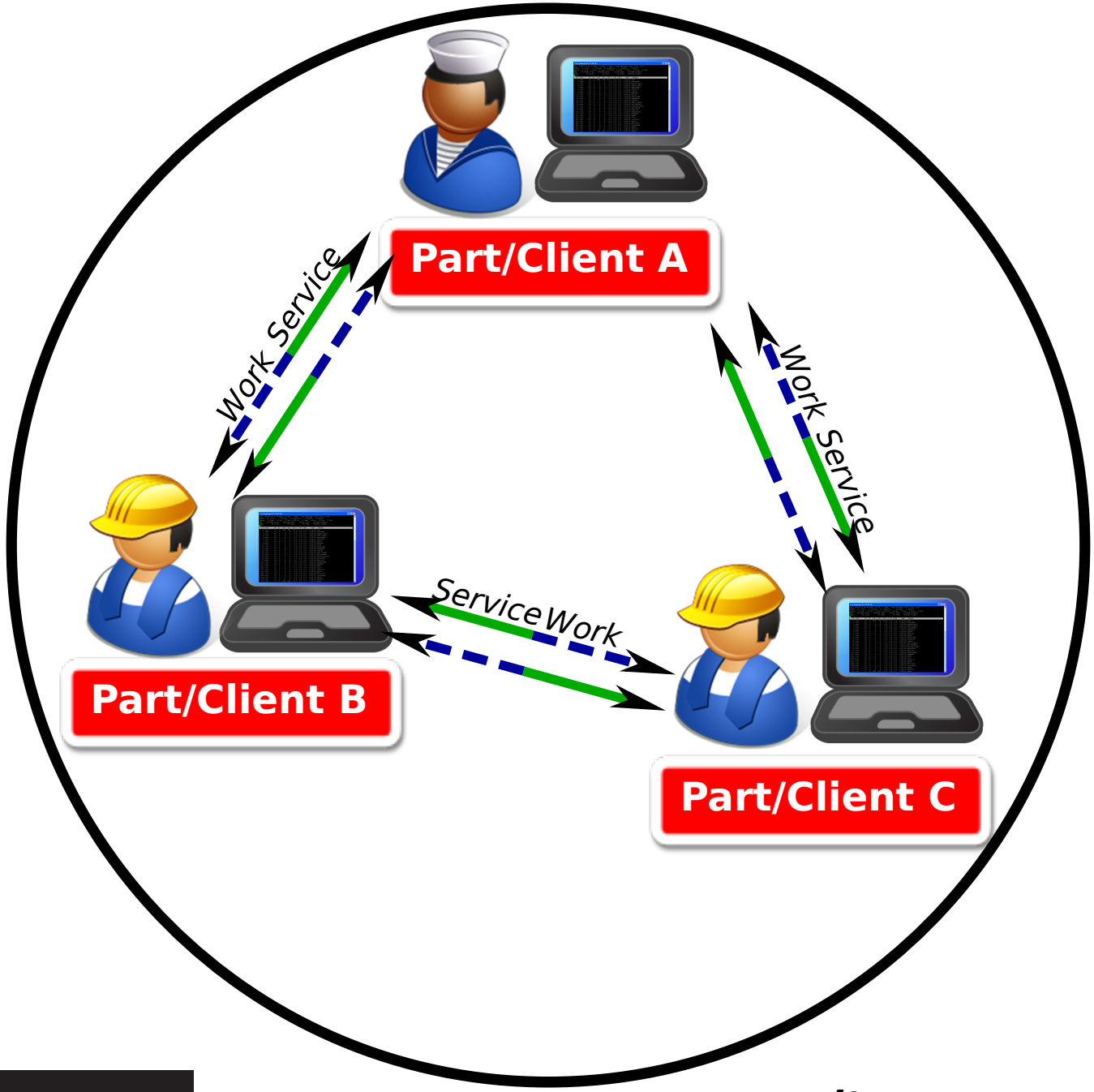
	Volunteriness (Resource Provision)		Scalability		Symmetry (Resource Utilization)		Engagement	
	Volunteer	*Non-volunteer*	*Global*	*Local*	*Symmetric*	*Asymmetric*	*Active*	*Passive*
BOINC	●	○	●	○	○	●	○	●
The Mini-Grid	●	○	○	●	●	○	○	●
BitTorrent	●	○	●	○	●	○	○	●
Peestripe	○	●	●	○	●	○	○	●
FoldIt	●	○	●	○	○	●	●	○



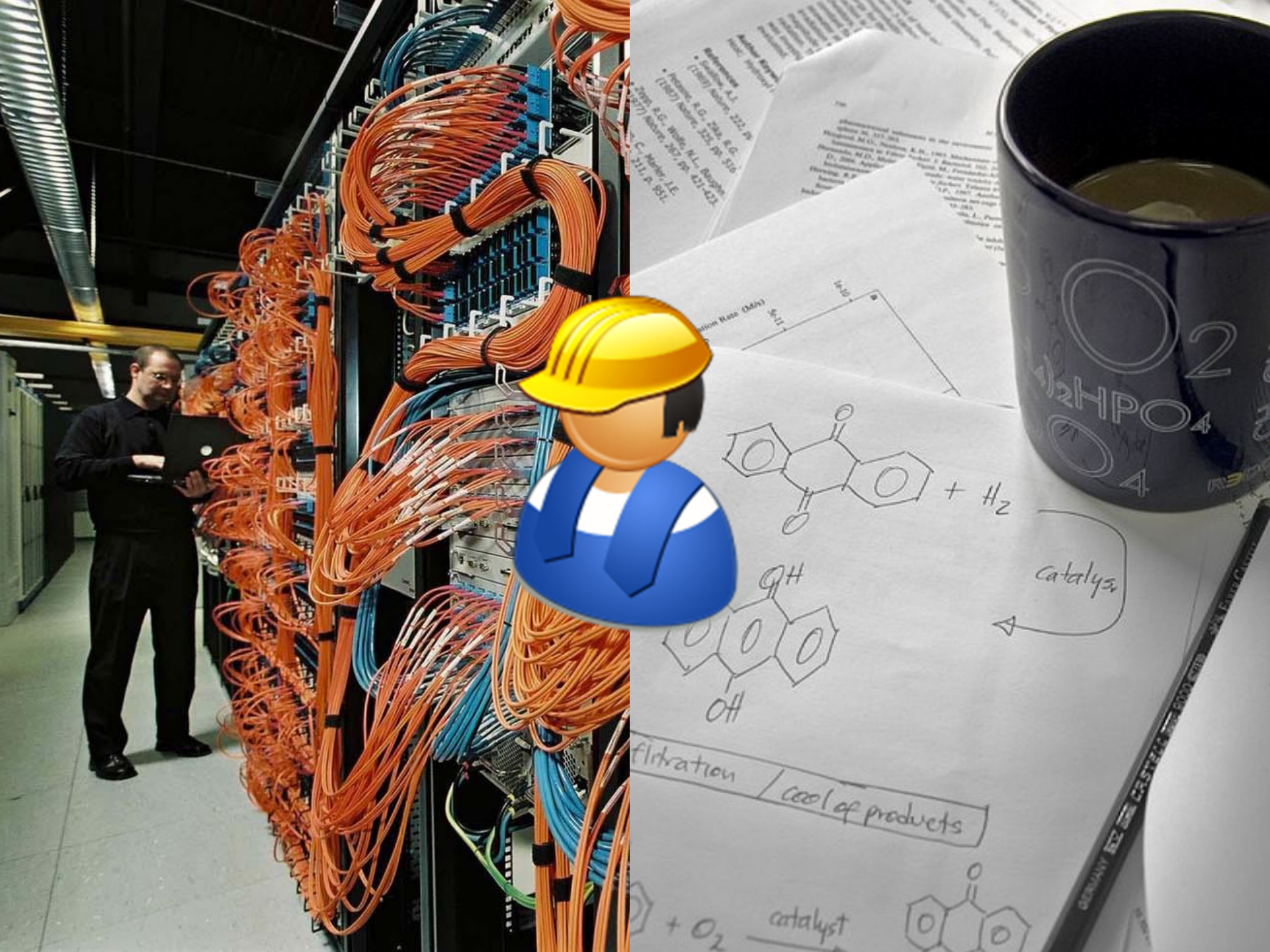
[The Mini-Grid is invisible]

Poole et al. studied this invisibility in home network systems [Poole et al.'09] and RFID technologies [Poole et al.'08]. Their findings suggest that invisibility hinders trust and adoption, and keeps users from forming correct mental models of the infrastructure.

[Why invisibility is not a desirable feature – Page 49]



[Symmetry – Page 52 bottom]

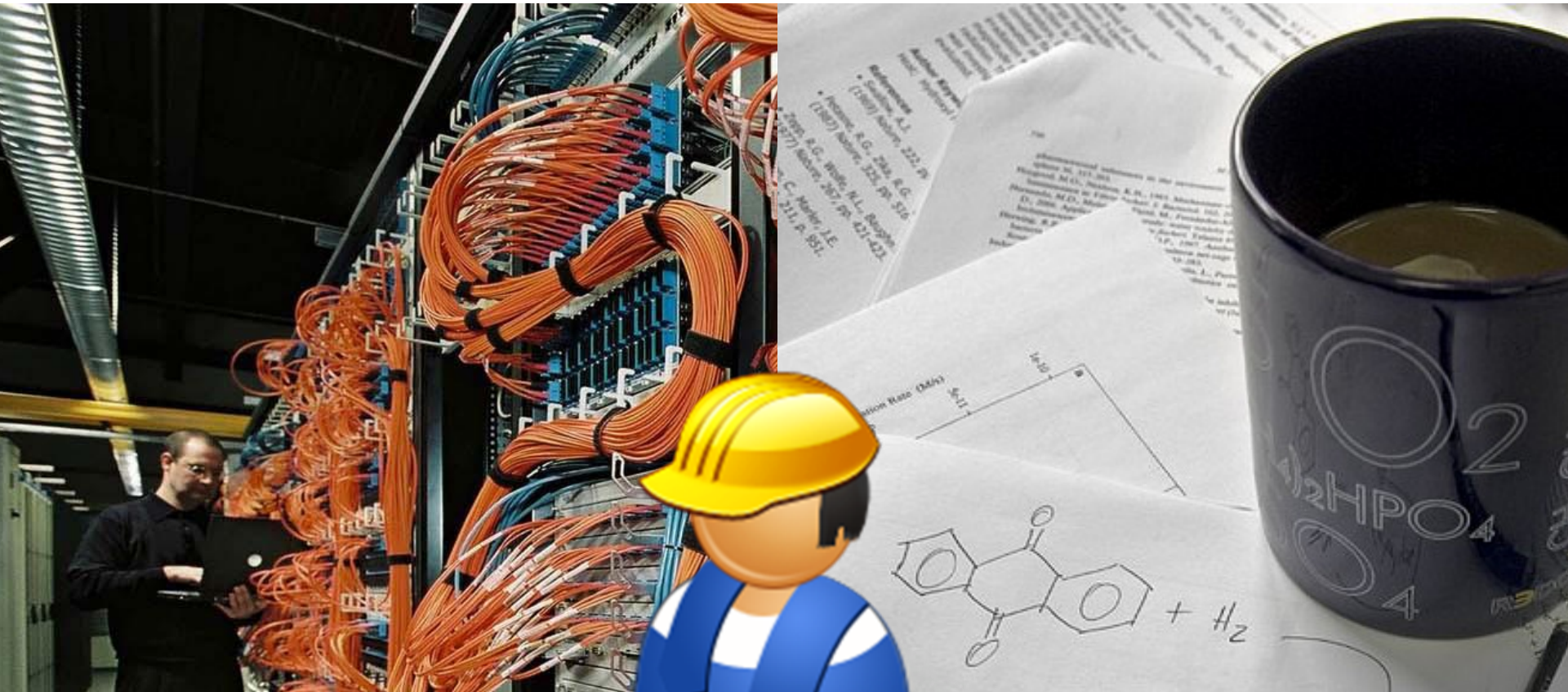

+ H2
catalyst
filtration / cool of products
+ O2
catalyst

How can we design the interactions between the participative computational infrastructure and its participants, in a way that satisfies the needs of these two roles?

Infrastructures == Heidegger's equipment

present-at-hand

ready-to-hand



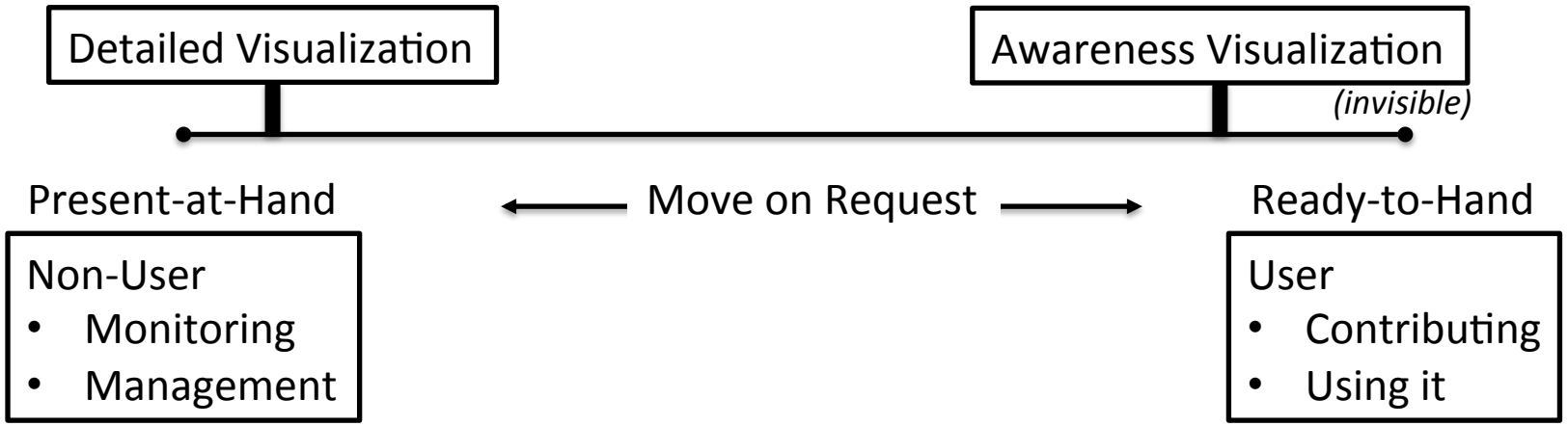
Dourish's Embodied Interaction

Embodied Interactions
… are those that we can understand and form correct mental models for because they occur in real-time and real-space.

Accessible in the Background
… systems need to provide ways for users to move between ready-to-hand (background) and present-at-hand (focus)… [and] moving between the two is a fundamental part of embodied interaction…

[Dourish'01 cited in page 54]

Infrastructure ~~Invisibility~~ Awareness



Infrastructure Awareness *is a feedback mechanism on the state of, and changes in, the properties of [computational] infrastructures provided in the periphery of the user's attention, and supporting gradual disclosure of detailed information on user's request.*

Design

Part II

Agenda

Part I – Introduction

Part II – Design

- Fieldwork Studies
- Design Process
- GridOrbit Public Displays
- GridOrbit Notification System

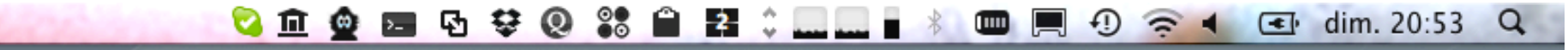
Part III – Evaluation

Part IV – Discussion

GridOrbit

1 Public Displays

2 Notification System

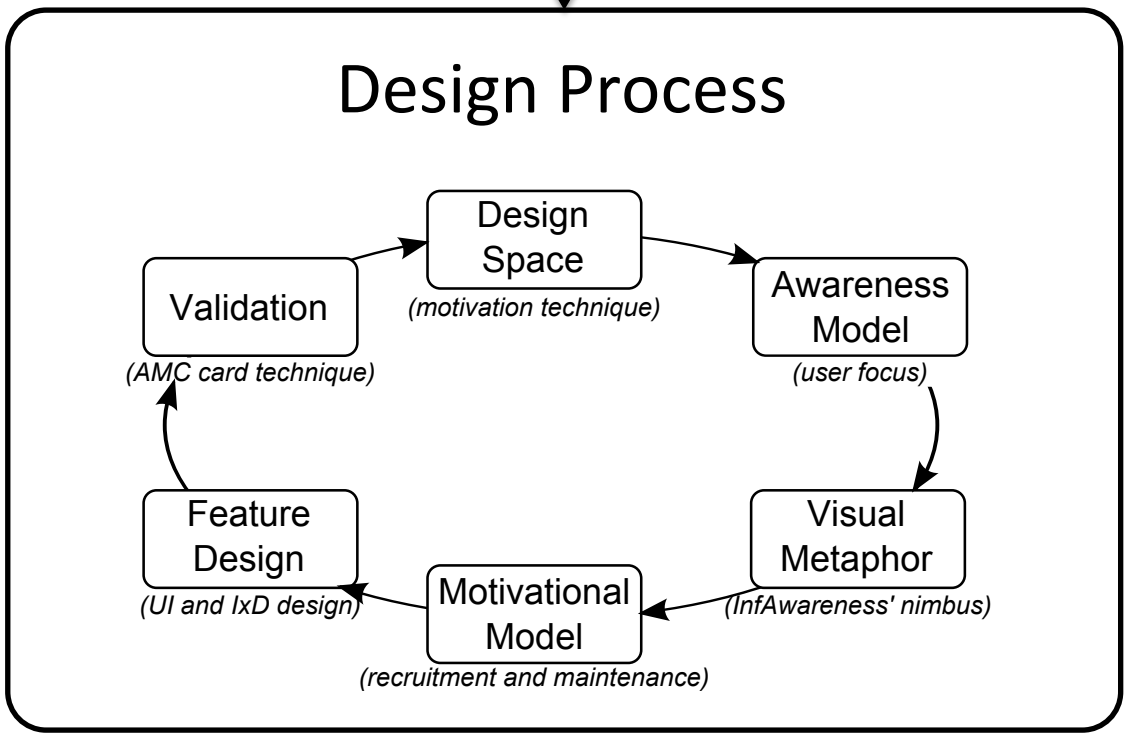


Mini-Grid / CLCbio Workbench

You contributed 12% less than other contributors this week.

Click here to contribute more by launching CLCbio.

Fieldwork Studies



What are the opportunities for the development of infrastructure awareness systems for the Mini-Grid based on the ***existing infrastructures*** and ***sharing practices***?

[Studies of Biologists at Work – Chapter 4]

- Place-based observations – the lab
- Event-based observations – the experimental execution
- Open ended and semi-structured interviews
- Video recordings and pictures

Work Processes

Equipment

Group Composition

Physical Spaces

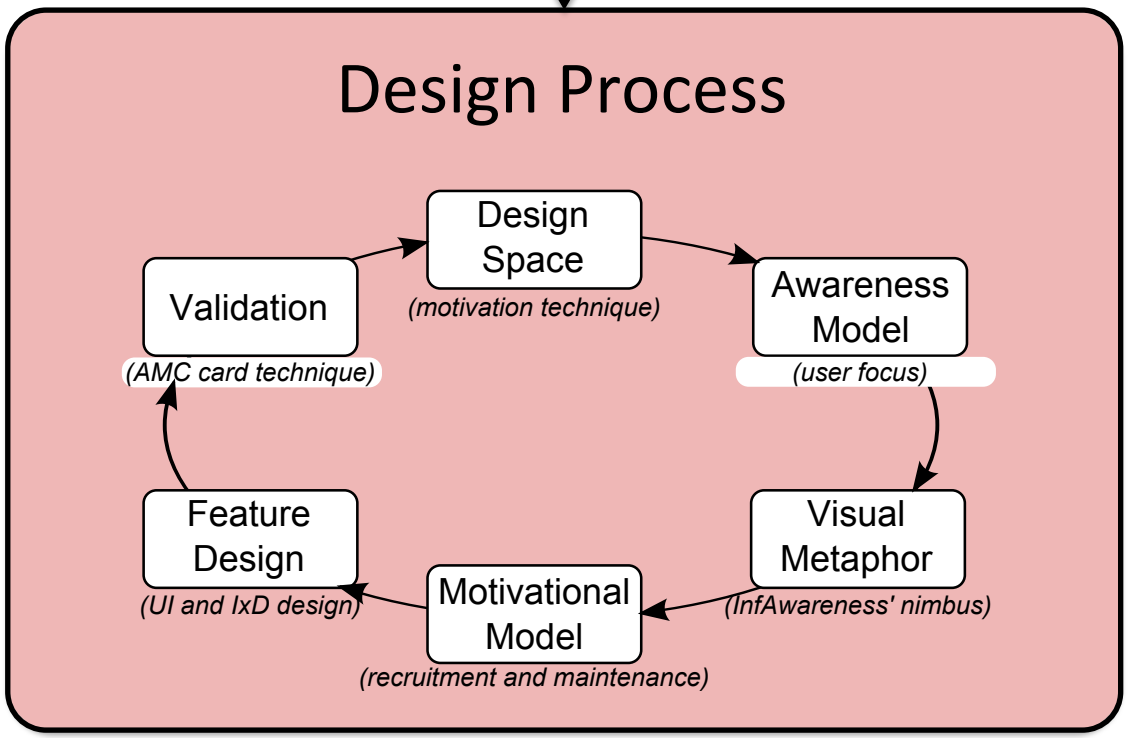
Infrastructures

Sharing Practices

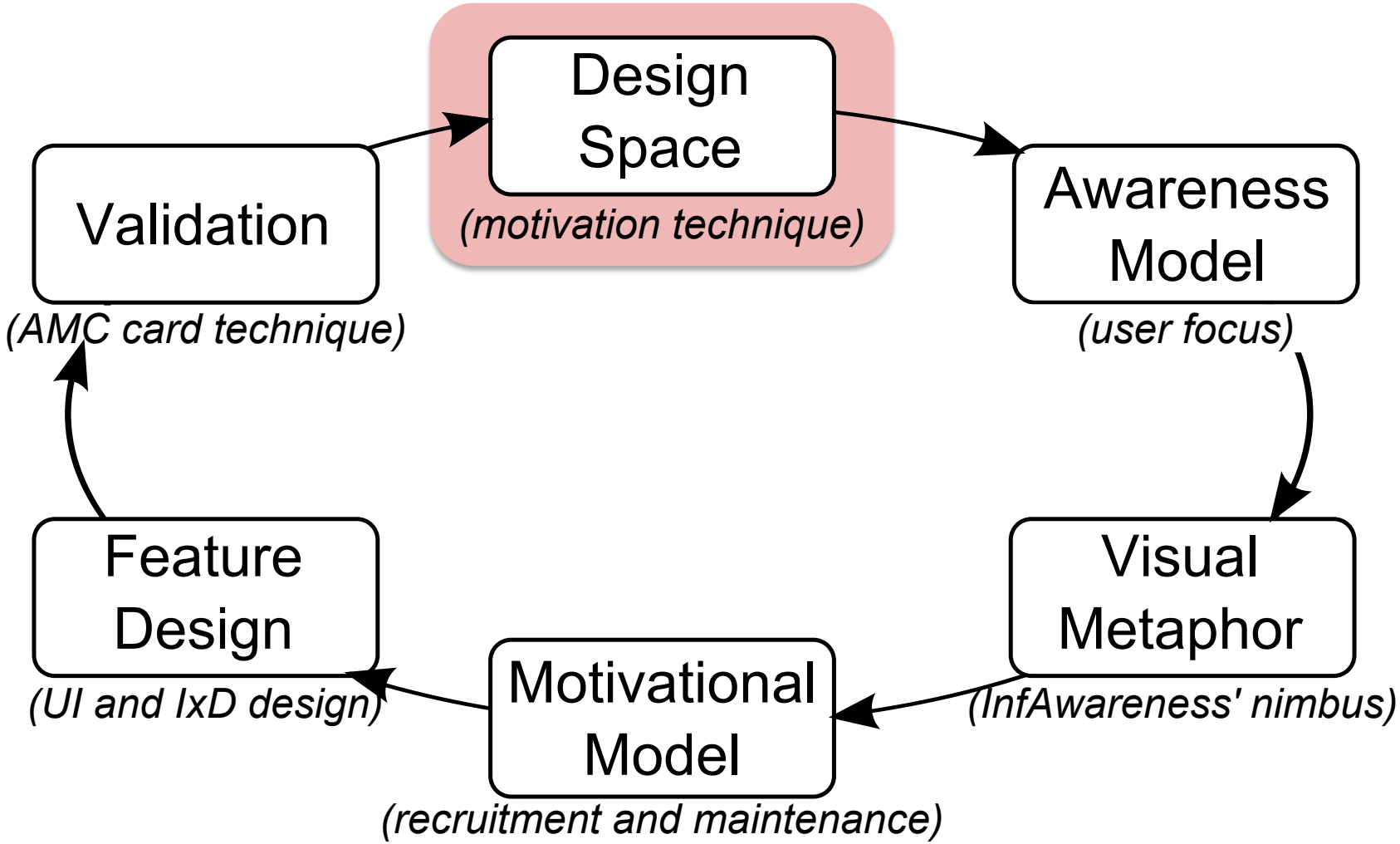
Fieldwork Results

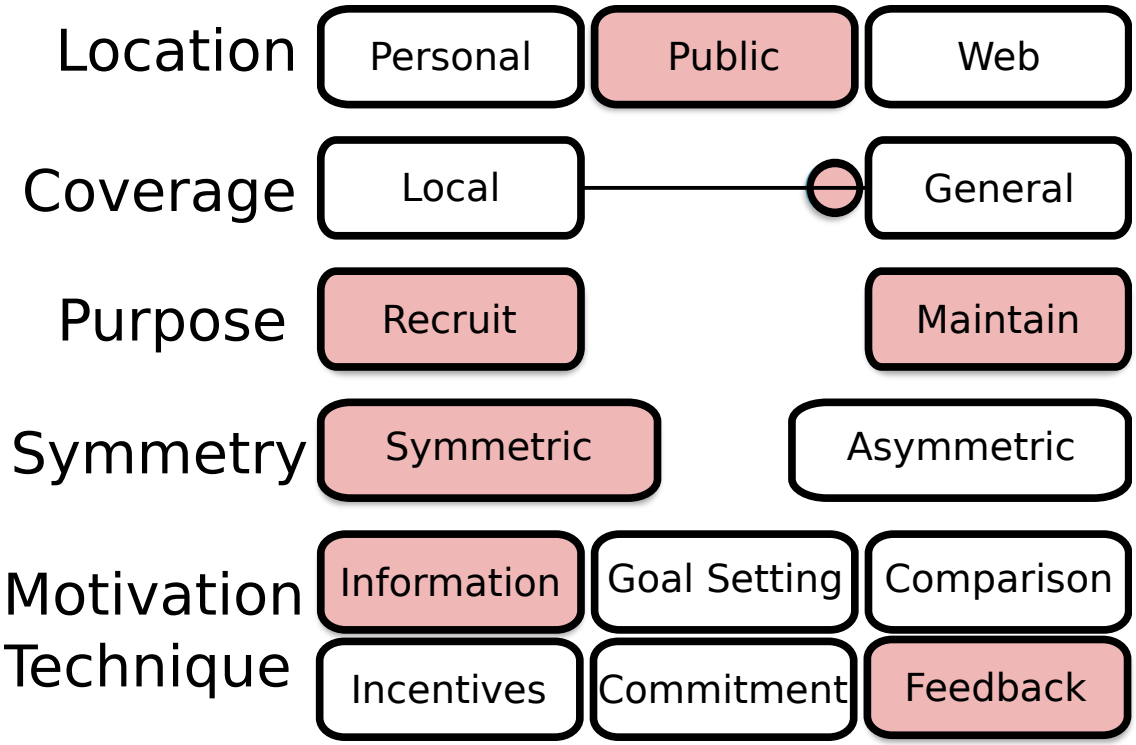
- Awareness mechanisms are already in use in their simplest form.
- Recruitment should target both research and administrative personnel.
- Multiple technological mechanisms covering the different locations where they work (lab/office).

Fieldwork Studies



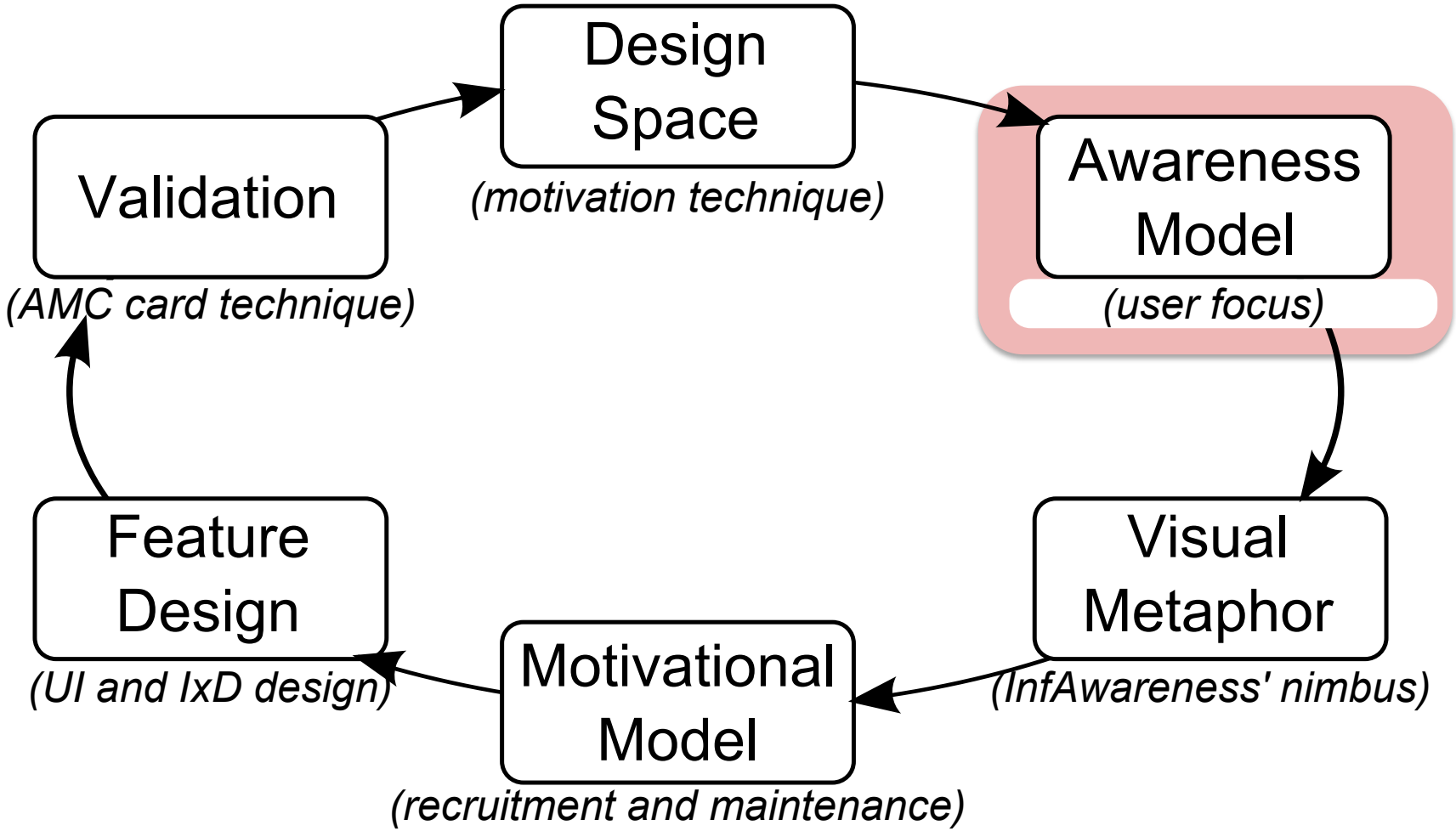
[Design Process – Chapter 4 – Page 87 & 94]


Design Space
(motivation technique)
Awareness Model
(user focus)
Visual Metaphor
(InfAwareness' nimbus)
Motivational Model
(recruitment and maintenance)
Feature Design
(UI and IxD design)
Validation
(AMC card technique)


Location
Personal
Public
Web
Coverage
Local
General
Purpose
Recruit
Maintain
Symmetry
Symmetric
Asymmetric
Motivation
Information
Goal Setting
Comparison
Technique
Incentives
Commitment
Feedback

Building 1:
Corridor in front of the Cafeteria

Building 2:
Elevator +Mail Box Waiting Area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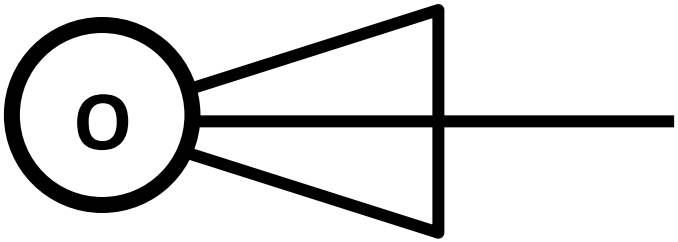
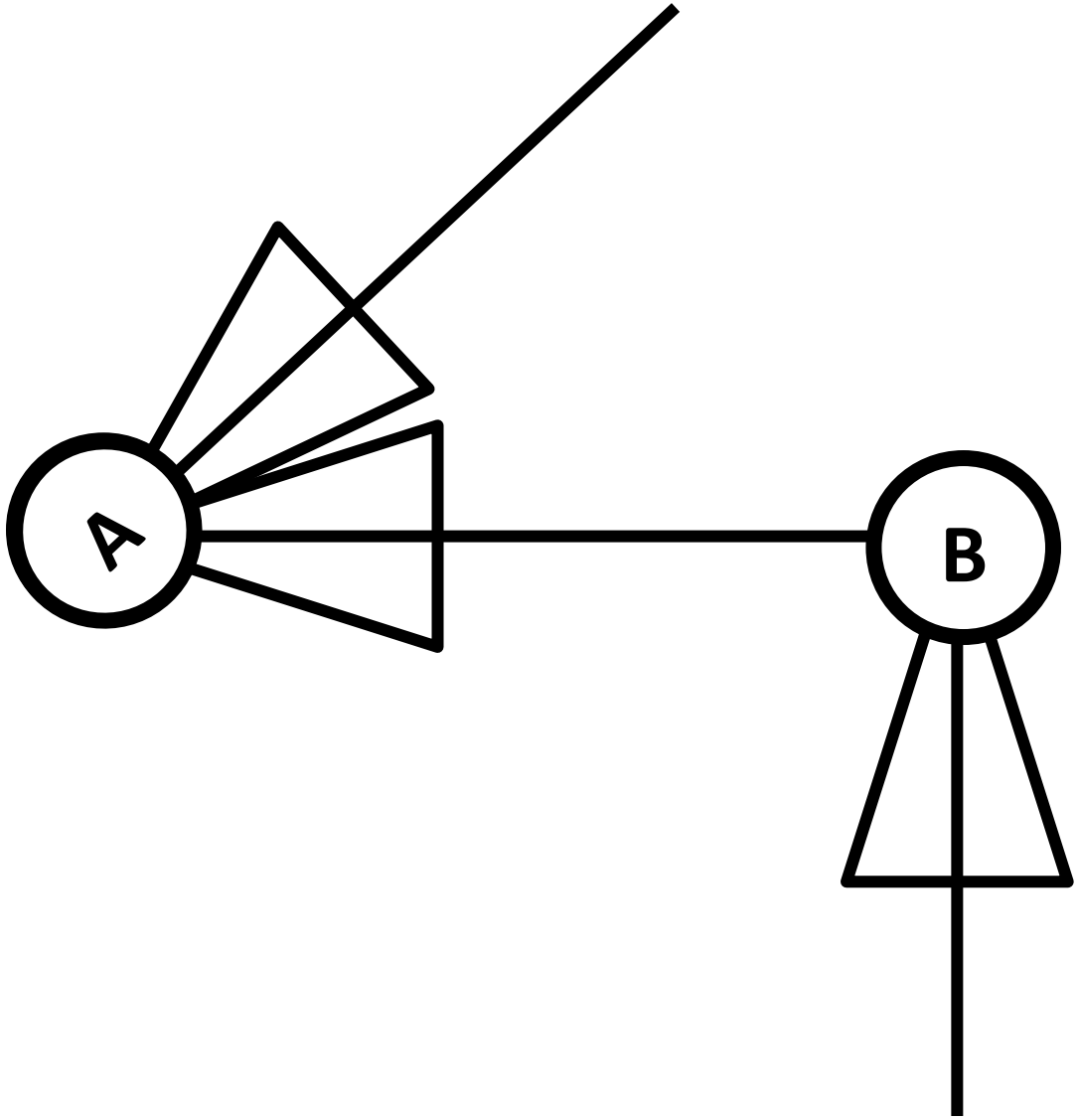
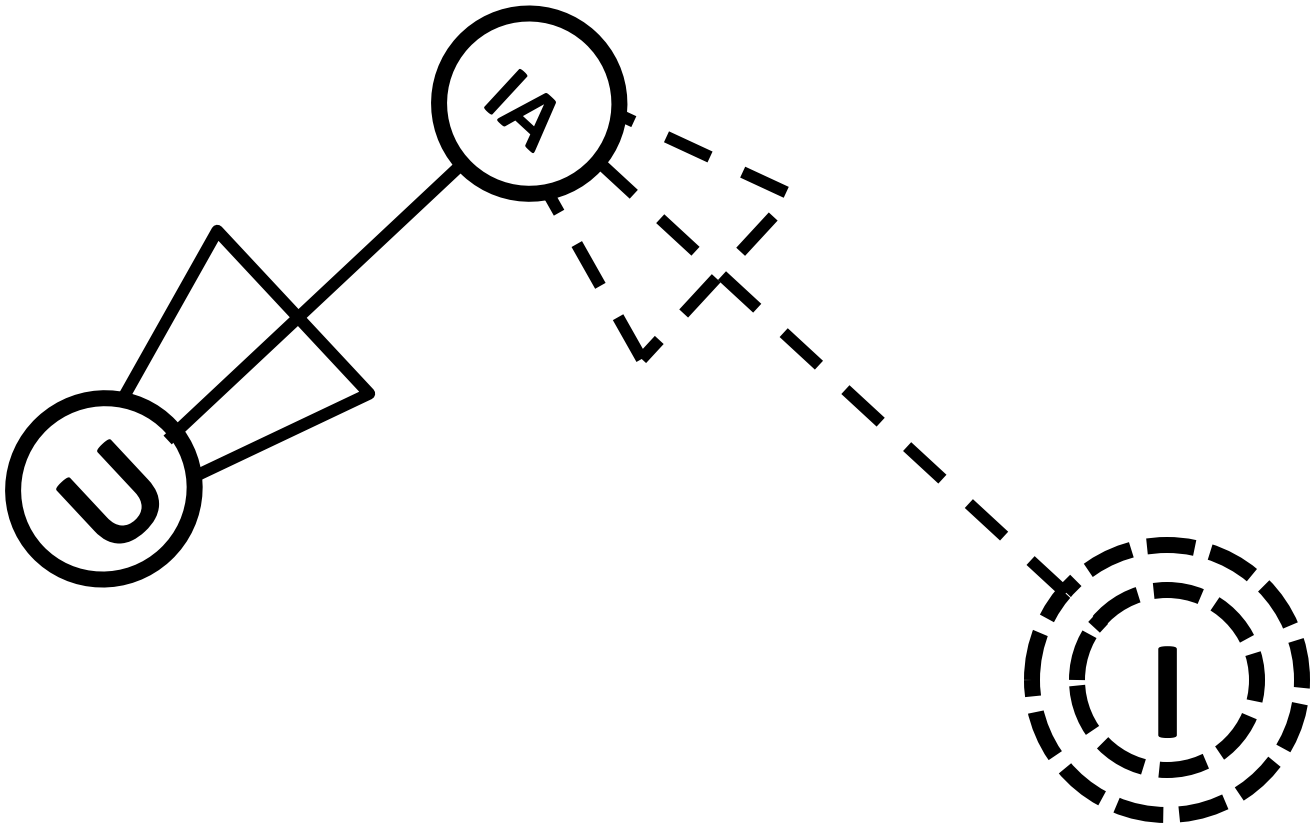
Infrastructure Awareness Model



Nimbus
What the entity projects about itself

Focus:
What the entity is interested in


A
B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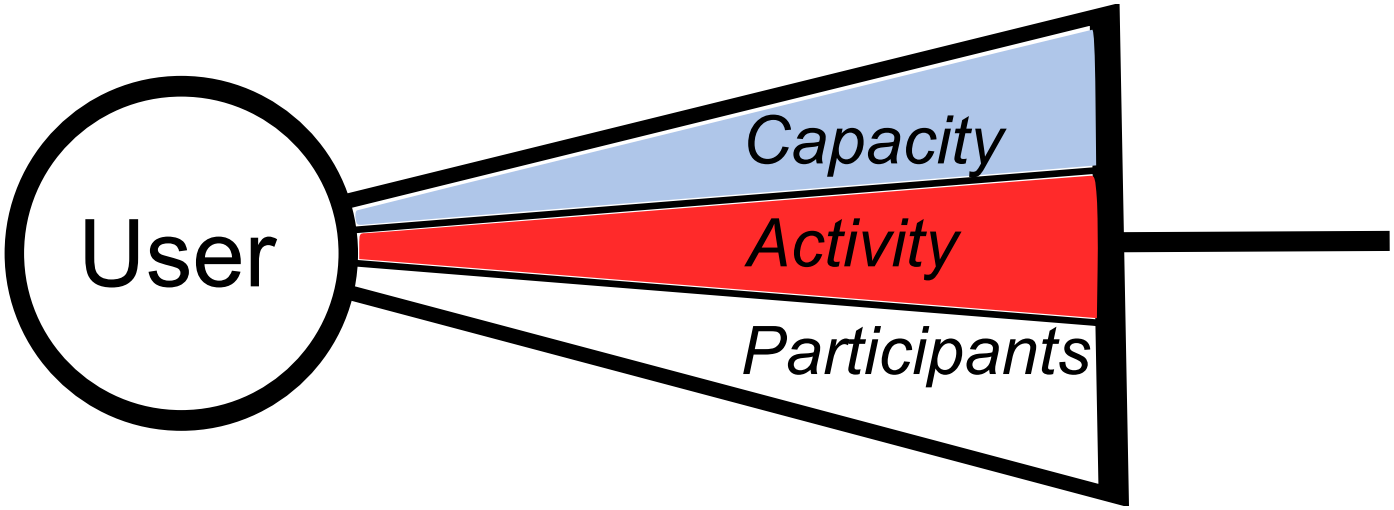
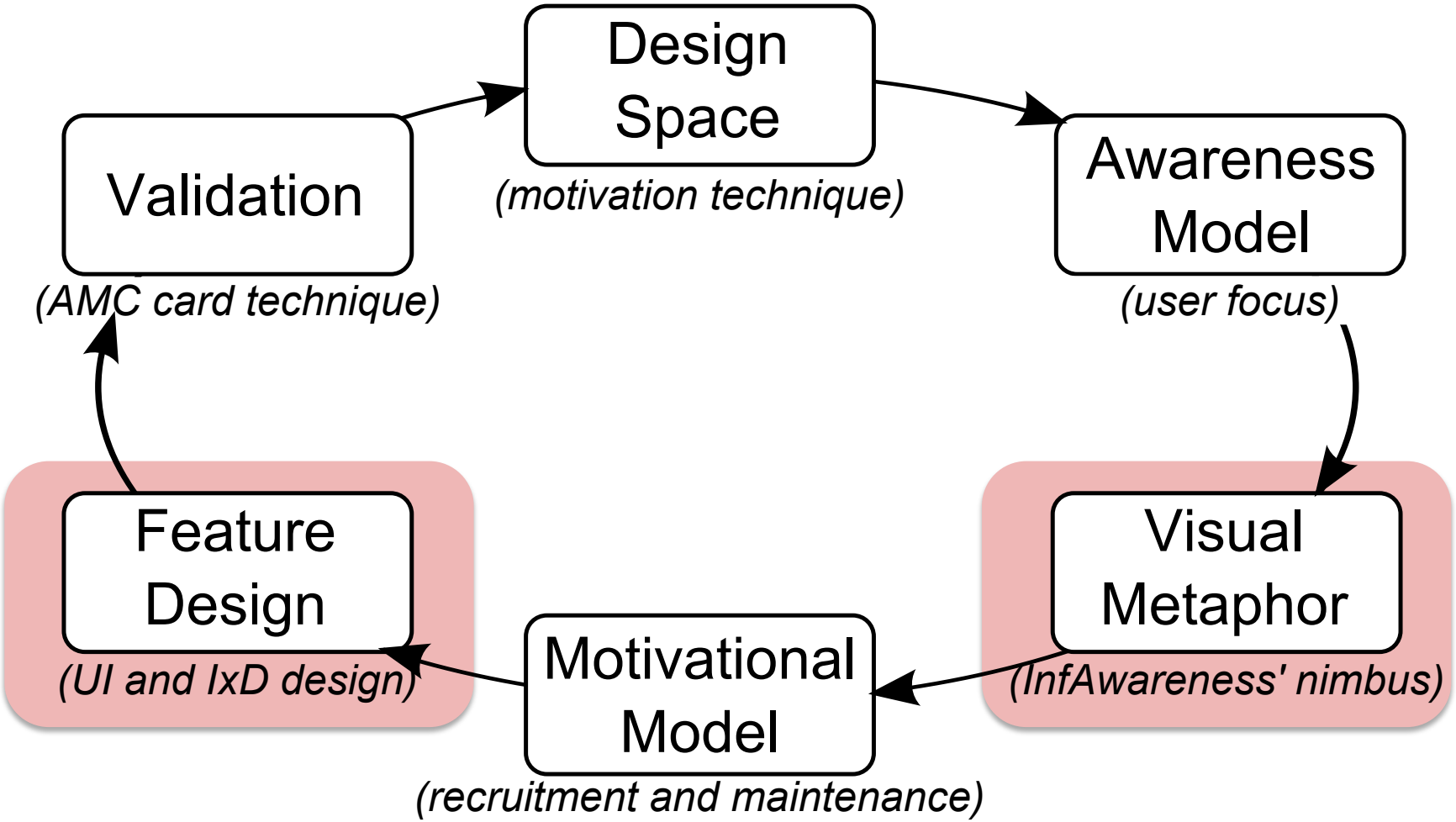


[GridOrbit's awareness model – Page 95]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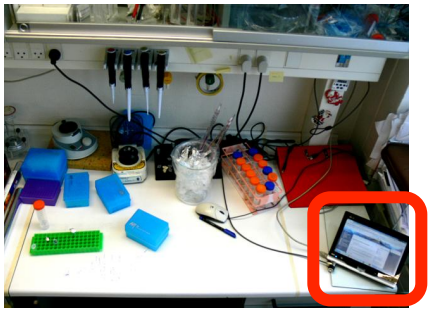
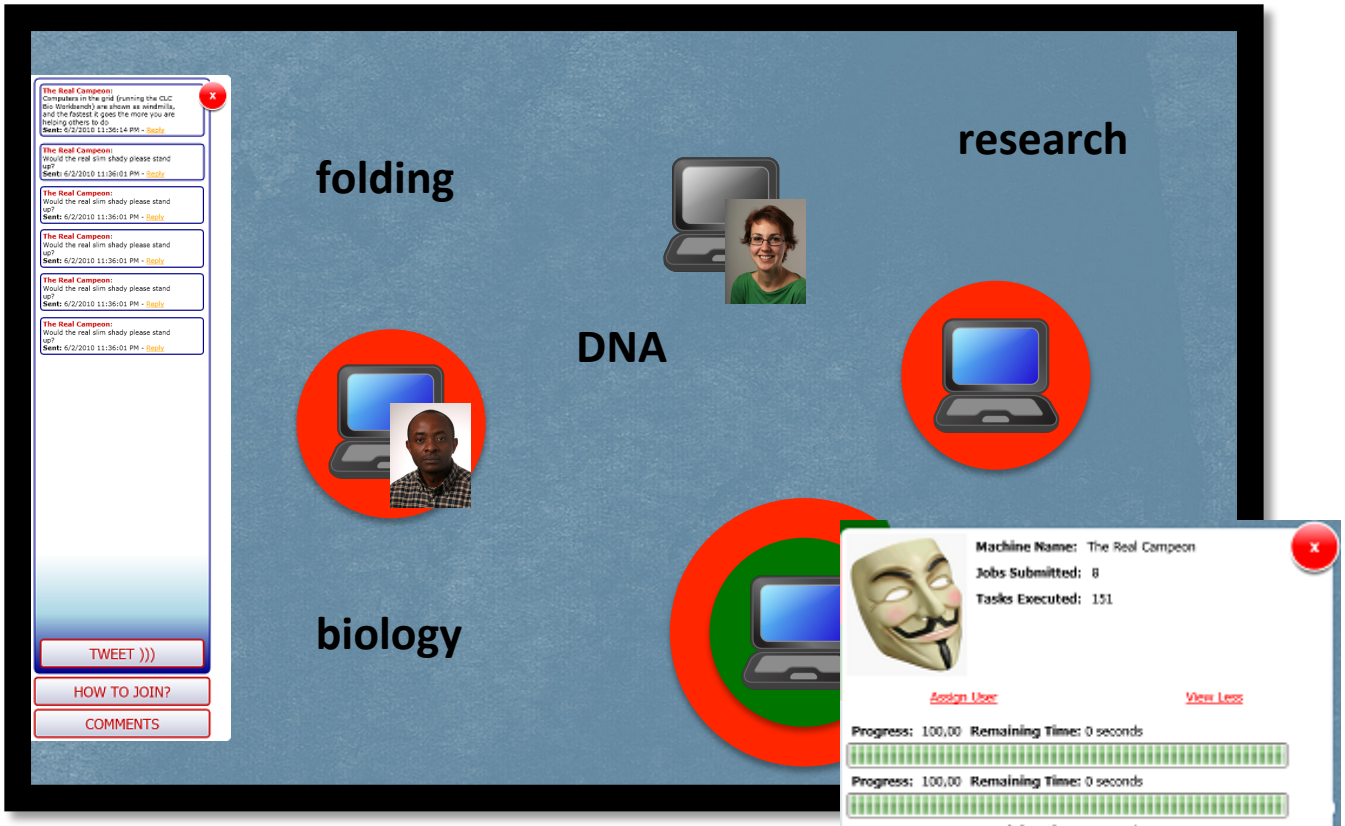
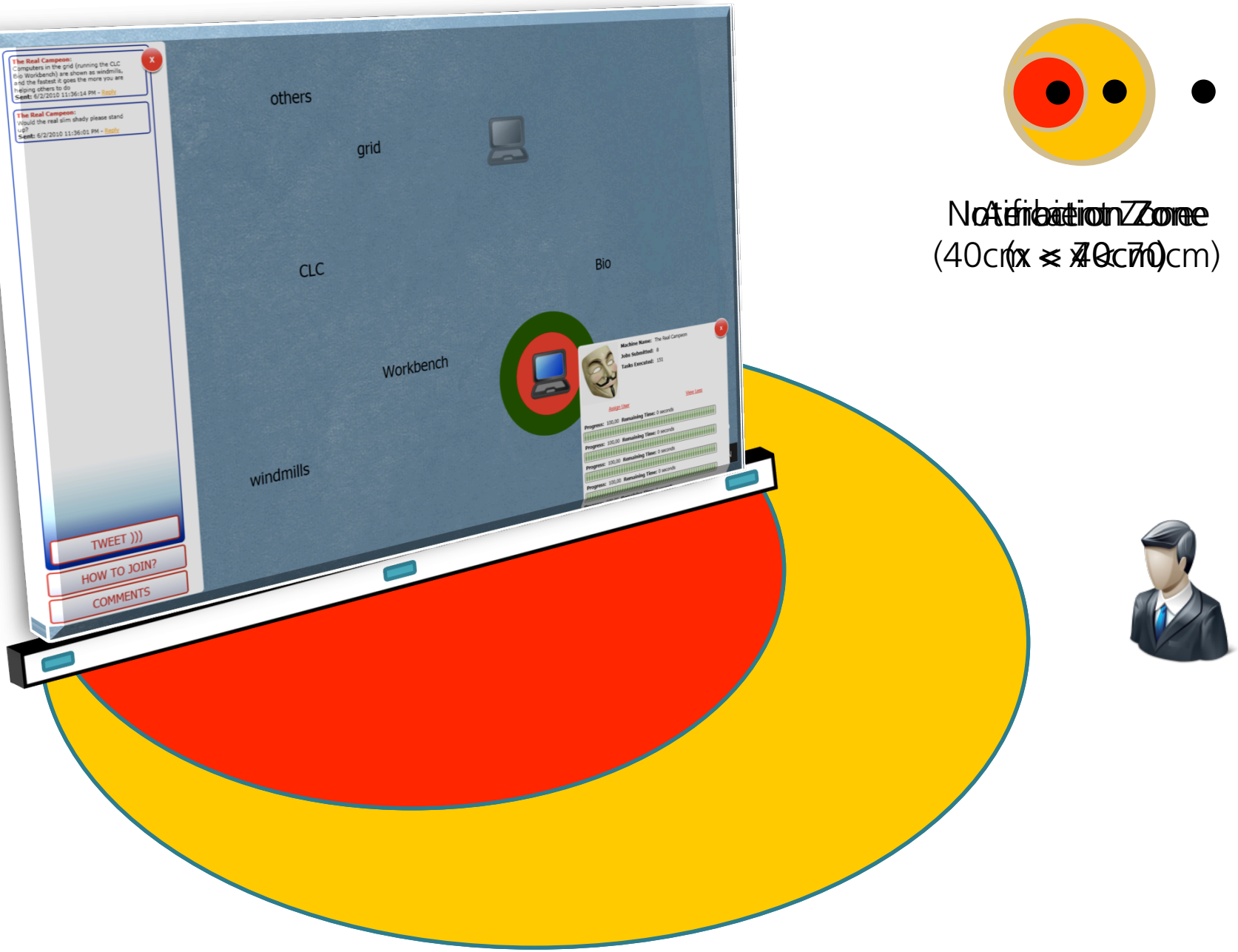
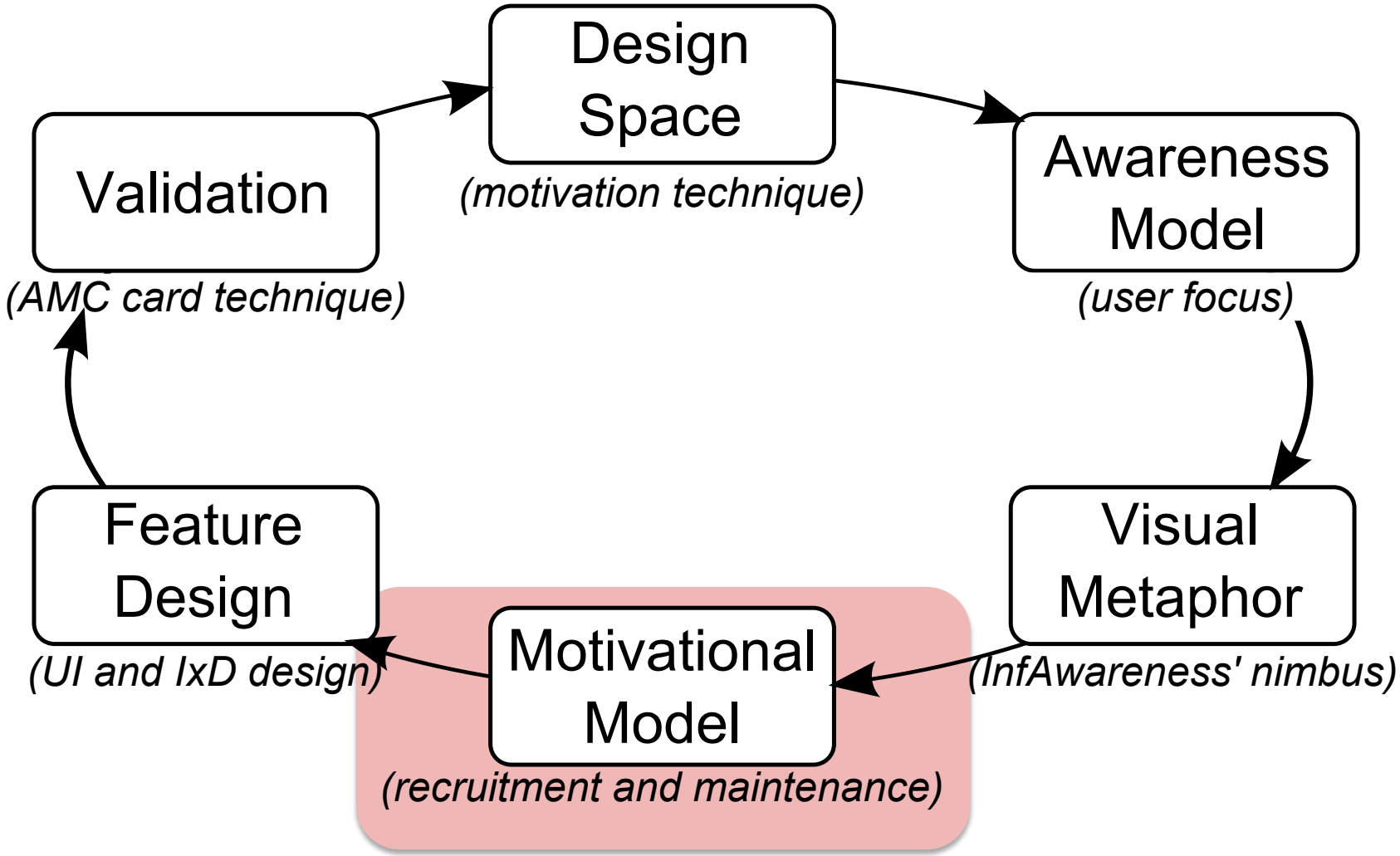



The Real Campeon:
Computers in the grid (running the CLC Bio Workbench) are shown as windmills, and the fastest it goes the more you are helping others to do
Sent: 6/2/2010 11:36:14 PM - Reply
The Real Campeon:
Would the real slim shady please stand up?
Sent: 6/2/2010 11:36:01 PM - Reply
TWEET)))
HOW TO JOIN?
COMMENTS
folding
research
DNA
biology
Machine Name: The Real Campeon
Jobs Submitted: 8
Tasks Executed: 151
Assign User
View Logs
Progress: 100,00 Remaining Time: 0 seconds
Progress: 100,00 Remaining Time: 0 seconds
Progress: 100,00 Remaining Time: 0 seconds
Progress: 100,00 Remaining Time: 0 seconds


others
grid
CLC
Bio
Workbench
windmills
TWEET)))
HOW TO JOIN?
COMMENTS
Notification Zone
(40cm x 40cm)
Affiliation Zone
(70cm x 70cm)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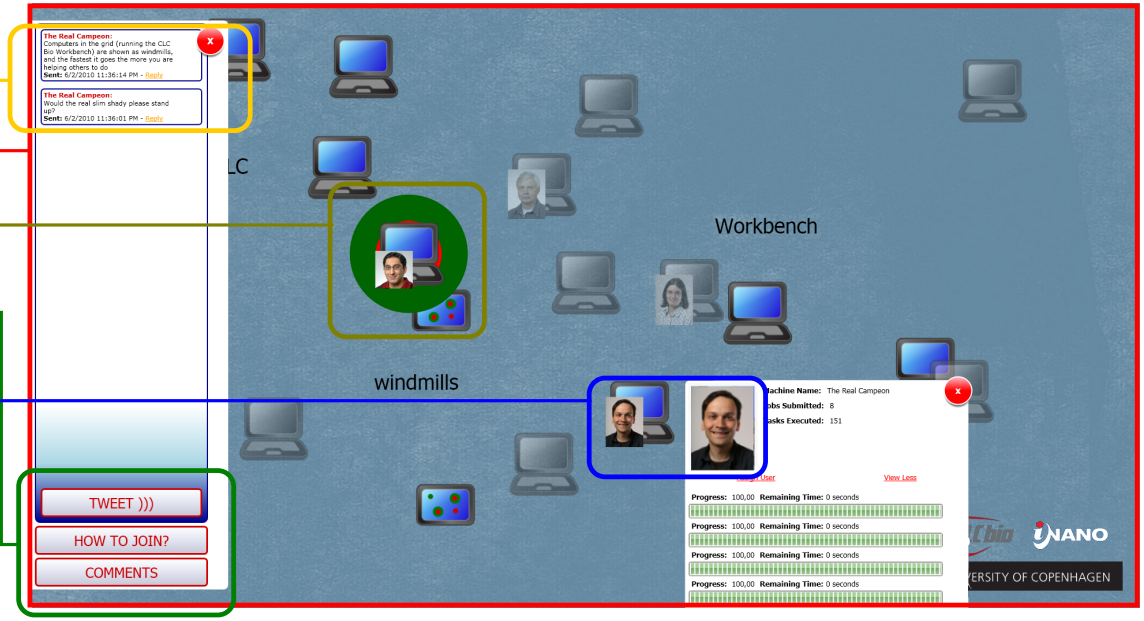
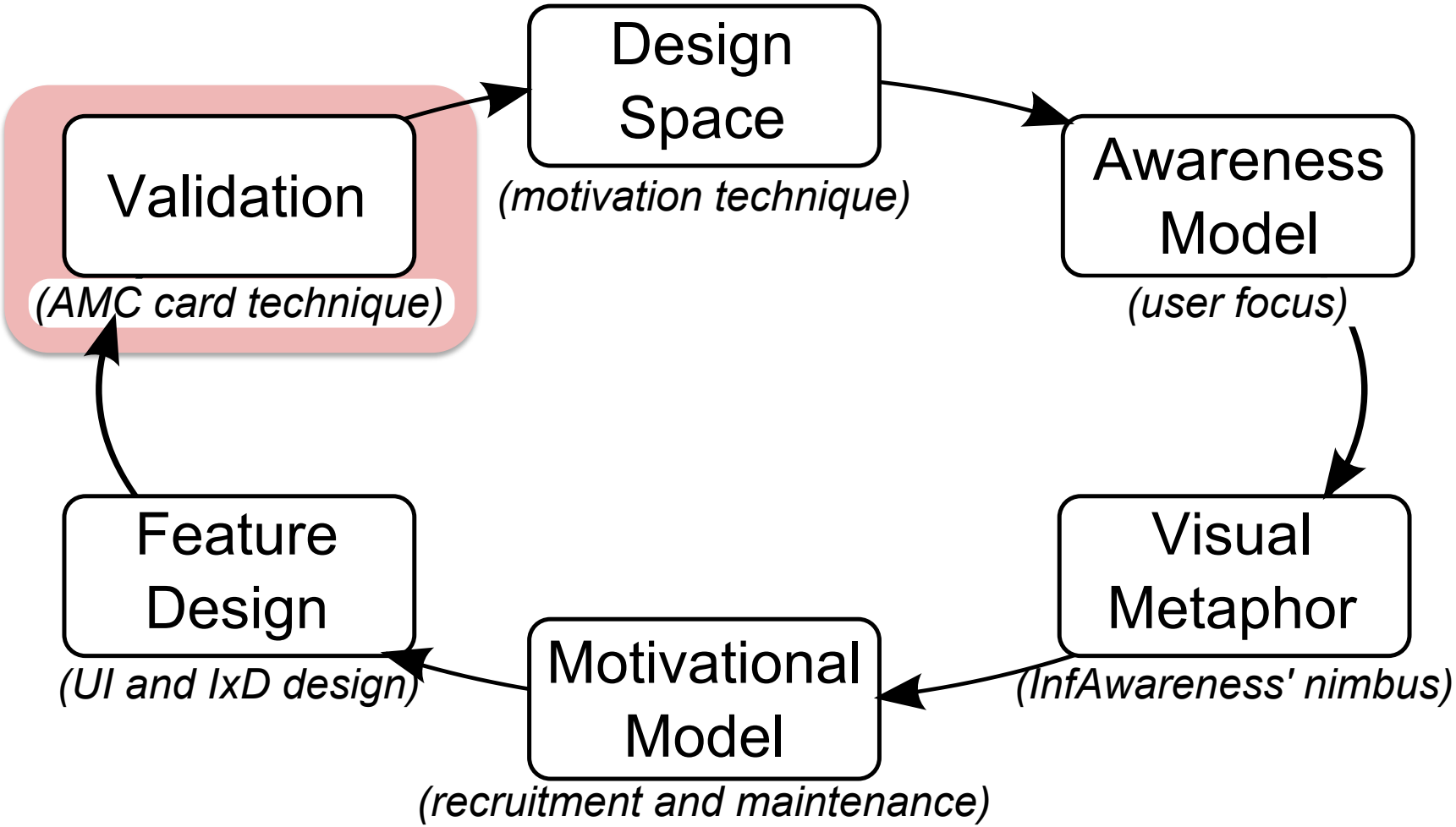
Intrinsic

Extrinsic

- Enjoyment (Beauty - Fun)
- Enhancement
- Self Expression
- Reputation
- Community



[Motivational Model – Page 97]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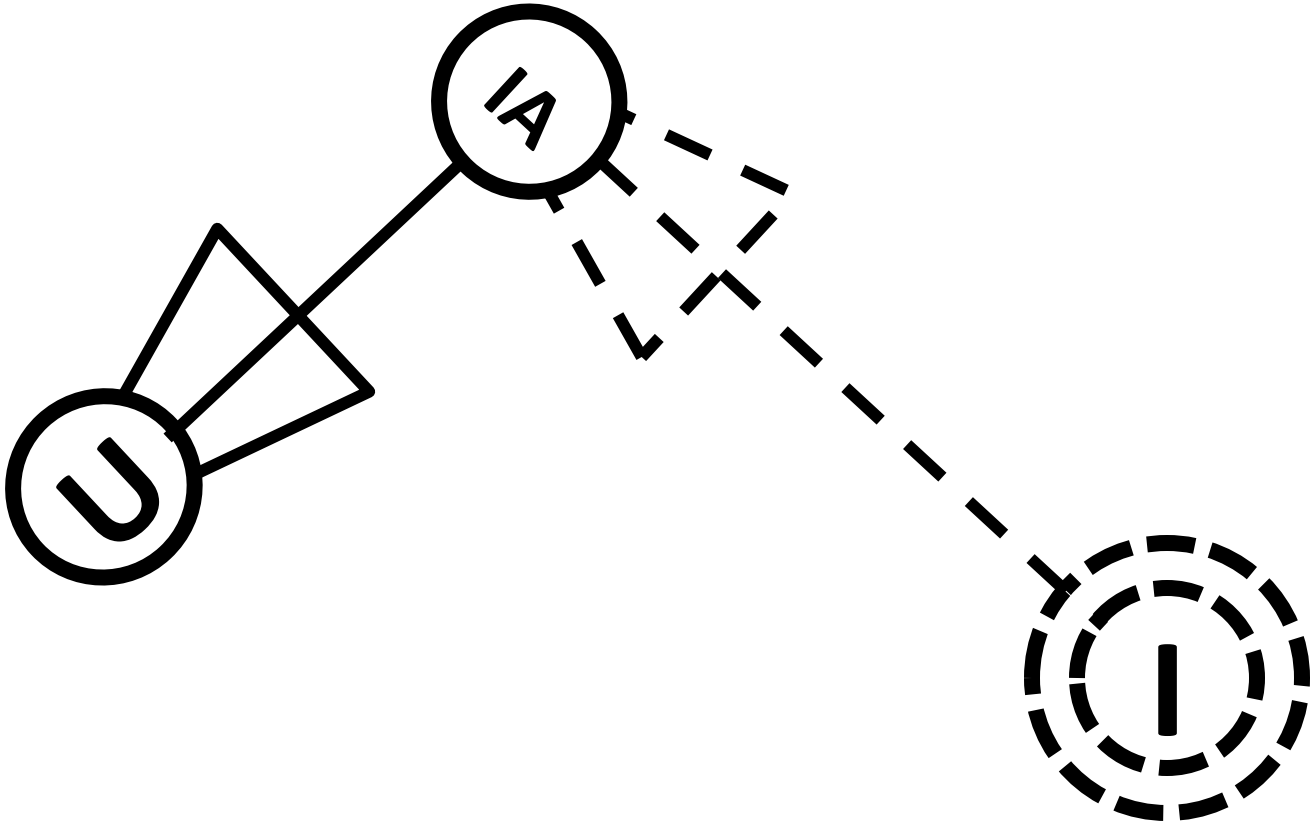
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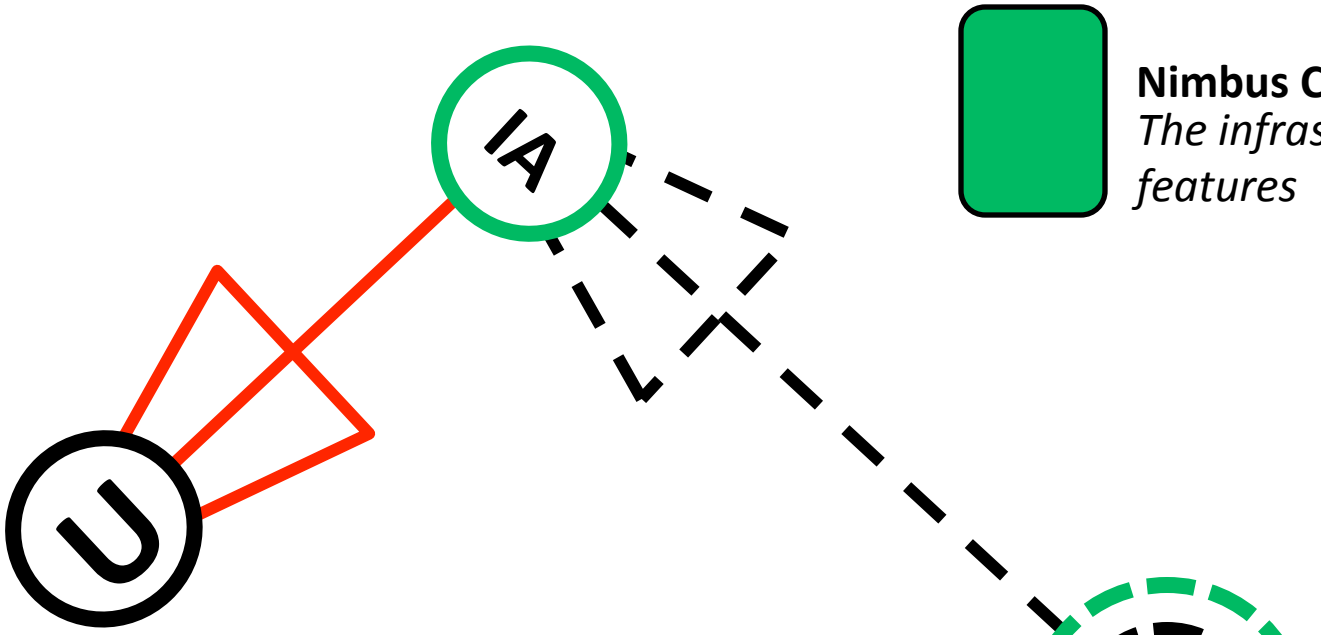
AMCard Technique

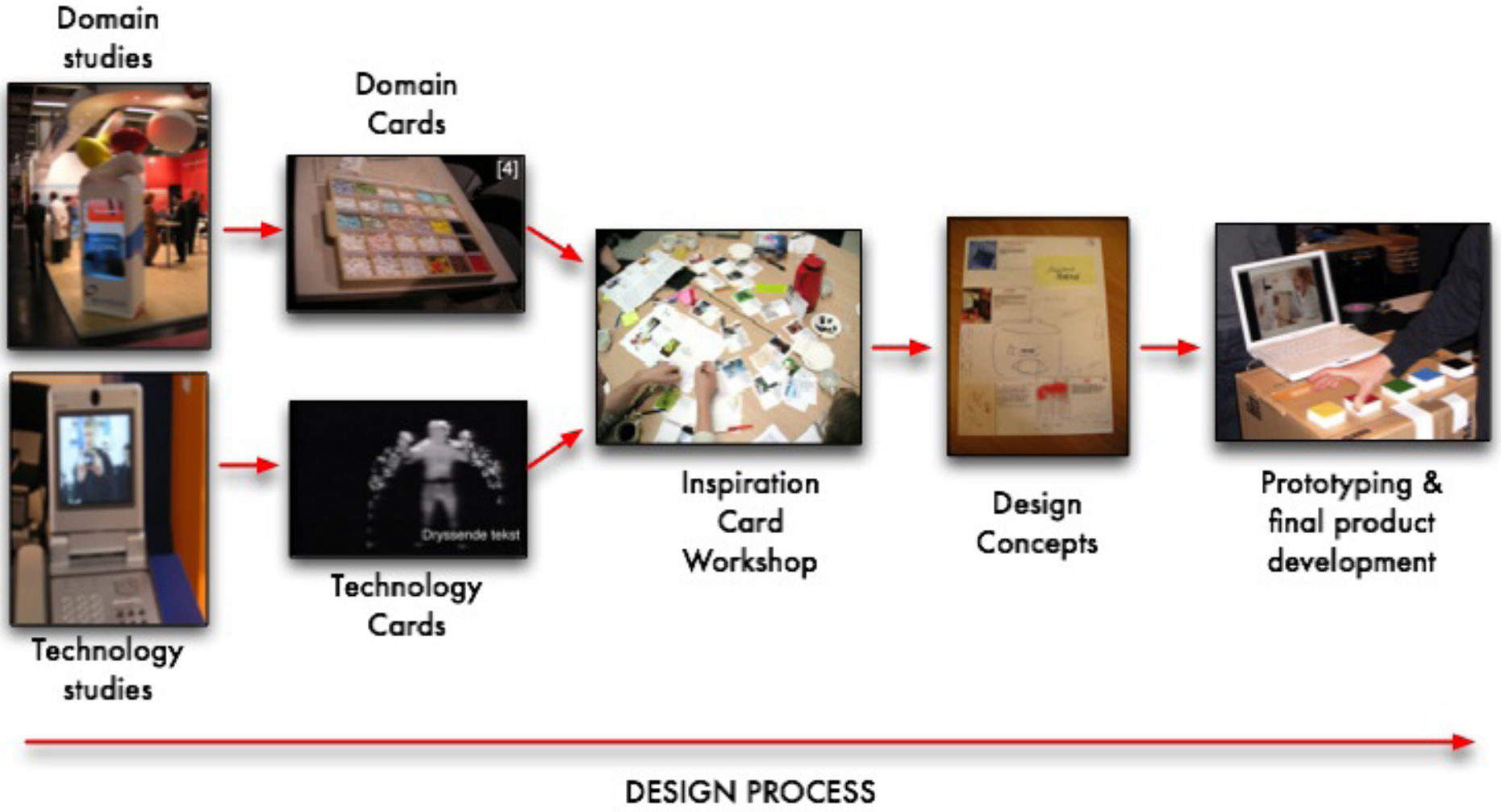


Nimbus Cards
The infrastructure's features

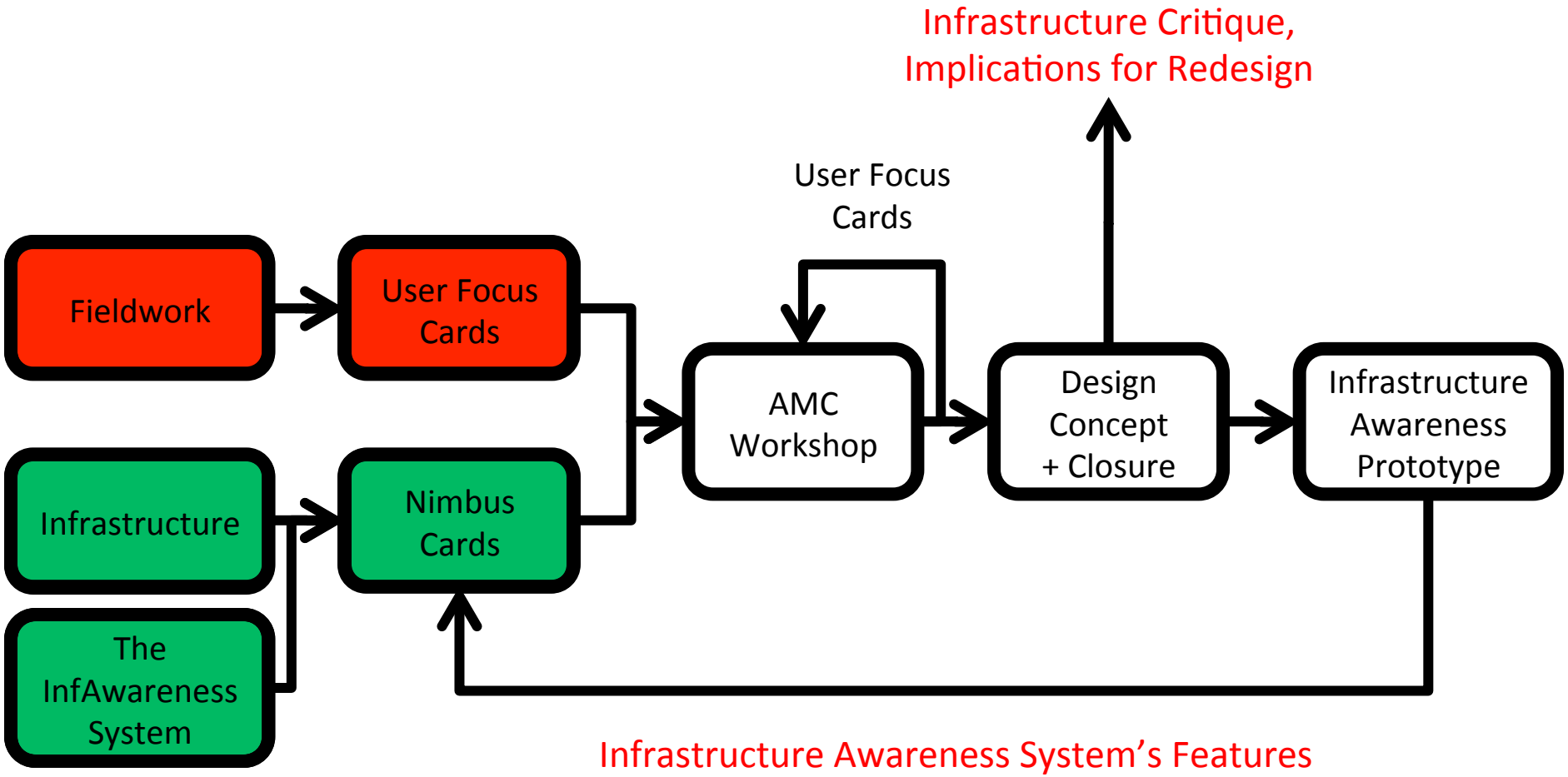
Focus Cards
The users' interests

[Hincapie-Ramos, Tabard & Bardram @ DIS'10]

Inspiration Cards



Picture taken from the original paper: Halskov, K. and Dalsgård, P. 2006. **Inspiration card workshops.** In *Proceedings of the 6th Conference on Designing interactive Systems* (University Park, PA, USA, June 26 - 28, 2006). DIS '06. ACM, New York, NY, 2-11.
DOI= http://doi.acm.org/10.1145/1142405.1142409



[Hincapie-Ramos, Tabard & Bardram @ DIS'10]

CPU consompti

Load

Machines connected

Capacity

Resources

Resource Availability

I would like to know what's the actual or historical availability of certain shared resources.

Data used

Jobs' progress

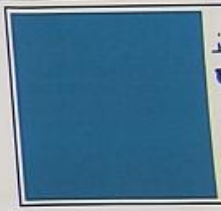
Collaboration

What's going on?

I would like to know the latest events, news, web posts, etc.

Calenda-
-Overview of upcoming events

Tag Cloud



interested in what other ppl are interested in.

Tasks submitted but not executed yet

Submitter

Project

Explorations of ongoing project

Tasks being executed

Tweets

Tweet
- constructs
- help
- jokes
-
-

MBE - emails
hack the screen & up

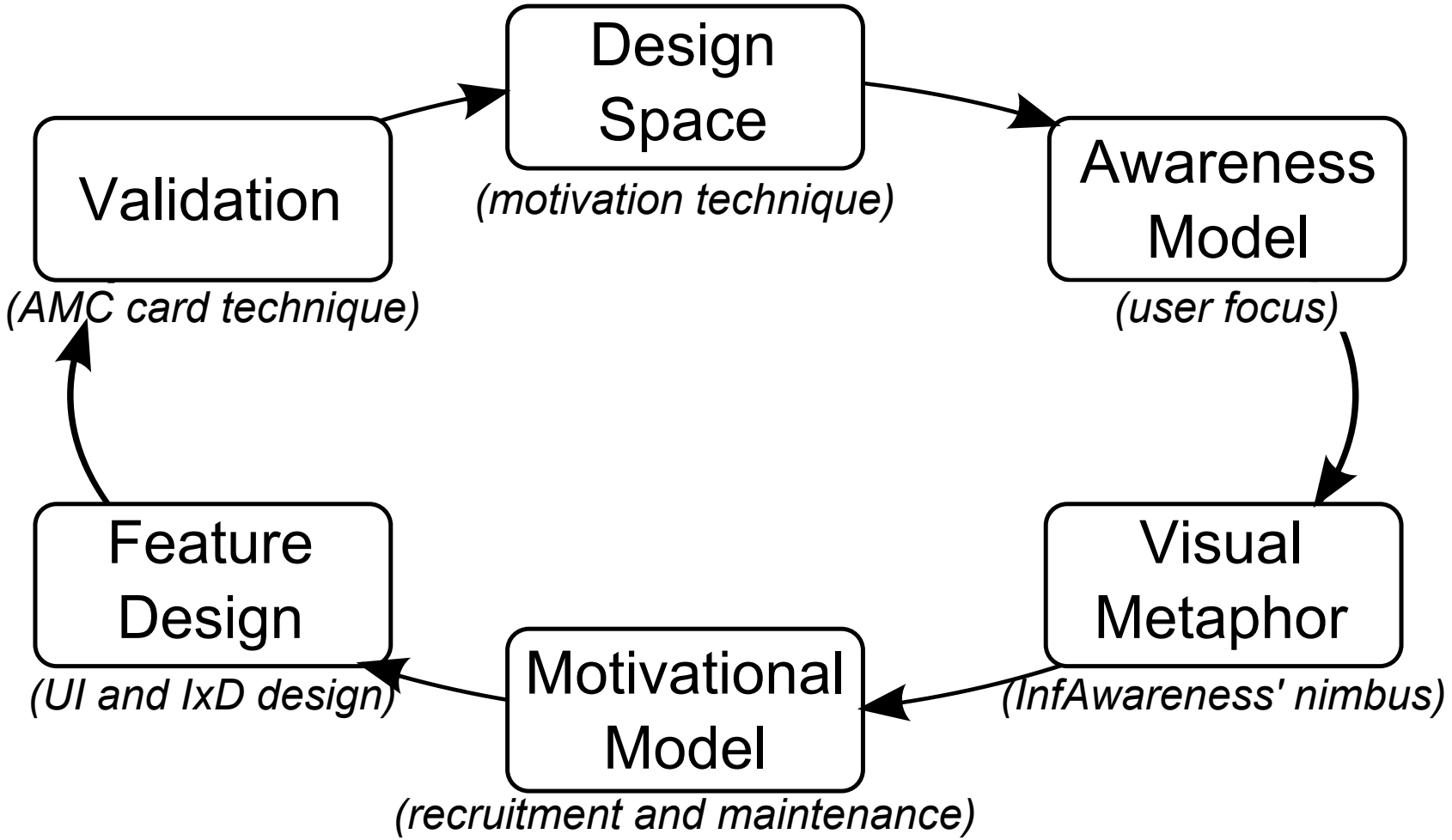
Project

Tasks executed
finished

Jobs' progress

Updates about last week activities.

images or videos of results.


Design Space
(motivation technique)
Awareness Model
(user focus)
Visual Metaphor
(InfAwareness' nimbus)
Motivational Model
(recruitment and maintenance)
Feature Design
(UI and IxD design)
Validation
(AMC card technique)

Finder File Edit View Go Window Help dim. 20:53

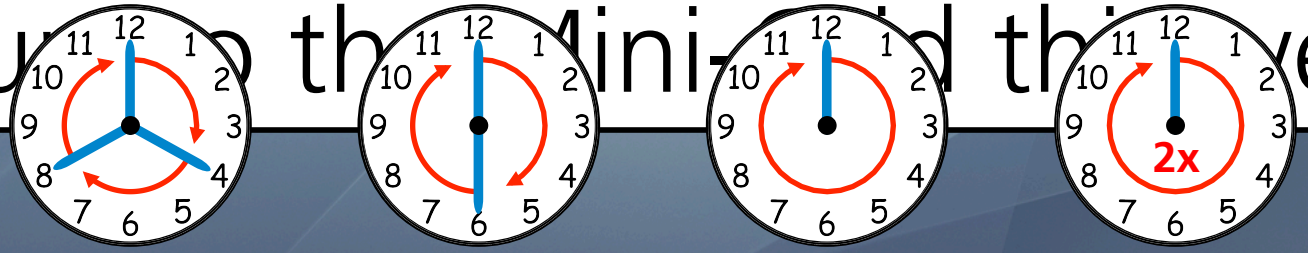
Mini-Grid / CLCbio Workbench

You contributed 12% less than other contributors this week.

Click here to contribute more by launching CLCbio.

Personal Motivation

You contributed for less than 40 hours to the Mini-Grid this week



Evaluation

Part III

Agenda

Part I – Introduction

Part II – Design

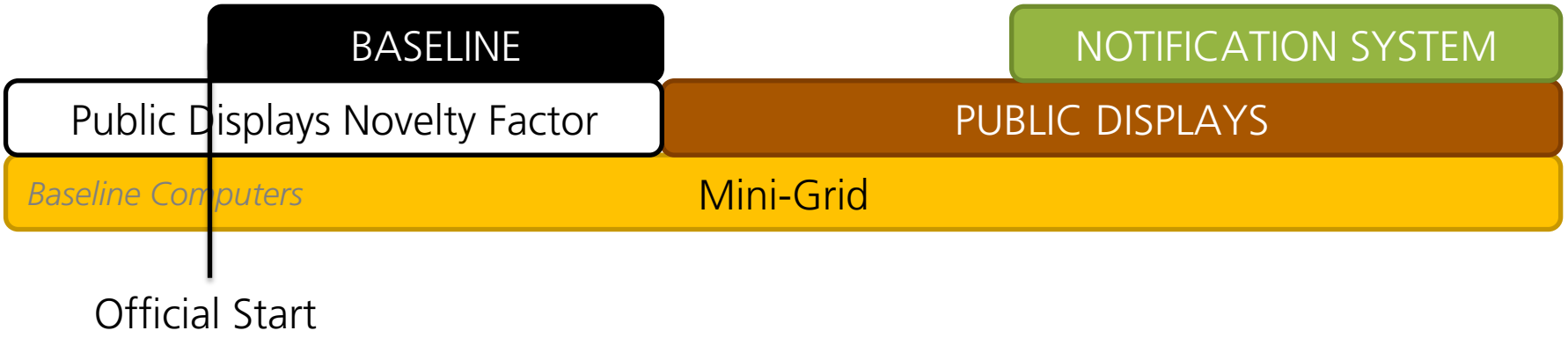
Part III – Evaluation

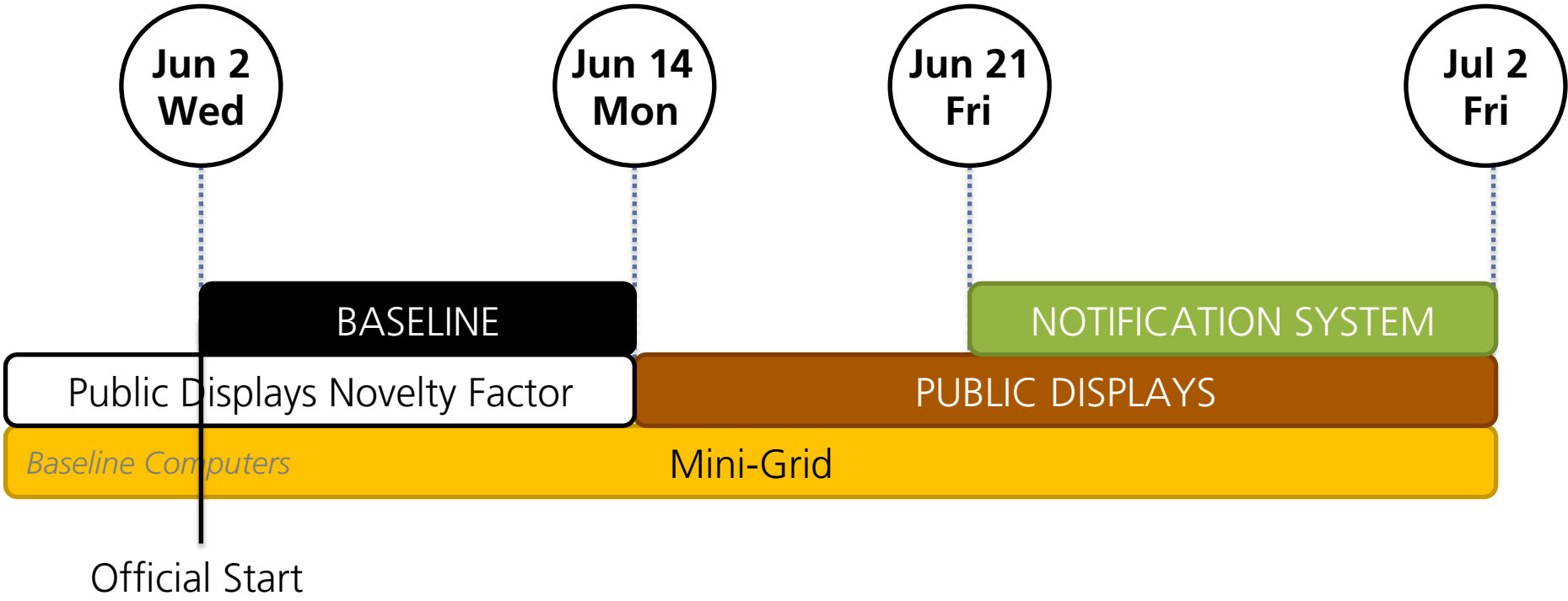
- Study Setup
- Quantitative Results
- Usage Patterns
- Adoption Impact
- GridOrbit Usage
- Interviews

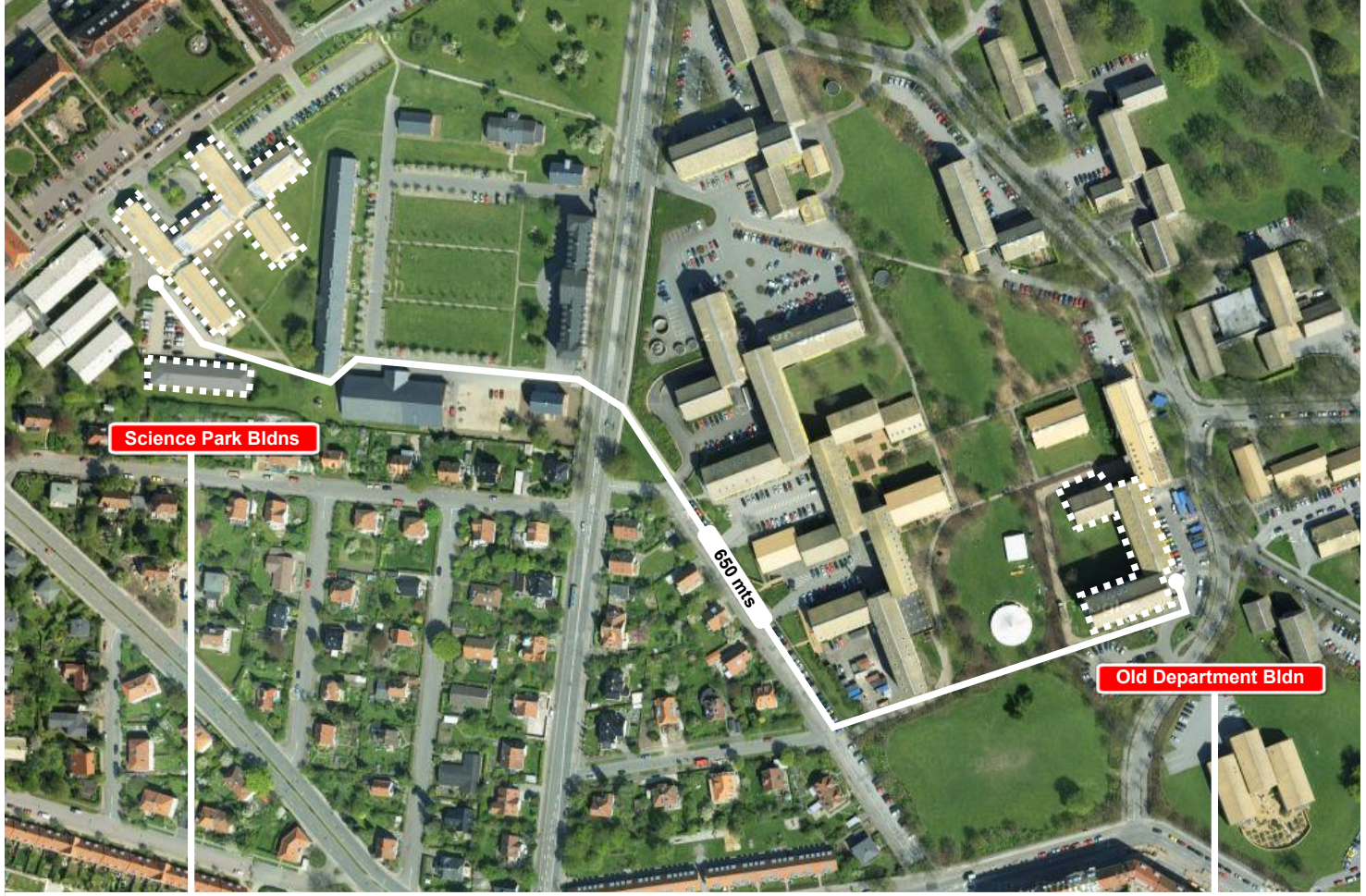
Part IV – Discussion

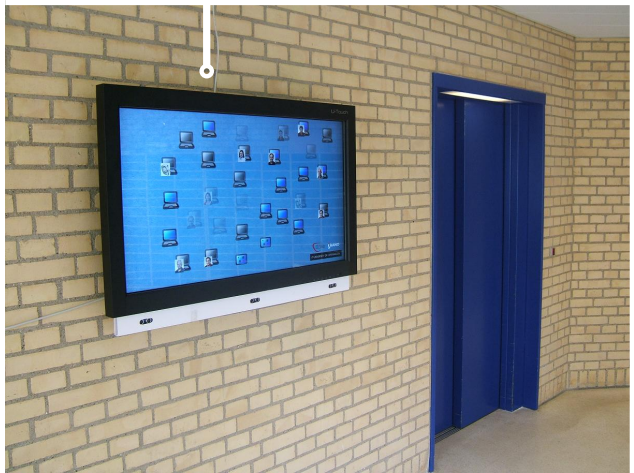
1- See what the impact of these awarness technologies is in the recruitment of volunteers.

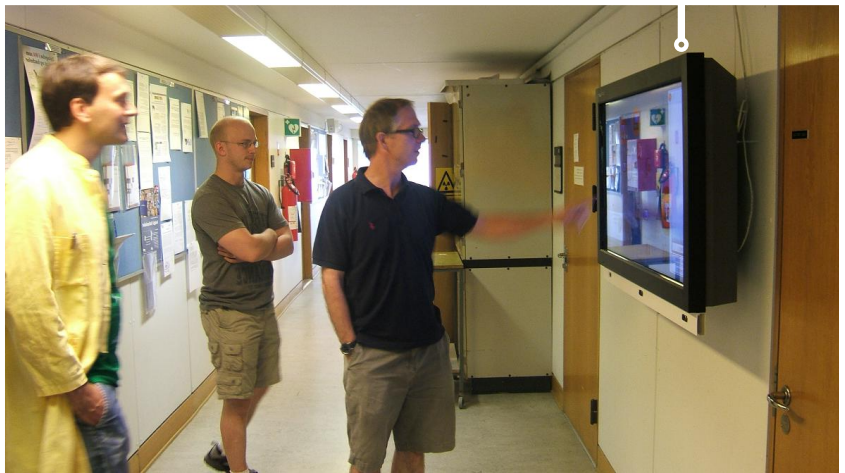
2- Gather empirical information about the relation of users and these awareness technologies.


BASELINE
NOTIFICATION SYSTEM
Public Displays Novelty Factor
PUBLIC DISPLAYS
Baseline Computers
Mini-Grid
Official Start


Jun 2
Wed
Jun 14
Mon
Jun 21
Fri
Jul 2
Fri
BASELINE
NOTIFICATION SYSTEM
Public Displays Novelty Factor
PUBLIC DISPLAYS
Baseline Computers
Mini-Grid
Official Start


Science Park Bldns
650 mts
Old Department Bldn





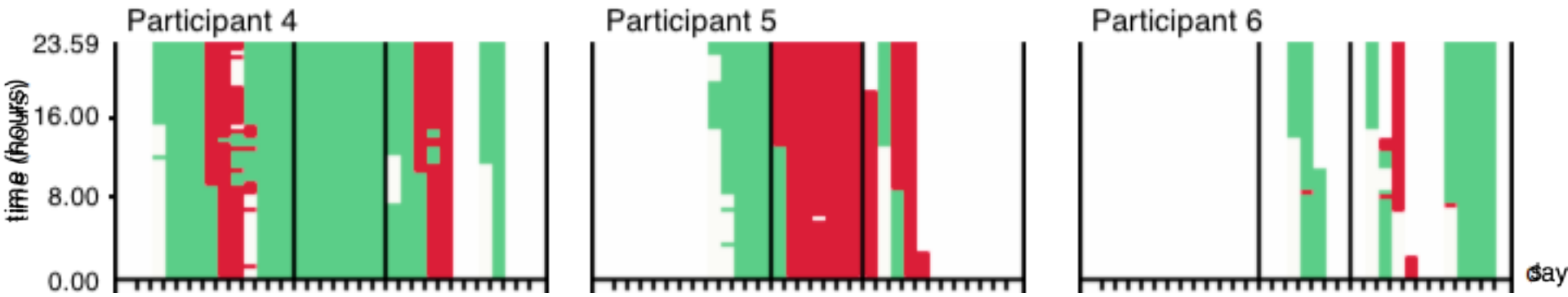
- machines
- Mini-Grid tasks
- visits and interactions
- GridOrbit notifications
- interviews

35 participant machines contributed at least once
8 machines submitted tasks

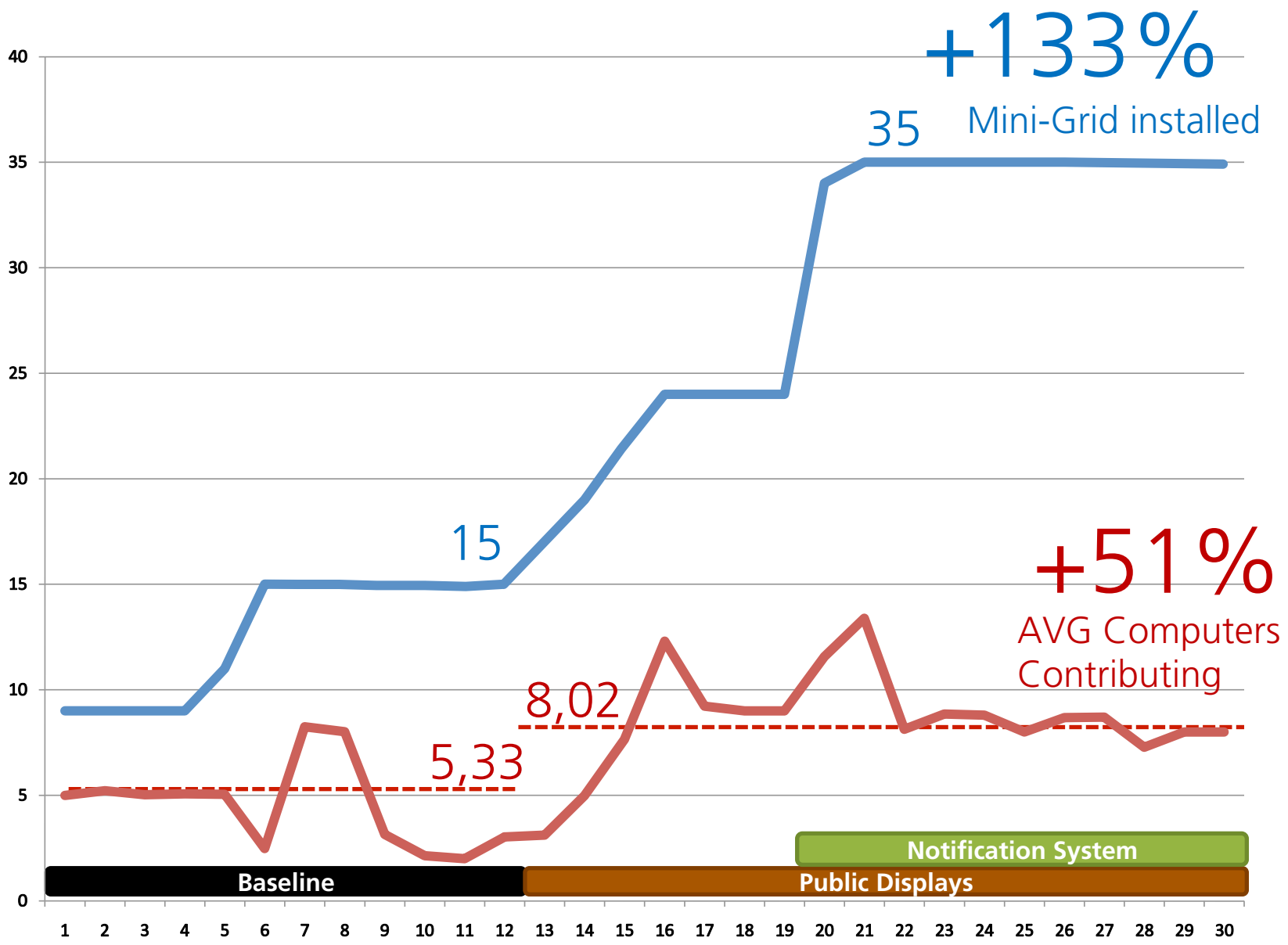
103 task batches
7264 individual tasks

5022 visits to the public displays
592 involved some kind of interaction
14 on-screen messages
54 pictured assigned to machines

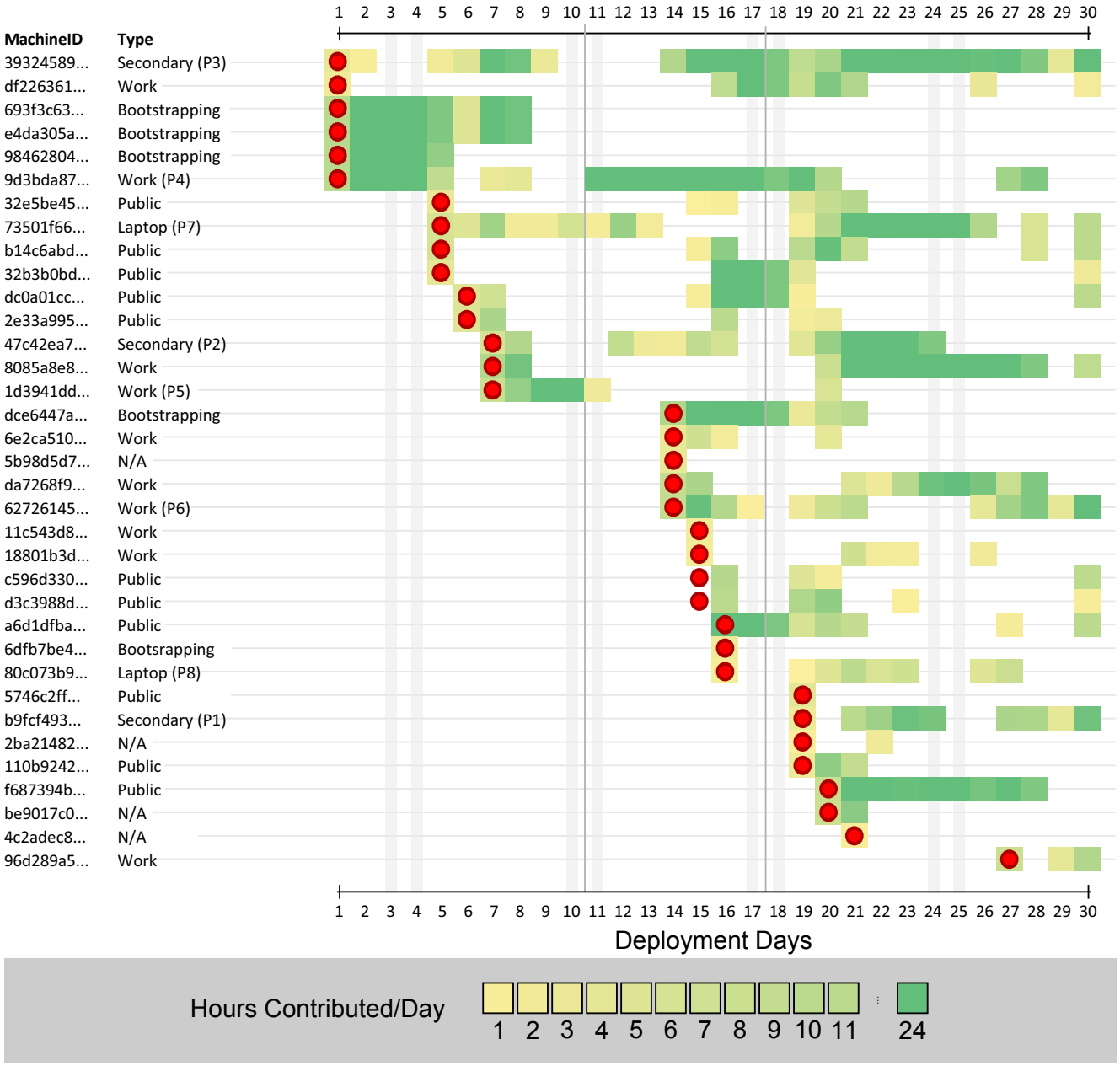
8 users for the notification system (N.S.)
44 state queries
14 launches of the Mini-Grid client form the N.S.



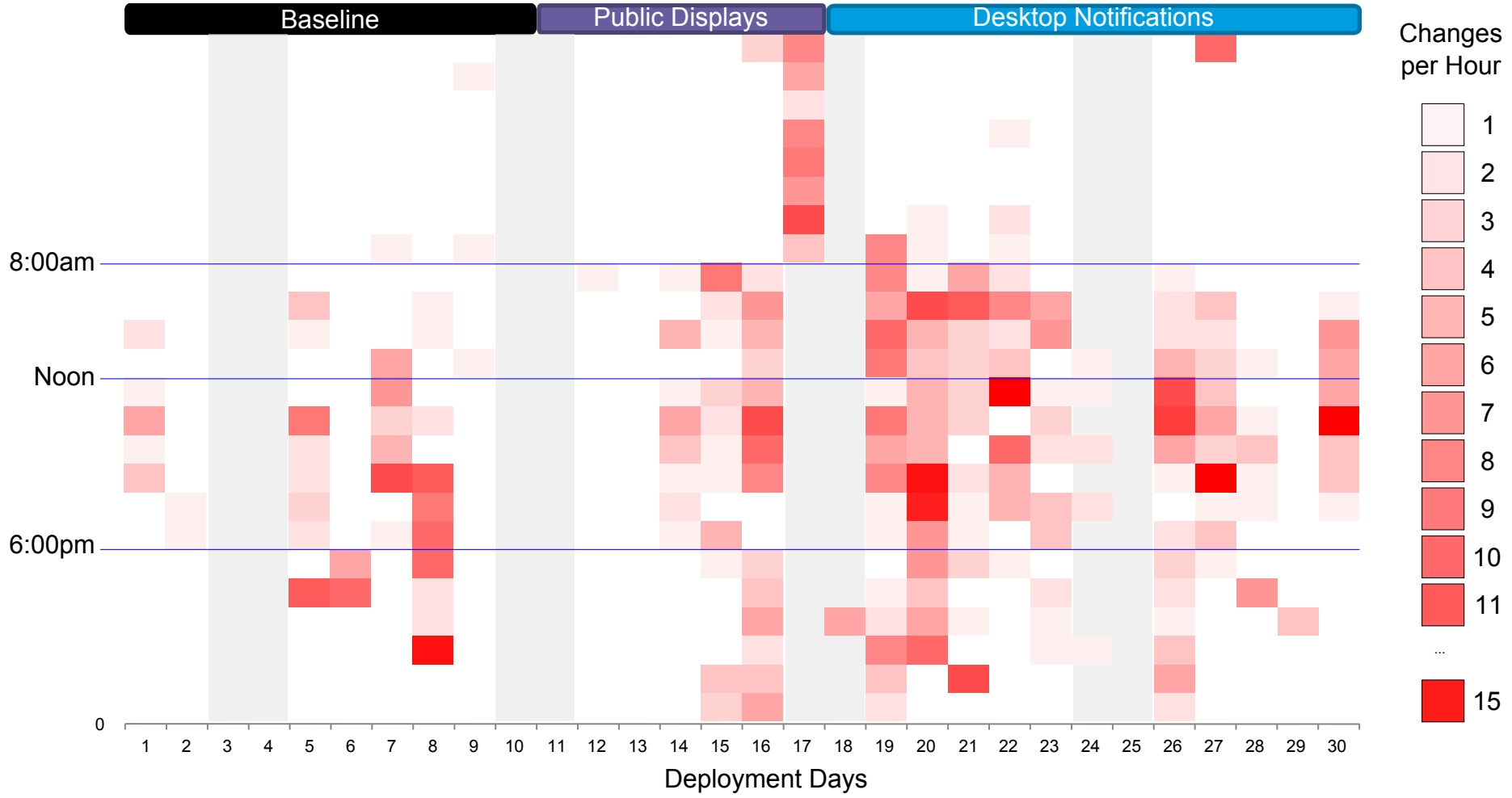
- Dedicated Secondary Computers
- Work Desktops
- Laptops (intermittent use)
- Bootstrapping Computers



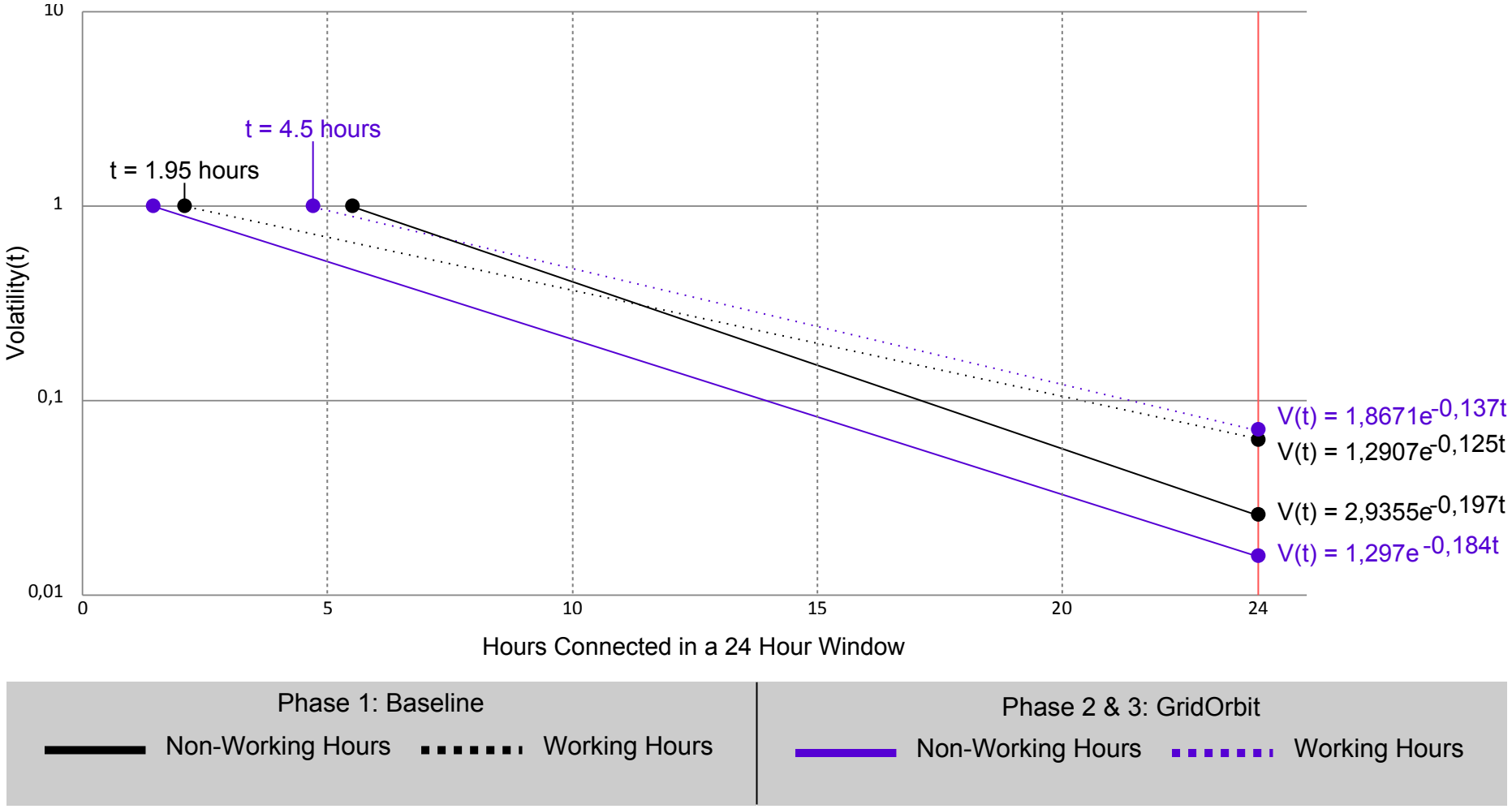
[Adoption Impact – Page 121]



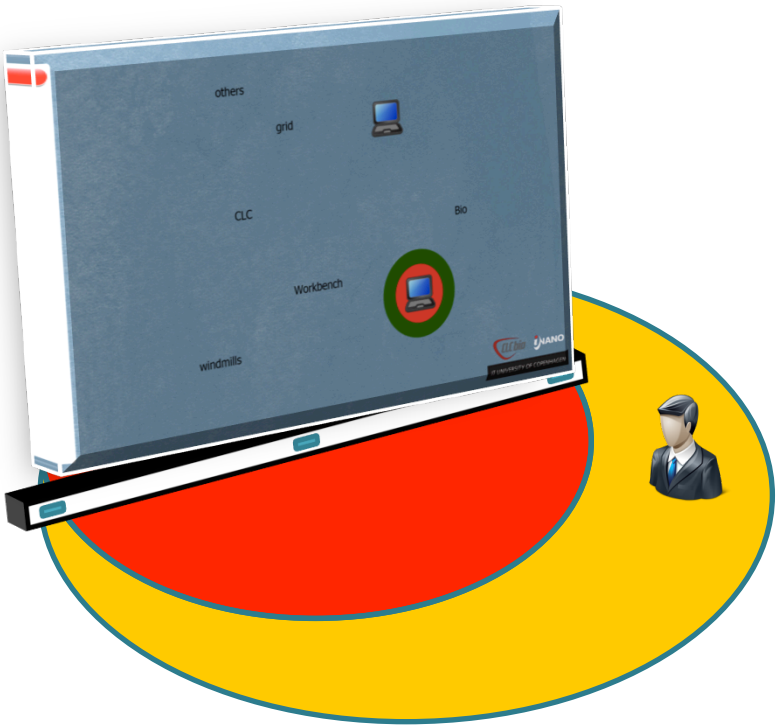
[Participants' Contribution to the Mini-Grid – Page 123]



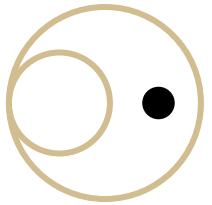
[Number of changes (join/leave) per hour – Page 123]



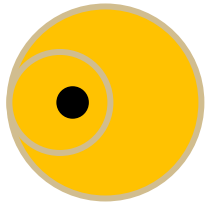
[Mini-Grid volatility in relation to participants – Page 124]



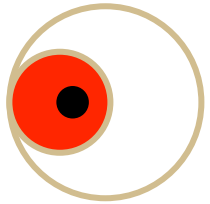
Aware
60% of the Visits
Ambient Zone



Curious
30% of the Visits
Int + Notification Zone
- Touch Interaction



Explorer
10% of the Visits
Interaction Zone
+ Touch Interaction



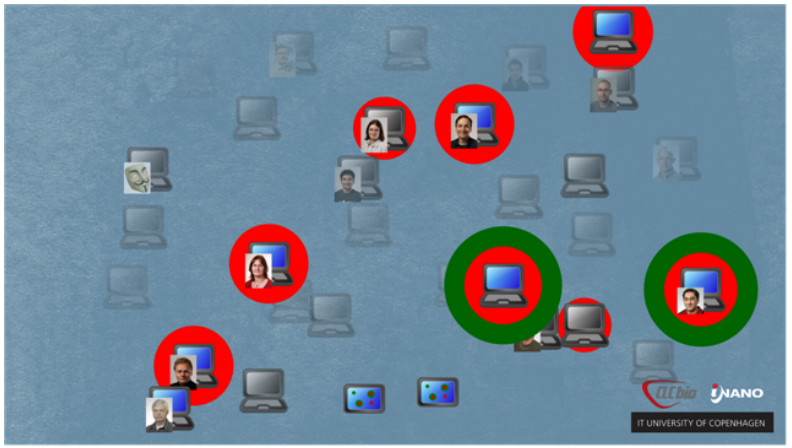
[Δt = 1500ms – GridOrbit public display visitors – Page 125]

Visits to the Public Displays

-

Capacity

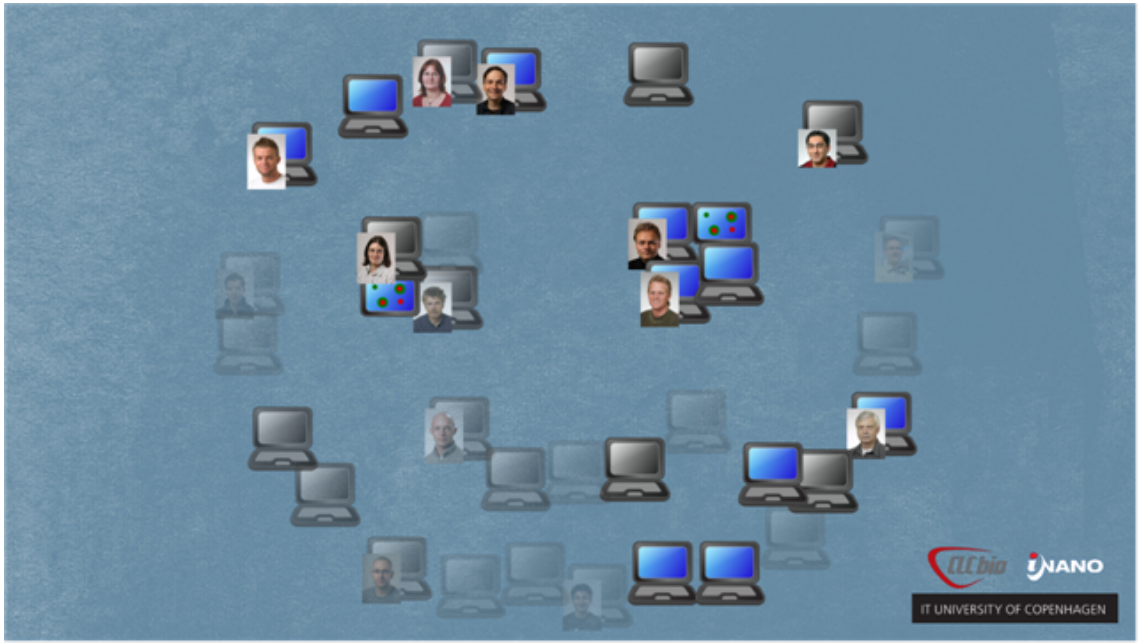
+

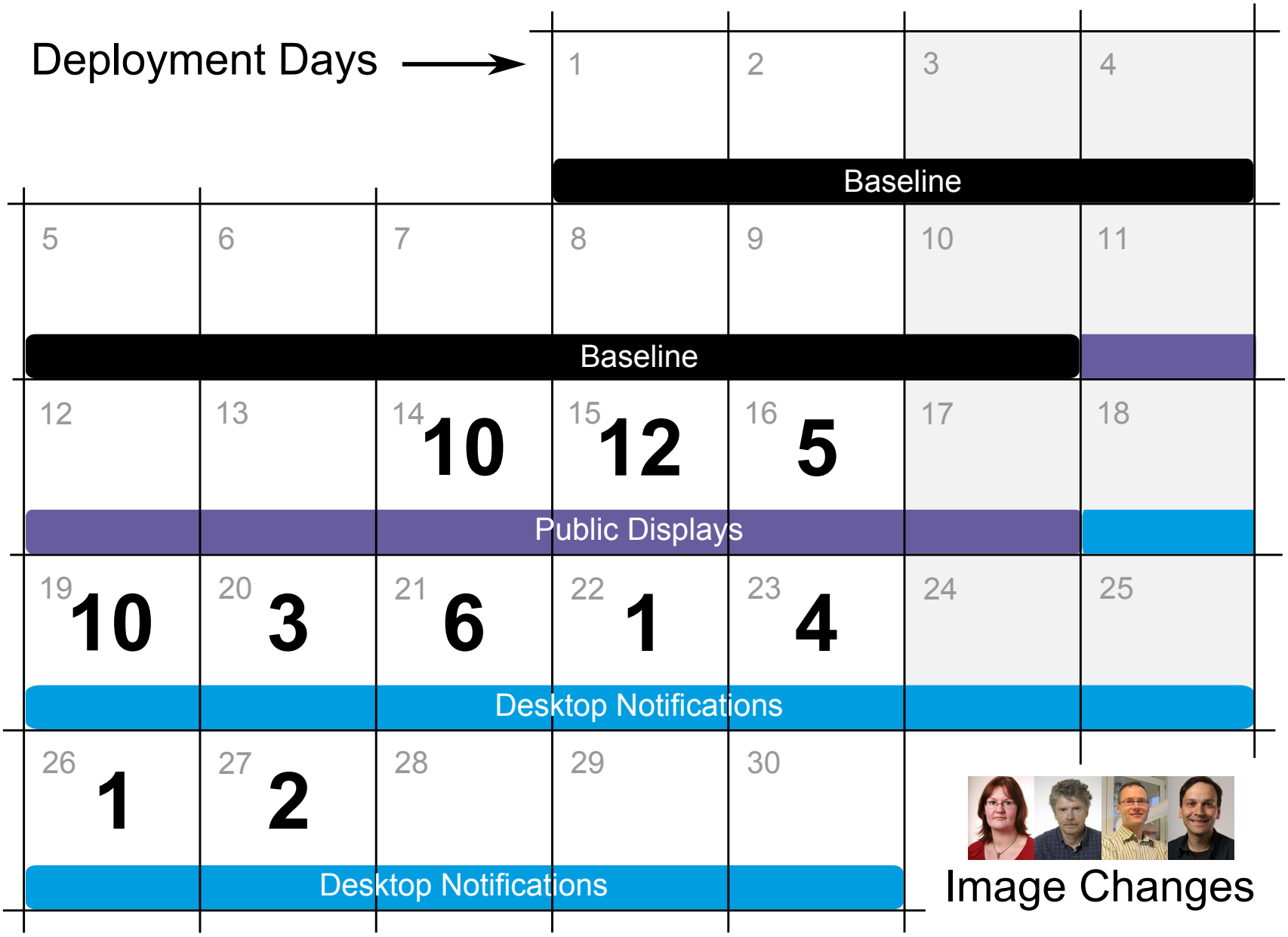


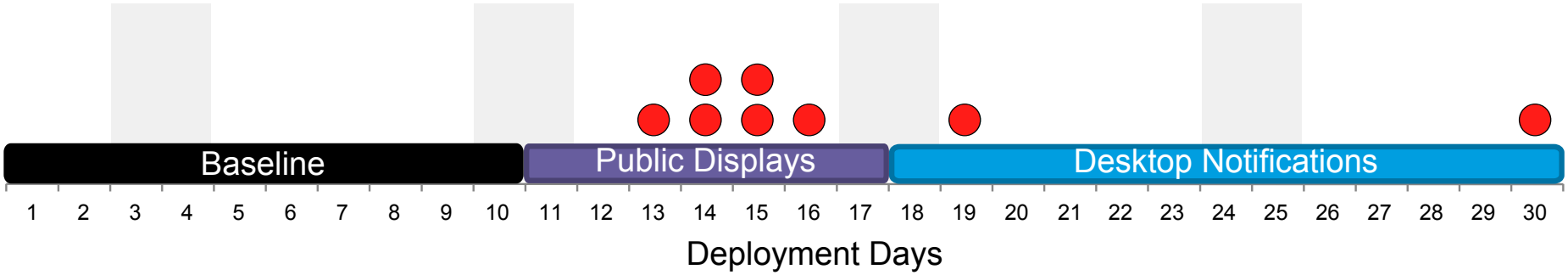
Activity

[Awareness Stagnation – Page 127]

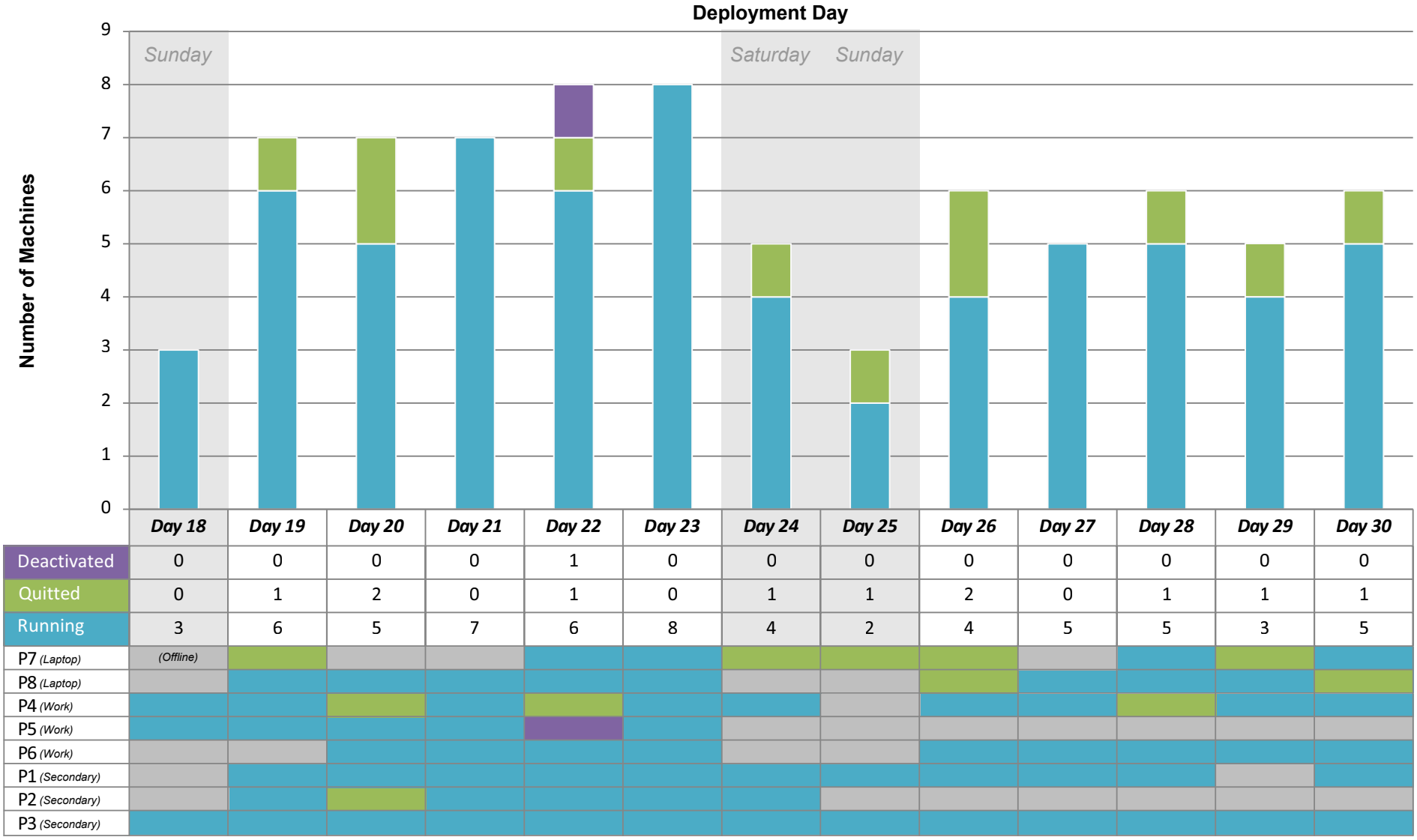

IT UNIVERSITY OF COPENHAGEN


IT UNIVERSITY OF COPENHAGEN


Deployment Days
1
2
3
4
Baseline
5
6
7
8
9
10
11
Baseline
12
13
14
10
15
12
16
5
17
18
Public Displays
19
10
20
3
21
6
22
1
23
4
24
25
Desktop Notifications
26
1
27
2
28
29
30
Desktop Notifications
Image Changes

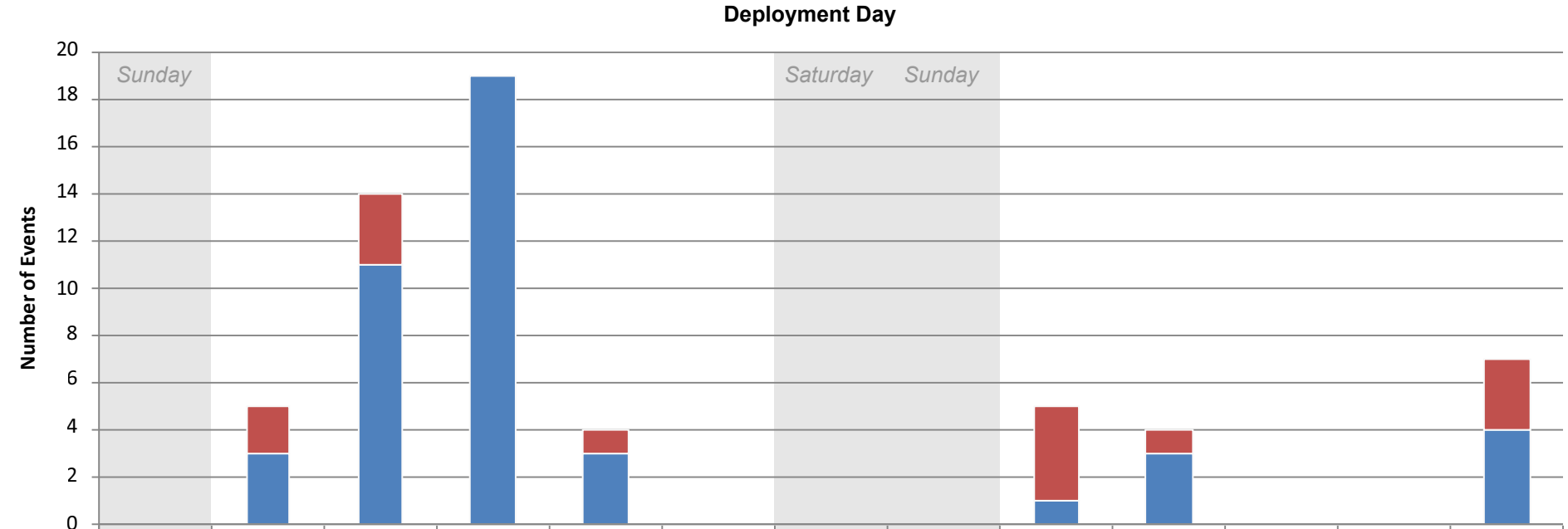


[How to Join requests from the public display – Page 128]



	Day 18	Day 19	Day 20	Day 21	Day 22	Day 23	Day 24	Day 25	Day 26	Day 27	Day 28	Day 29	Day 30
Deactivated	0	0	0	0	1	0	0	0	0	0	0	0	0
Quitted	0	1	2	0	1	0	1	1	2	0	1	1	1
Running	3	6	5	7	6	8	4	2	4	5	5	3	5
P7 *(Laptop)*	*(Offline)*												
P8 *(Laptop)*													
P4 *(Work)*													
P5 *(Work)*													
P6 *(Work)*													
P1 *(Secondary)*													
P2 *(Secondary)*													
P3 *(Secondary)*													

[Running status of the GridOrbit notification system – Page 128]



	Day 18	Day 19	Day 20	Day 21	Day 22	Day 23	Day 24	Day 25	Day 26	Day 27	Day 28	Day 29	Day 30
Click	0	2	3	0	1	0	0	0	4	1	0	0	3
Display	0	3	11	19	3	0	0	0	1	3	0	0	4
P7 *(Laptop)*	*(Offline)*												
P8 *(Laptop)*		2 2	1							2 1			1 1
P4 *(Work)*			2	14	3 1								
P5 *(Work)*			1	5									
P6 *(Work)*													
P1 *(Secondary)*		1	3 3							1			2 1
P2 *(Secondary)*			4										
P3 *(Secondary)*									1 4				1 1

[Queries to, and launching of the Mini-Grid from, GridOrbit notification system – Page 129]

- Necessity
- Curiosity (limits, ease)
- Enhancement
- Reputation (recognition, visibility)

[Motivations to participate – Page 130]

Face Time!

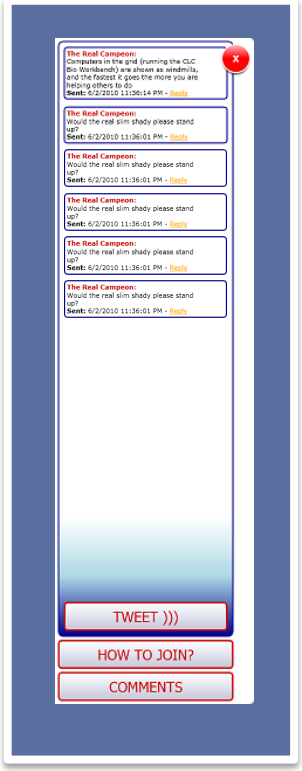
From: *Participant X*
Date: *Wed, Jun 16, 2010 at 1:51 PM*
Subject: *Re: GridOrbit hide details 6/16/10*

Hi Juan

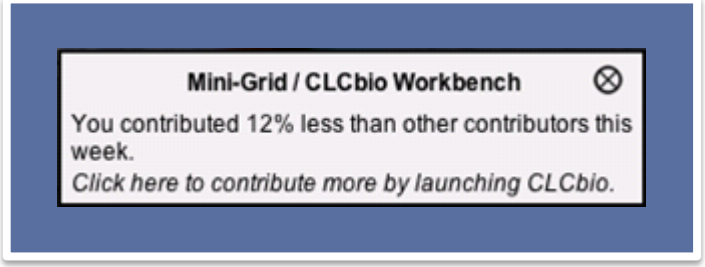
I got the plugin installed and the whole thing should be up and running. Now I just need to figure out how I can get my picture on the screen in the main building... Do I need to set up some profile somewhere or something like that?

Cheers

• The on-screen messaging functionality (bulleting board) was not used. We saw only 5 messages for the whole deployment.



• We did not find any significant impact of the different notifications strategies.



Discussion

Part IV

Agenda

Part I – Introduction

Part II – Design

Part III – Evaluation

Part IV – Discussion

- Hypotheses
- Hypothesis Analysis
- Volunteer Computing Case
- A World of Infrastructures
- Conclusions

		Hypothesis	Evidence For	Evidence Against
✓	1	**Feeback**	Interviews, PubDisp visitors, Desktop queries	
✓	2	**Recruitment**	Increased participation, +work/laptops	
–	3	**Maintenance**	Current capacity, higher volatility and return rate	Study not long enough
✓	4-1	**Enjoyment**	Playing with shapes and pictures	
✓	4-2	**Enhancement**	Interviews	
–	4-3	**Self-Expression**		No messages
✓	4-4	**Reputation**	Pictures, emails, interviews	
–	4-5	**Community**		No messages / explicit coordination
–	5-1	**Personal**		Not enough data
–	5-2	**Group**		Not enough data
–	6	**Mediate Interaction**	See hypothesis 1 (indirect mediation)	No messages
✓	7	**Foster Sharing & Usage**	See hypothesis 2	
–	8	**Understanding**	Self installing, everyday launching, current capacity	No qualitative data
✓	9	**Accesible-Background**	60|30|10 visitors pattern	

Hypothesis **1** Infrastructure awareness systems can provide volunteer computing participants with feedback on their contributions.

Hypothesis **2** Infrastructure awareness systems can foster the recruitment of participants to volunteer computing.

Hypothesis **3** Infrastructure awareness systems can help maintain the enrollment of existing participants to volunteer computing.

[as feedback mechanisms for volunteer computing]

Hypothesis **4** .**1** The enjoyment level induced by the infrastructure awareness representation is associated with participation.

Hypothesis **4** .**2** The enhancement level induced by the infrastructure awareness representation is associated with participation.

Hypothesis **4** .**3** The possibility of self expression through the infrastructure awareness systems is associated with participation.

Hypothesis **4** .**4** The possibility of increase the participant's reputation through the infrastructure awareness system is associated with participation.

Hypothesis **4** .**5** The possibility to join a community through the infrastructure awareness systems is associated with participation.

Hypothesis **5** .**1** Comparing one's performance to personal historical records positively impacts contributions to volunteer computing.

Hypothesis **5** .**2** Comparing one's performance with the group performance positively impacts contributions to volunteer computing.

[GridOrbit notification s. – as support for participants' motivations]

Hypothesis **6** Infrastructure awareness systems mediate the interactions between the members of the resource-centric informal human infrastructures formed around the volunteer computing infrastructure.

Hypothesis **7** Infrastructure awareness systems foster the sharing of resources to, and the usage of, a volunteer computing infrastructure.

[as support for resource sharing]

Hypothesis **8** Infrastructure awareness systems provide users with an understanding of the volunteer computing infrastructure, supporting the formation of correct mental models of it.

Hypothesis **9** Infrastructure awareness systems can make volunteer computing accessible in the background.

[as an infrastructure awareness system]

Infrastructure Awareness for V.C.

What we've seen:

- Infrastructure Awareness
- Design Space for V.C.
- Iterative Design Process
- Awareness Model
- Motivational Model

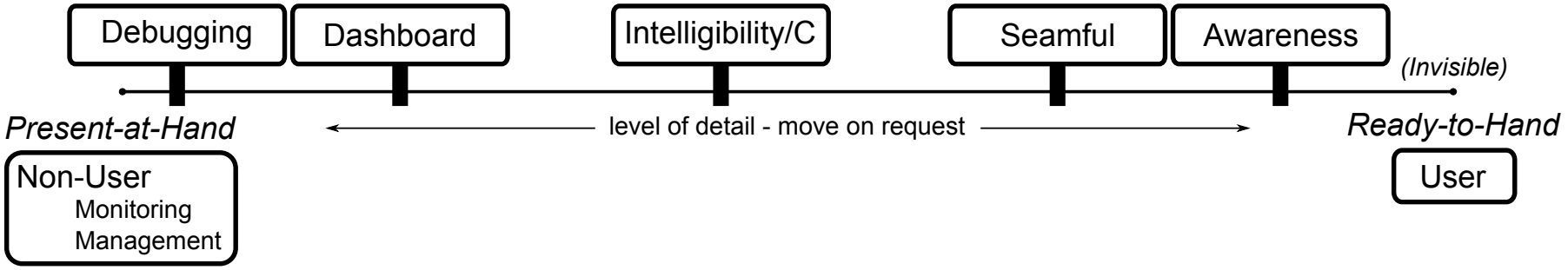
Study Implications:

- Local and Symmetric
  → Existing community
  → Solidarity and duty
  → Social dynamics
  → Leverage existing sharing practices

- Metaphor-guided Design
  → Awareness model
  → Motivational model
  → Motivation Techniques

A World of Infrastructures

- The prevalence of the duality user / non-user
- Digital Housekeeping
- Infrastructure Awareness with multiple detailed visualizations:
  - Seamful design → Troubleshooting and Workarounds
  - Intelligibility → Understanding, learning and control
  - Dashboard → Diagnosis



Thank you!

Ebbe, Zsuzsanna, Reeza, Morten, Jørgen

PIT LAB
The Pervasive Interaction Technology Lab
THE PERVASIVE INTERACTION TECHNOLOGY LAB

Jakob, Aurelien, Sokoler, Neela, Tinus & Dinesh

CLC bio
Accelerating Scientific Research

Morten, Bjarne

[I am happy to answer questions]