

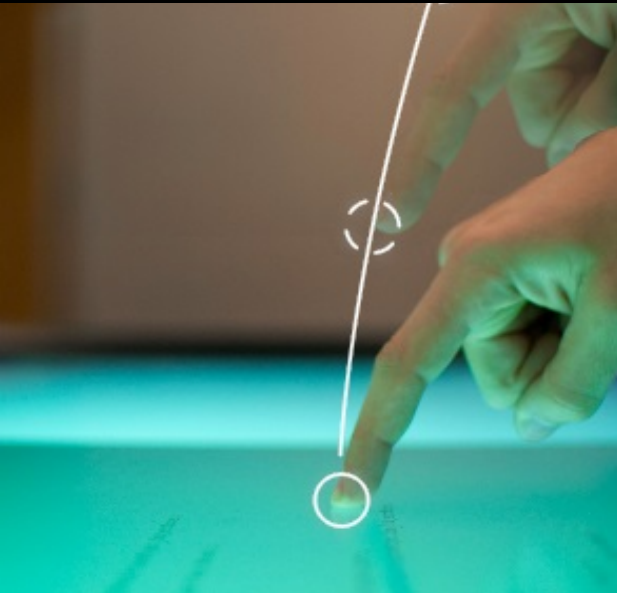
Towards Ad-hoc Collaboration Spaces with Cross-Device Interaction Techniques

Nicolai Marquardt
University College London
Invited talk at University of St Andrews

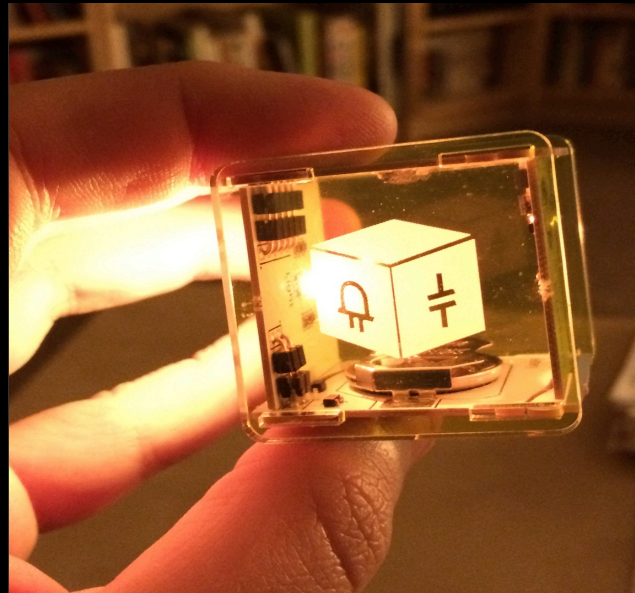


UCL

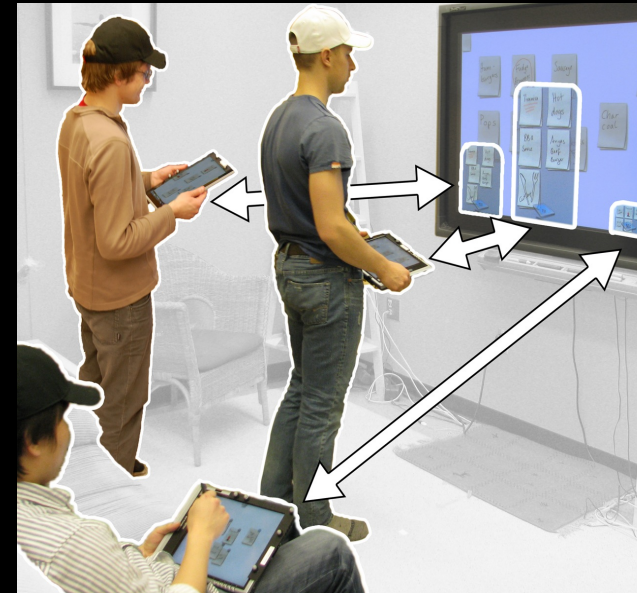




**Interaction on and
between digital
surfaces**



**Physical Computing
and Digital
Fabrication**



**Proxemics in HCI and
Proxemic-Aware
Technology**



Saul Greenberg
University of Calgary



Yvonne Rogers
Director UCL Interaction Centre



Ken Hinckley
Microsoft Research Redmond



Dominic Hey
University College London



Till Ballendat
Avanade (Microsoft/Accenture)



Roman Raedle
University Konstanz



Rob Diaz-Marino
SMART Technologies



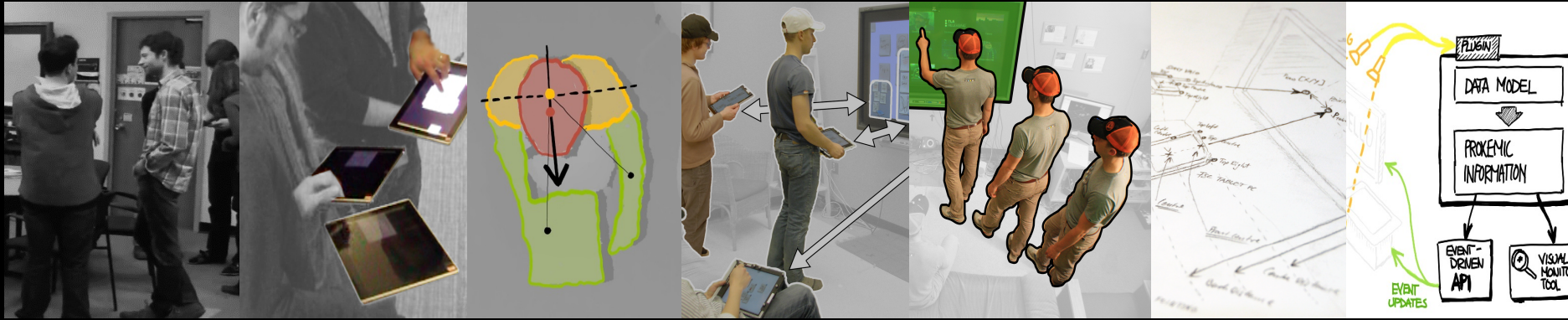
Christian Jetter
Postdoc INTEL ICRI



Sebastian Boring
University of Copenhagen



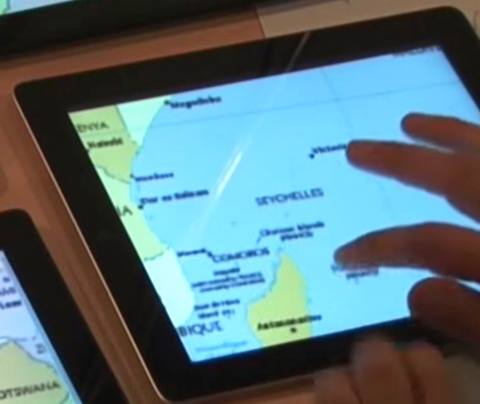
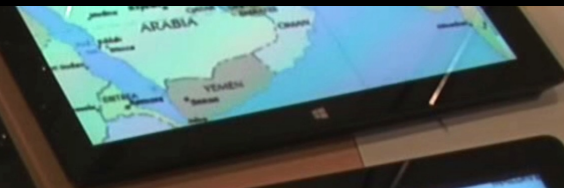
Harald Reiterer
University Konstanz

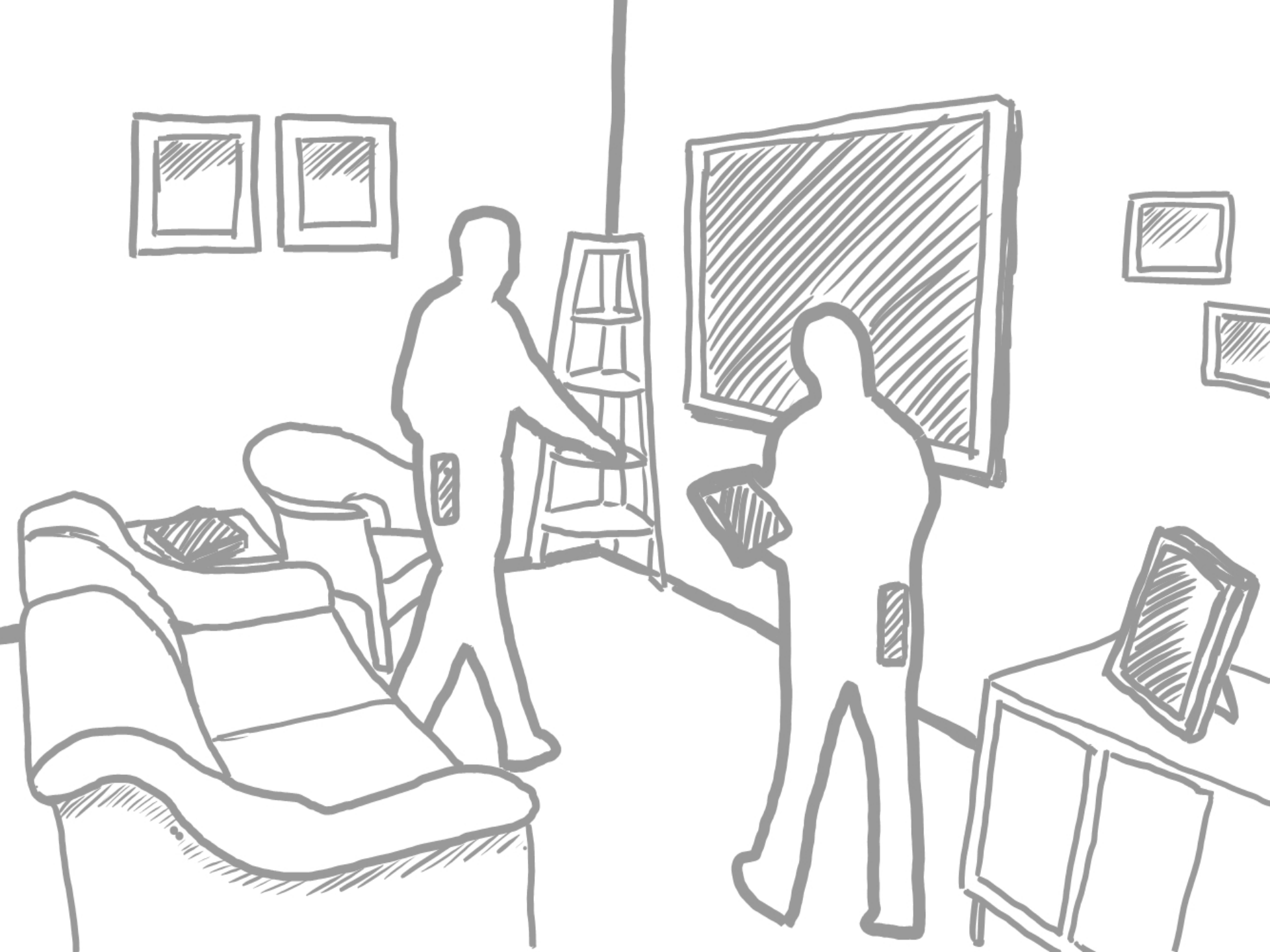


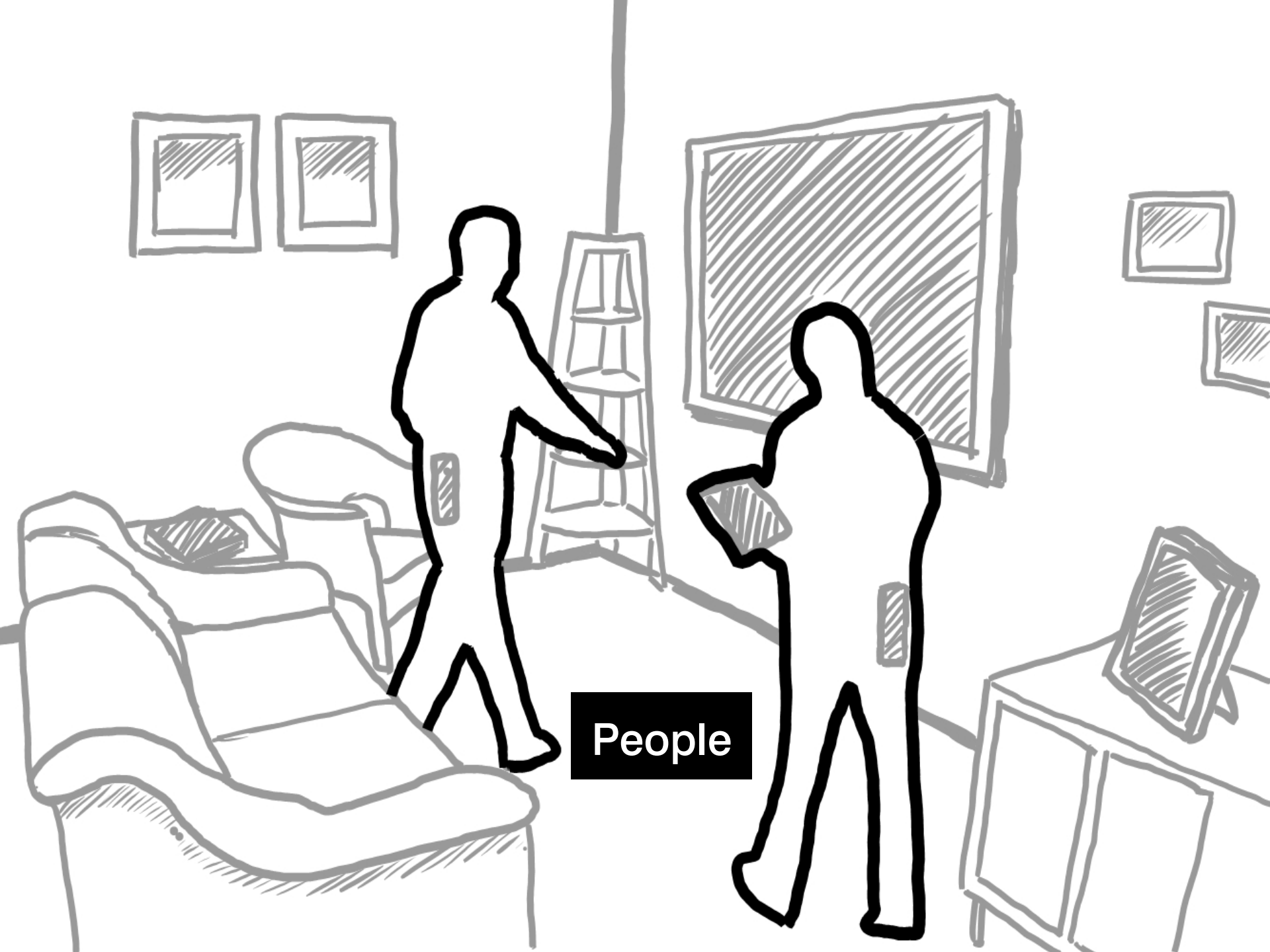
Towards Ad-hoc Collaboration Spaces with Cross-Device Interaction Techniques



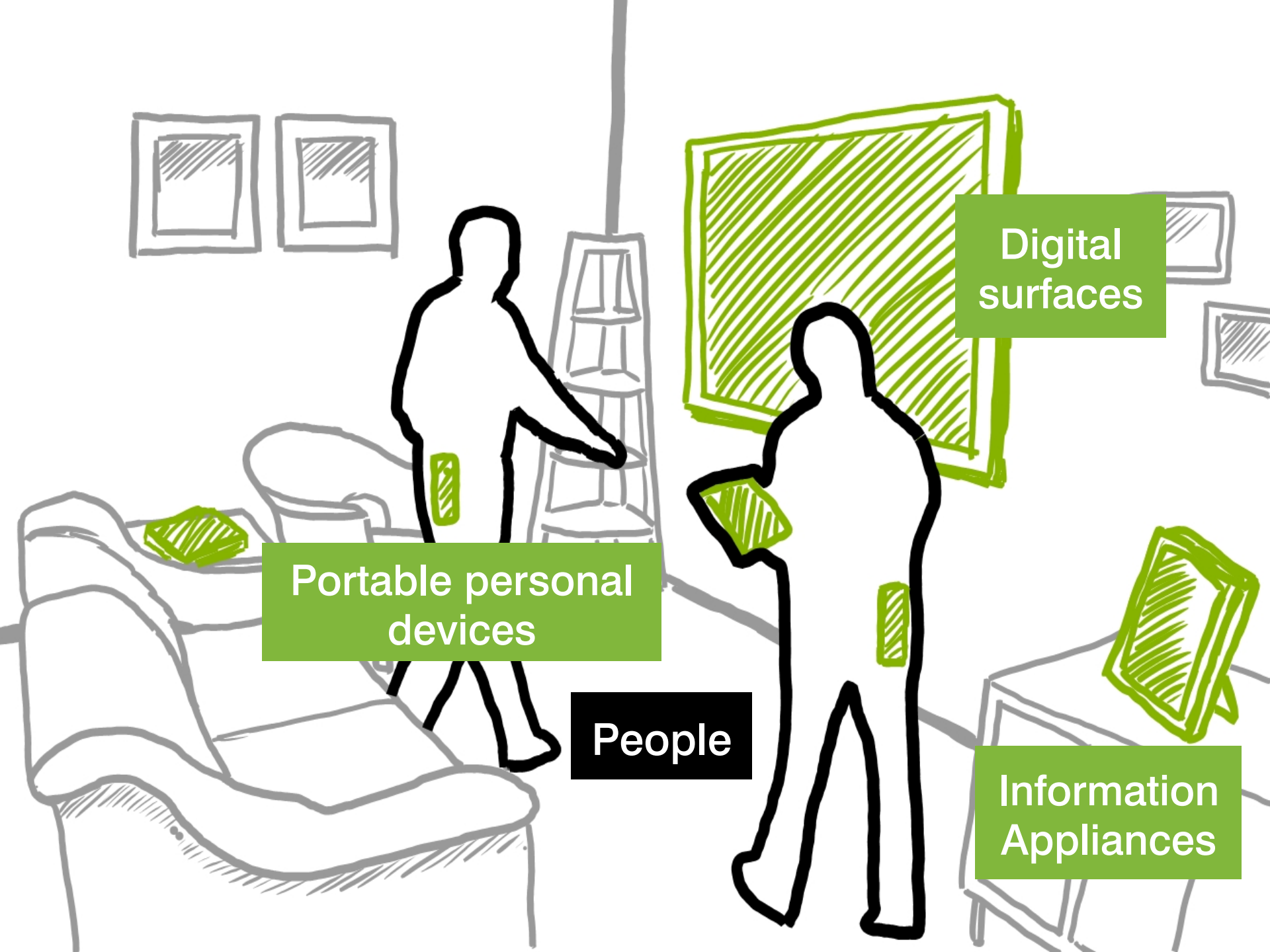








People



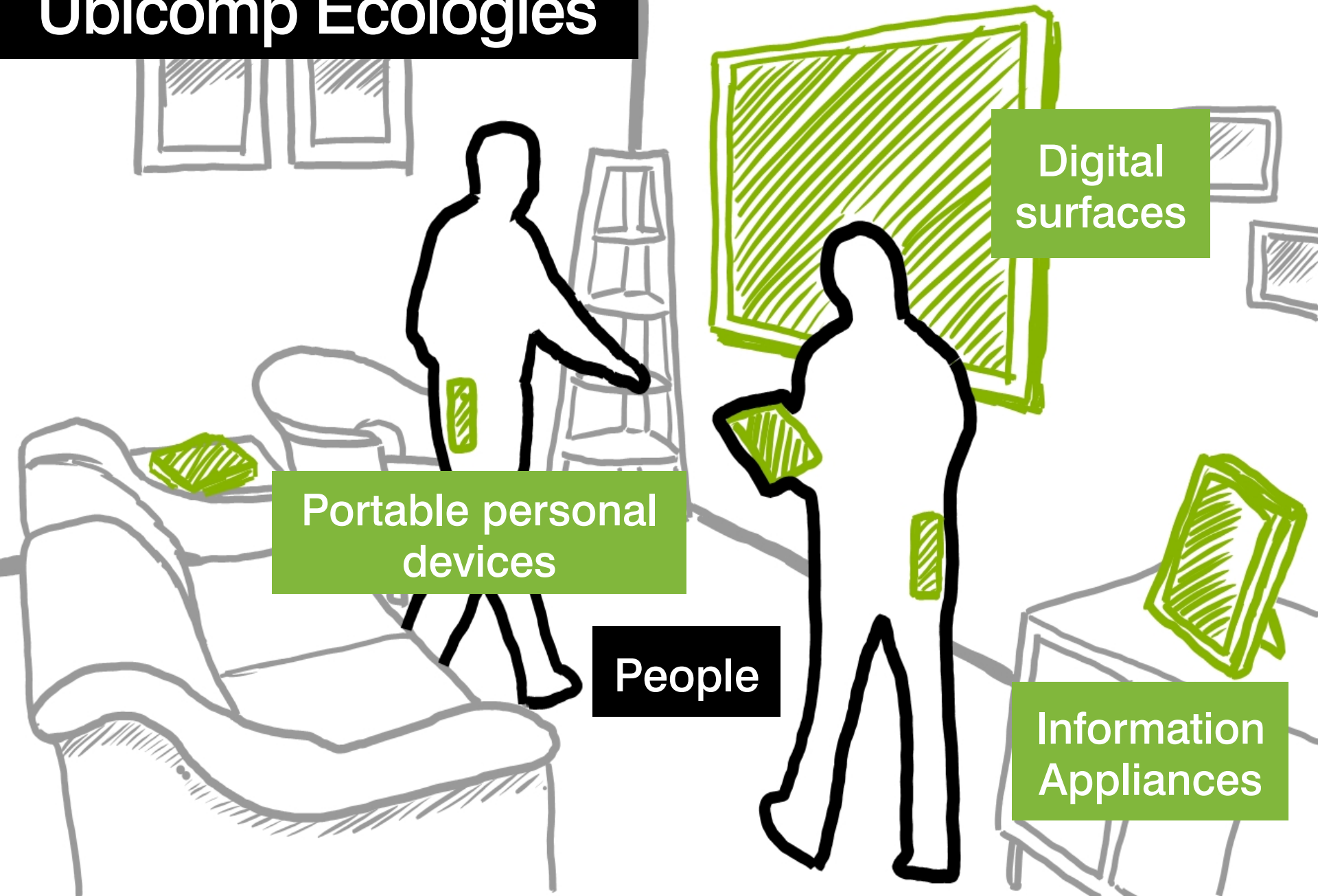
Digital surfaces

Portable personal devices

People

Information Appliances

Ubicomp Ecologies



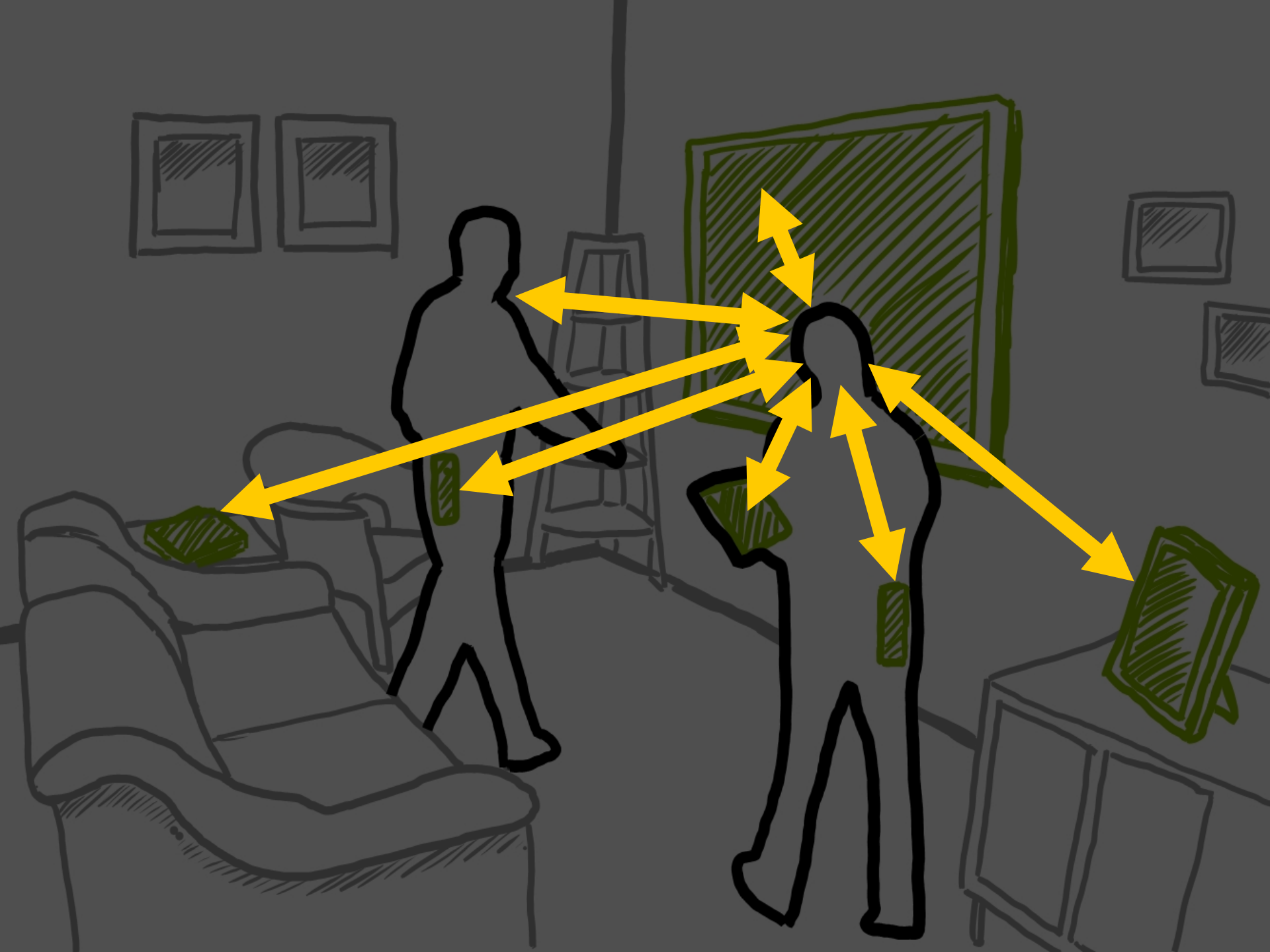
Digital
surfaces

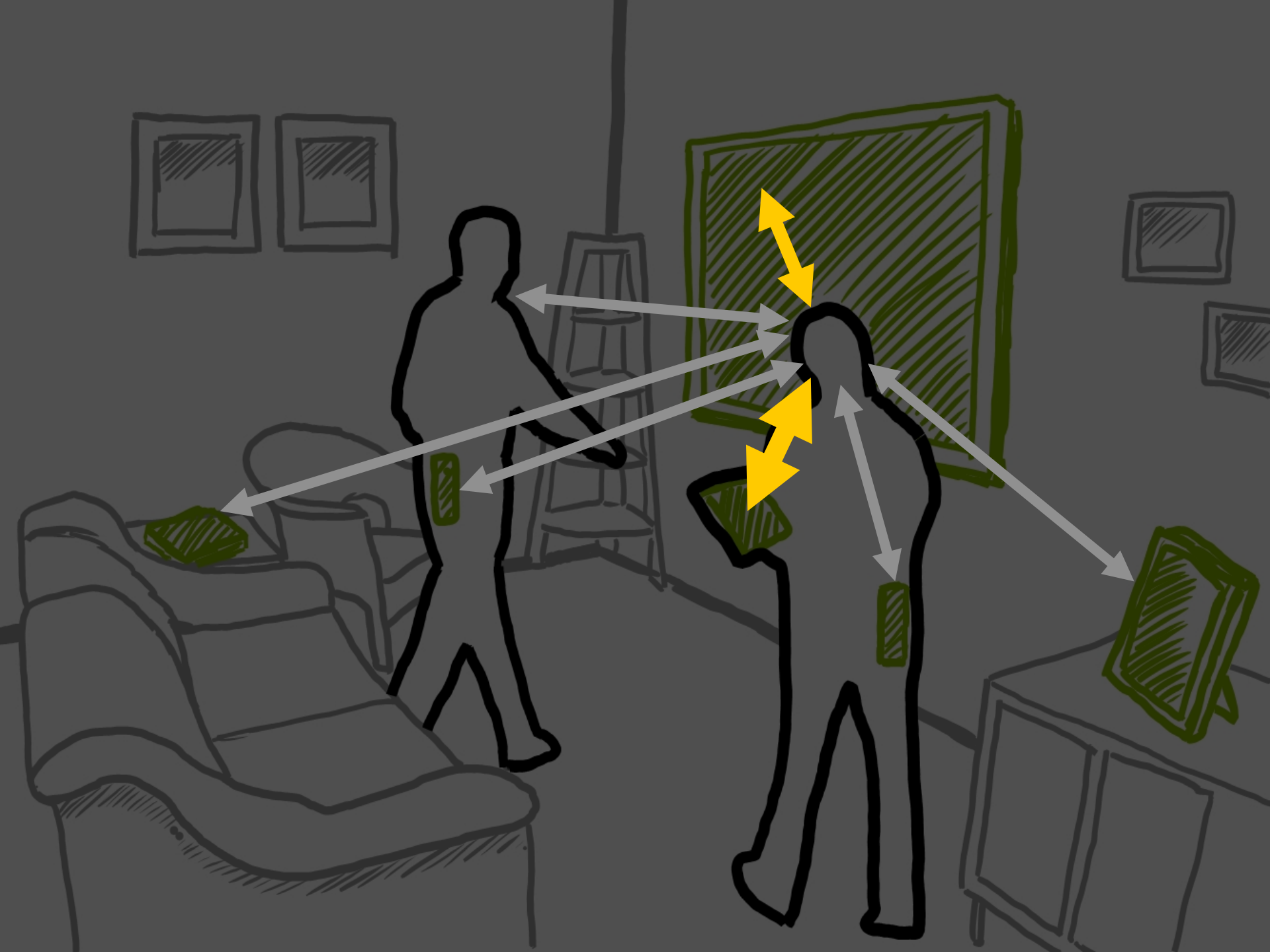
Portable personal
devices

People

Information
Appliances







Proxemics

People's understanding and use
of personal space

















Photo source: Library of Congress

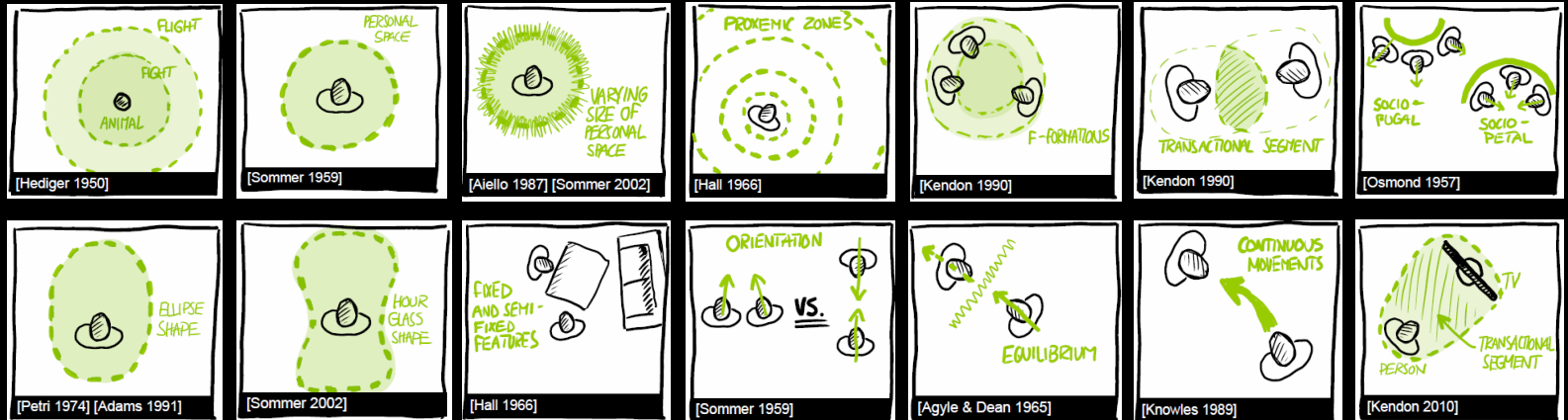
Proxemic Interaction

Proxemic Interaction

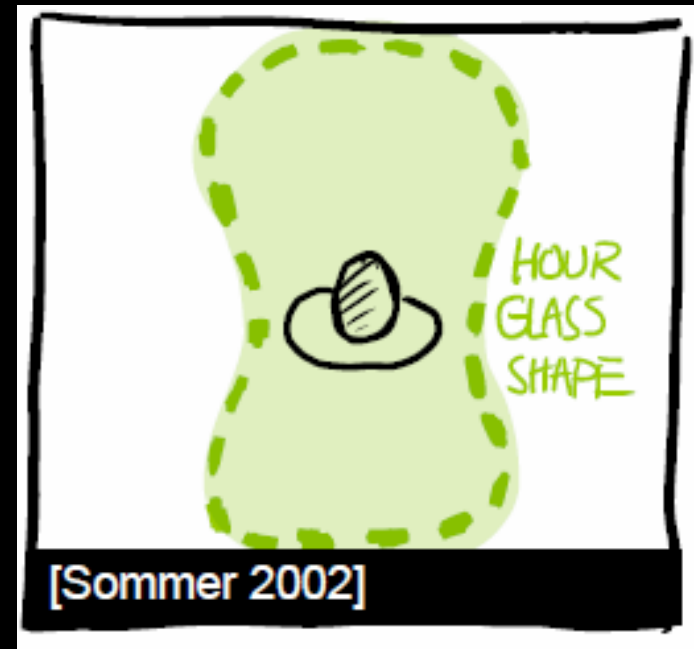
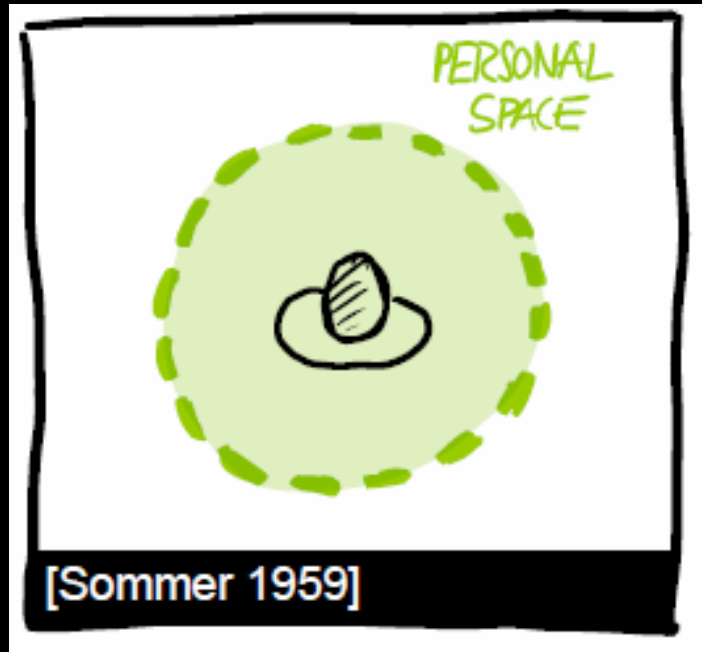
imagines a world of devices that have
fine-grained knowledge of nearby
people and other devices
and how such knowledge can be
exploited in ubicomp
interaction design.

Social Theories about people's use and understanding of personal space

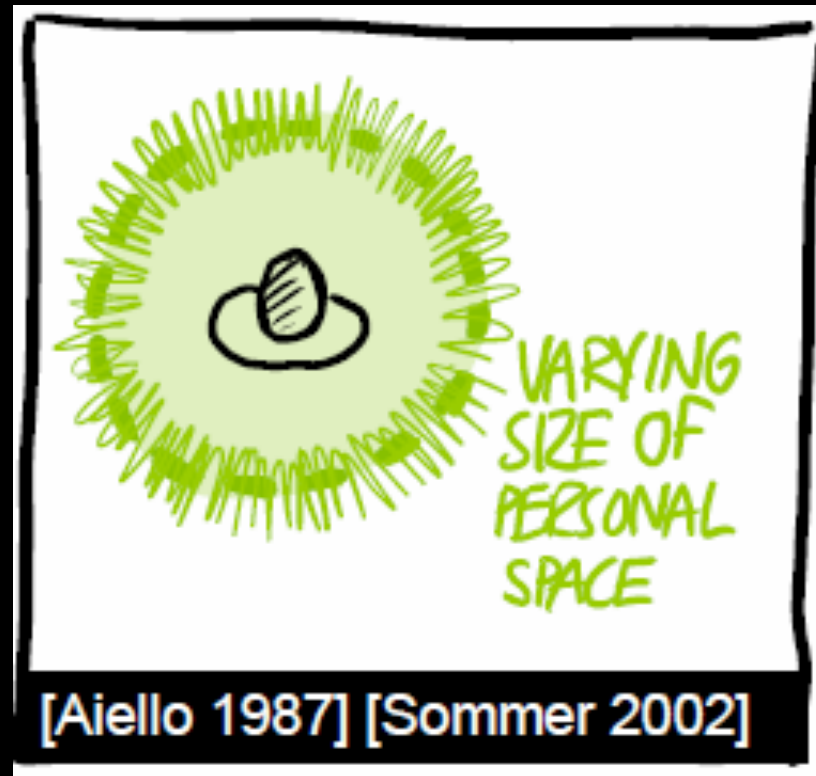
Social Theories...



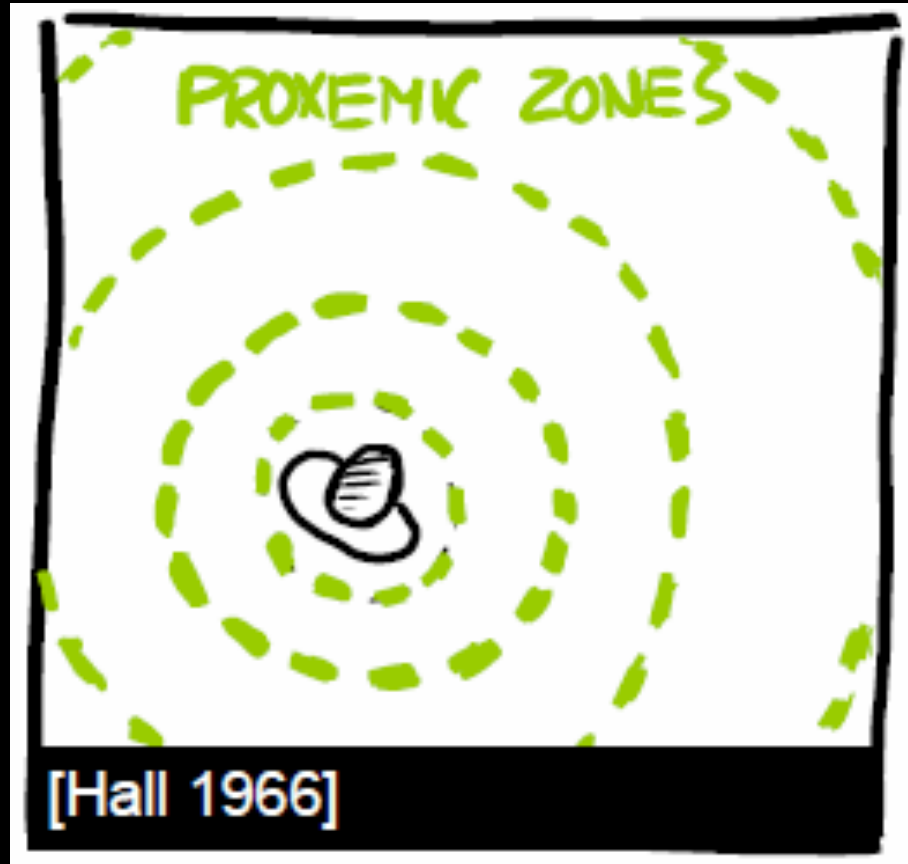
Personal Space



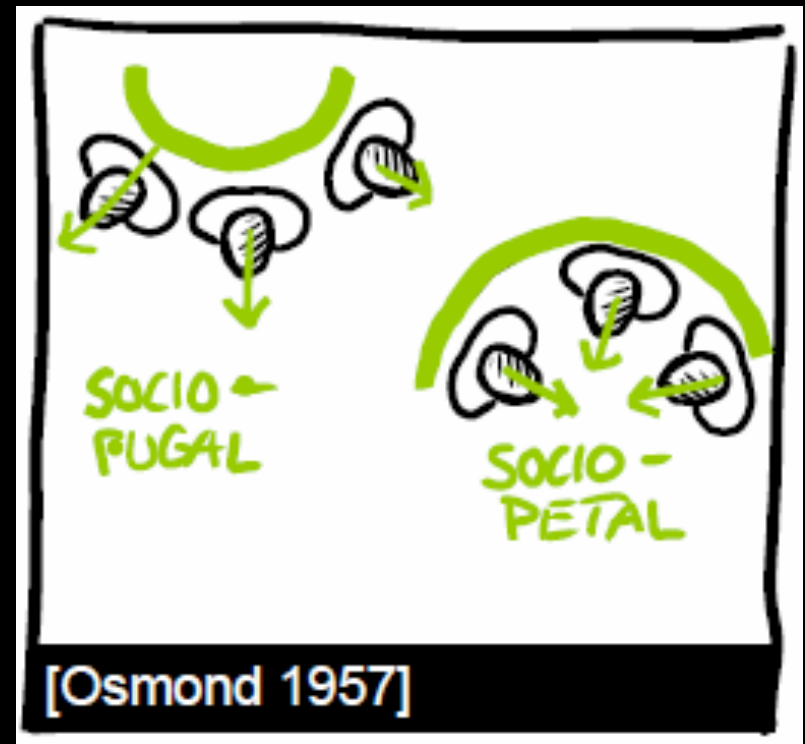
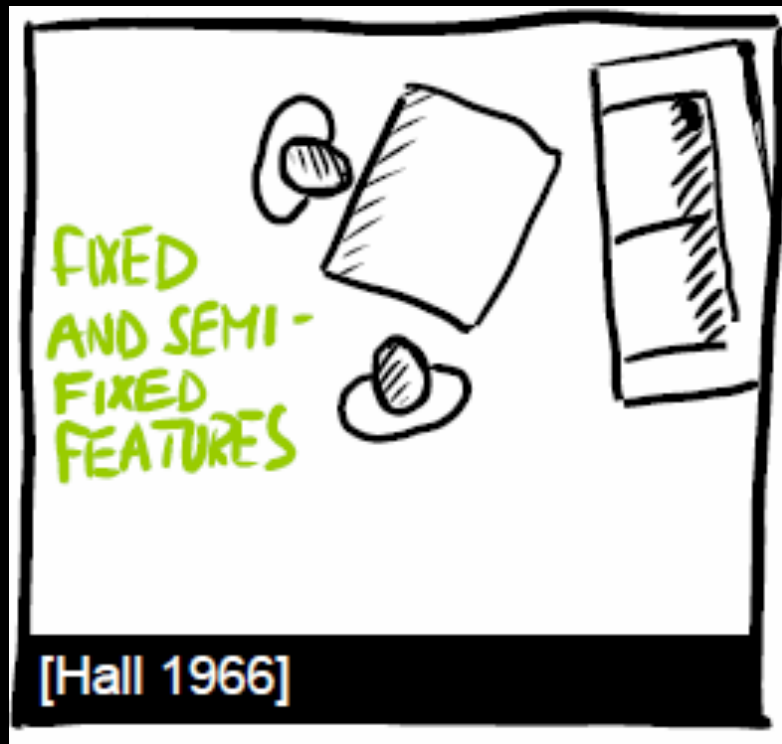
Varying Size



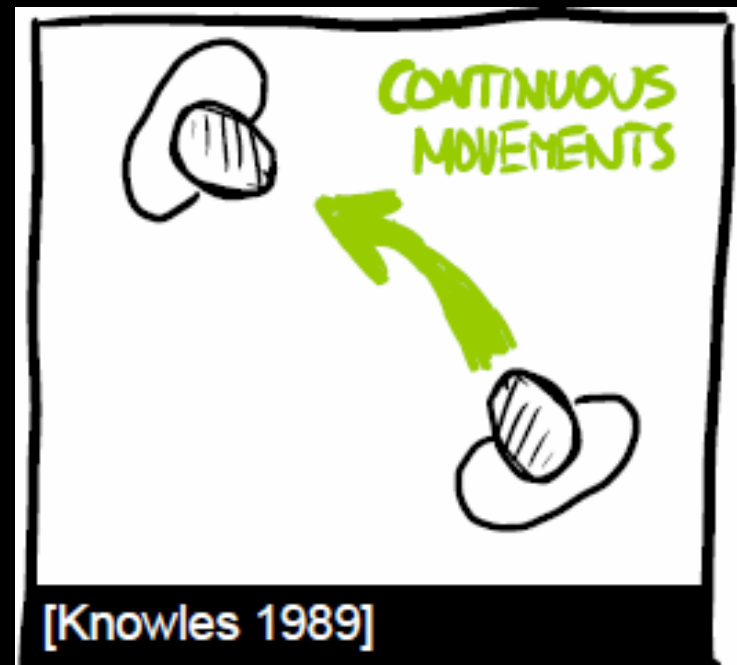
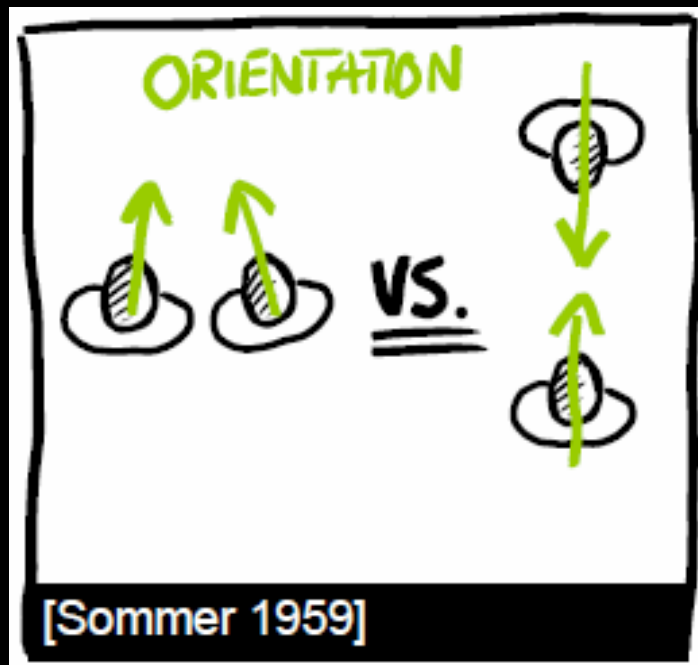
Hall's Proxemic Theory



Environment

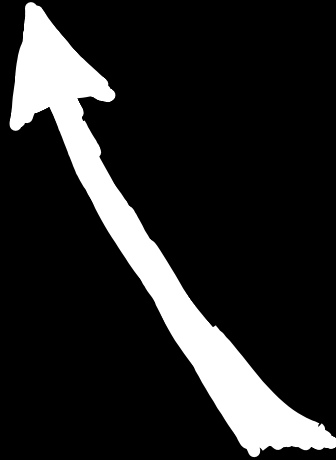


Orientation & Movements



Proxemic Theories

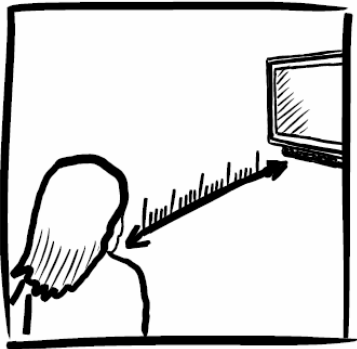
Operationalizing Proxemics for **Interaction Design**



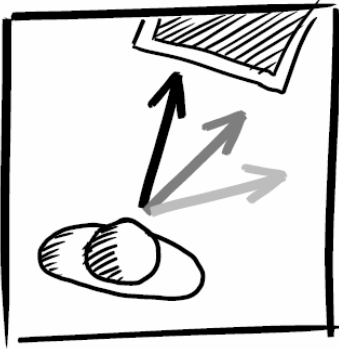
Proxemic Theories

Operationalizing Proxemics for **Interaction Design**

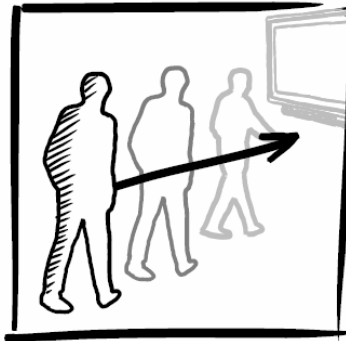
Operationalizing Proxemics for Interaction Design



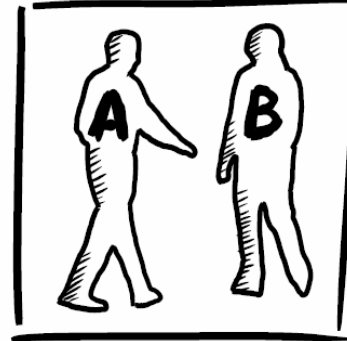
Distance



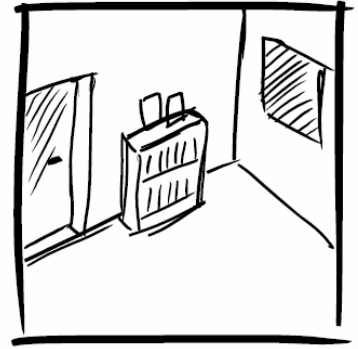
Orientation



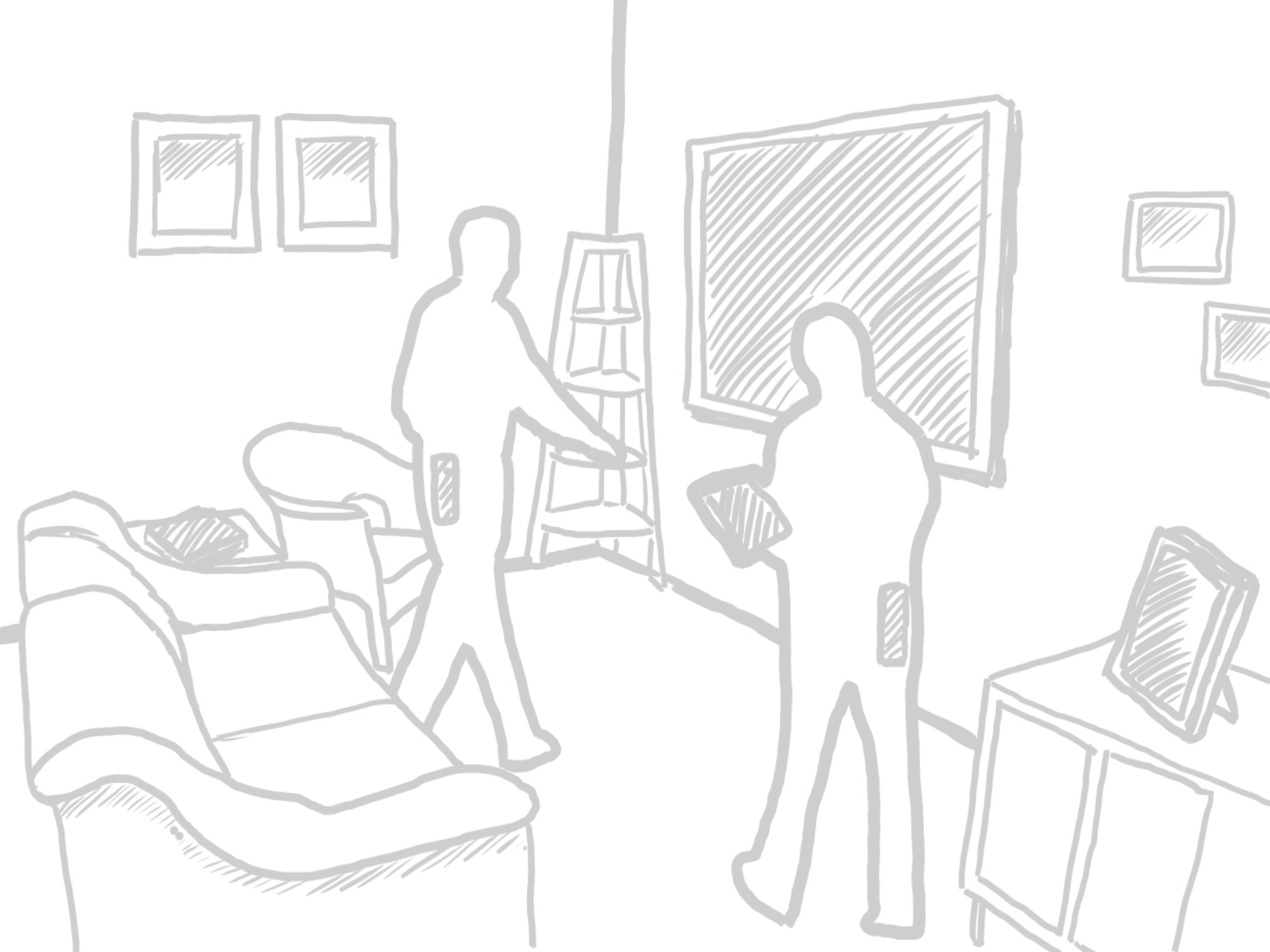
Movement



Identity

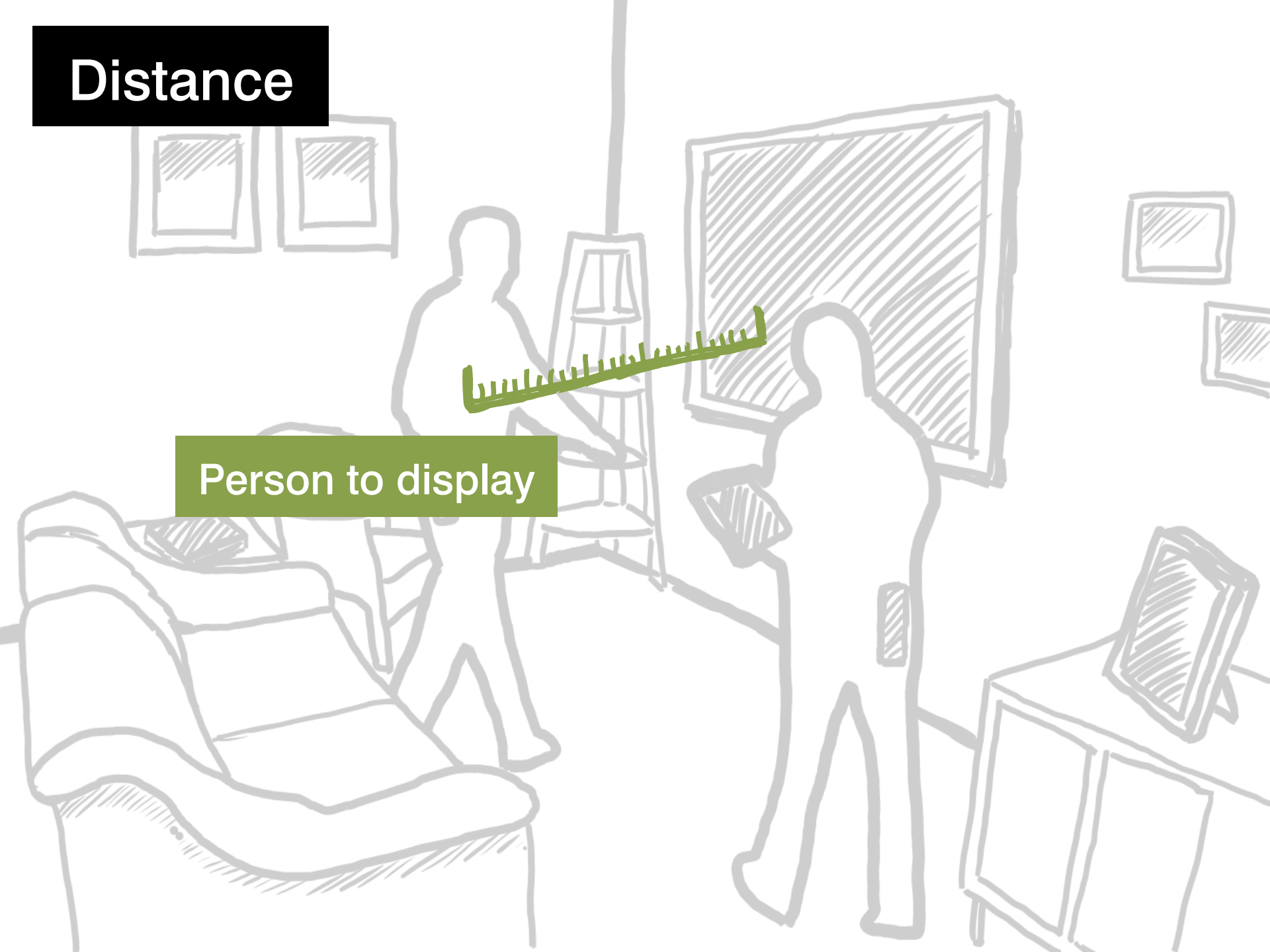


Location



Distance

Person to display



Distance



A hand-drawn sketch of a living room. On the left, a person stands near a lamp on a side table. On the right, another person stands holding a tablet. A large sofa is in the foreground. A large screen is on the wall. Two green lines with vertical tick marks indicate distances: one from the first person to the screen, and another from the second person to the screen. Labels are placed near these lines.

Person to display

Person to tablet

Distance



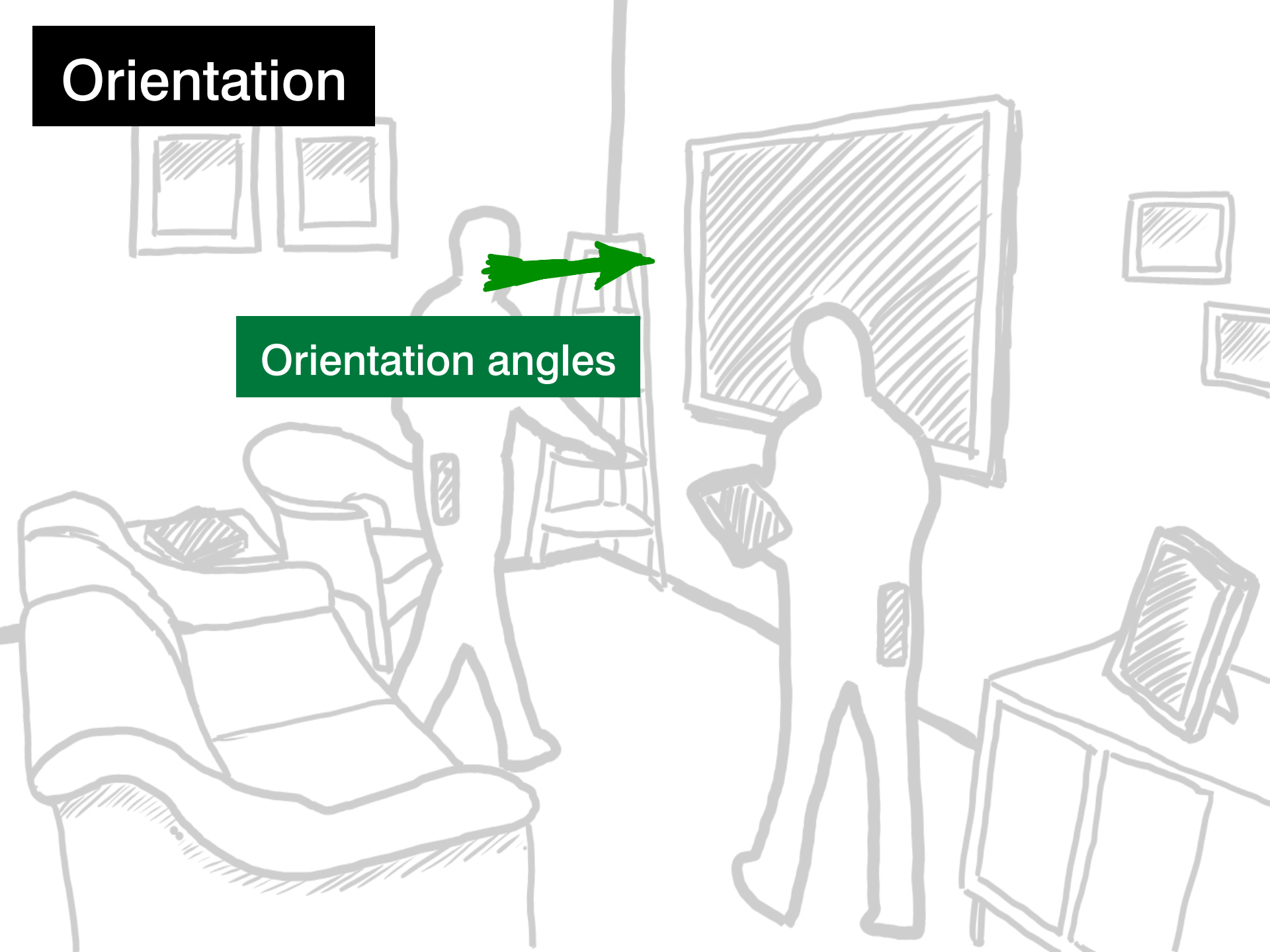
Person to display

Person to tablet

Device to device

Orientation

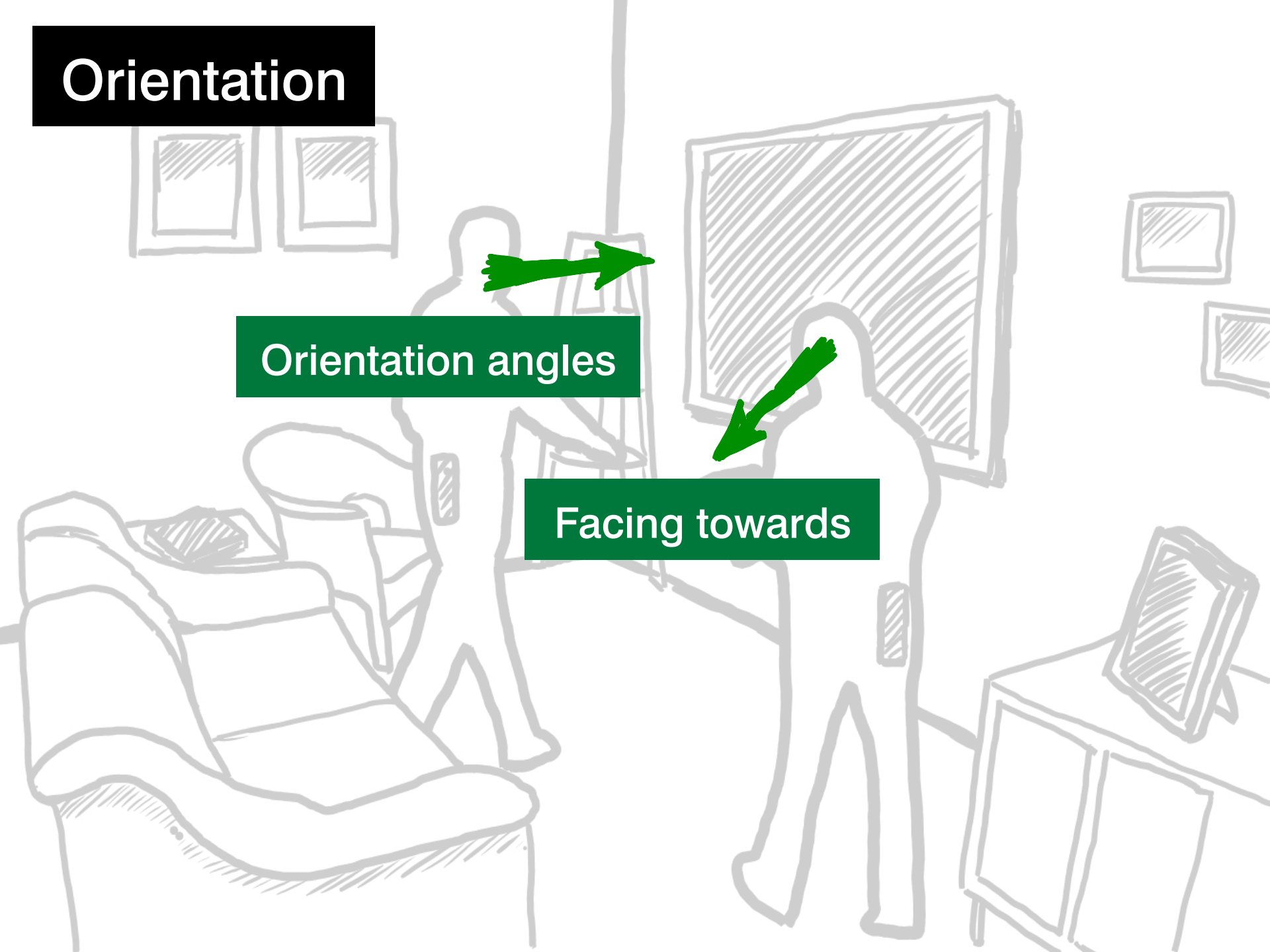
Orientation angles



Orientation

Orientation angles

Facing towards



Movement



Velocity

Acceleration

Identity

Type

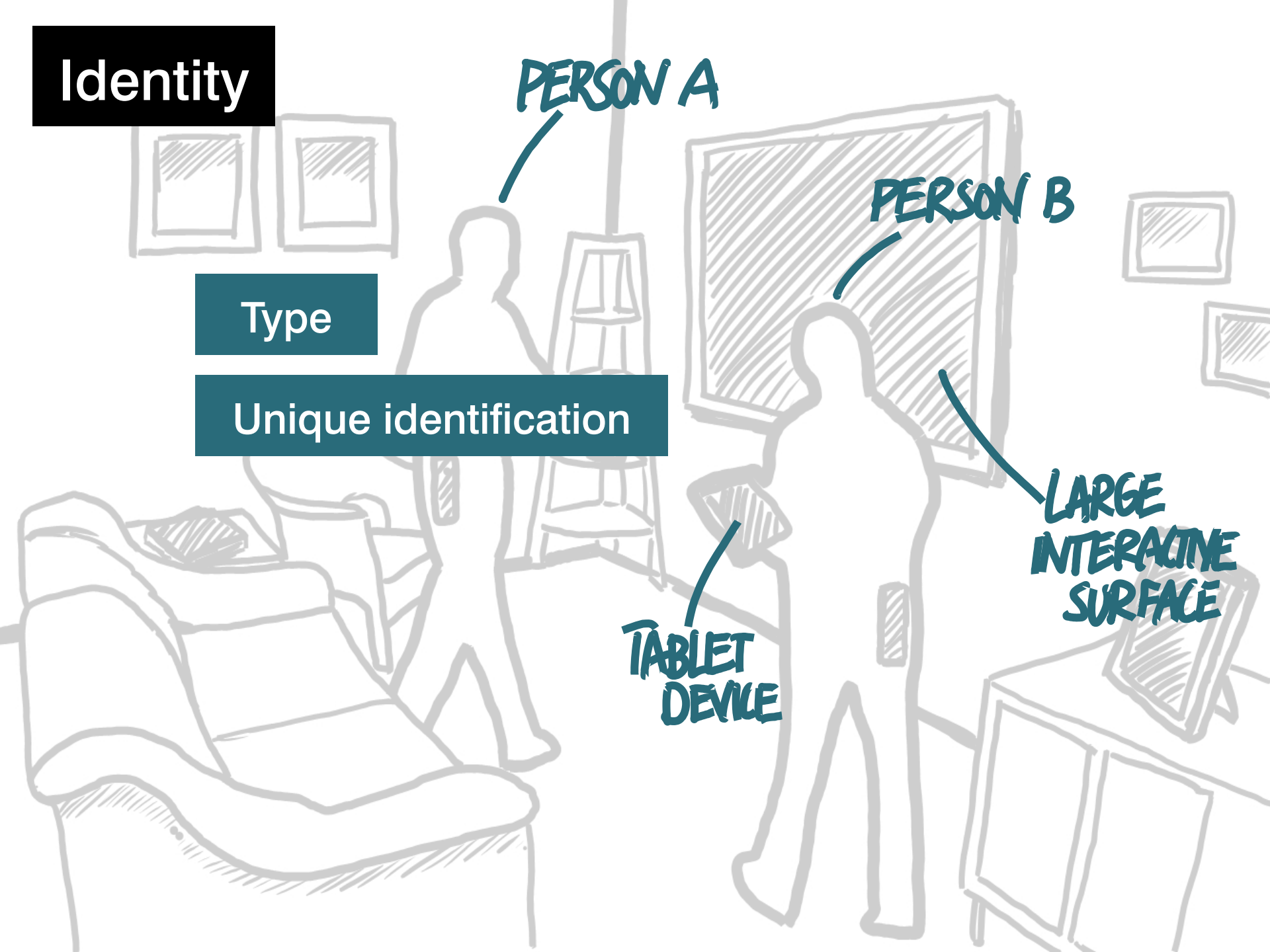
Unique identification

PERSON A

PERSON B

TABLET
DEVICE

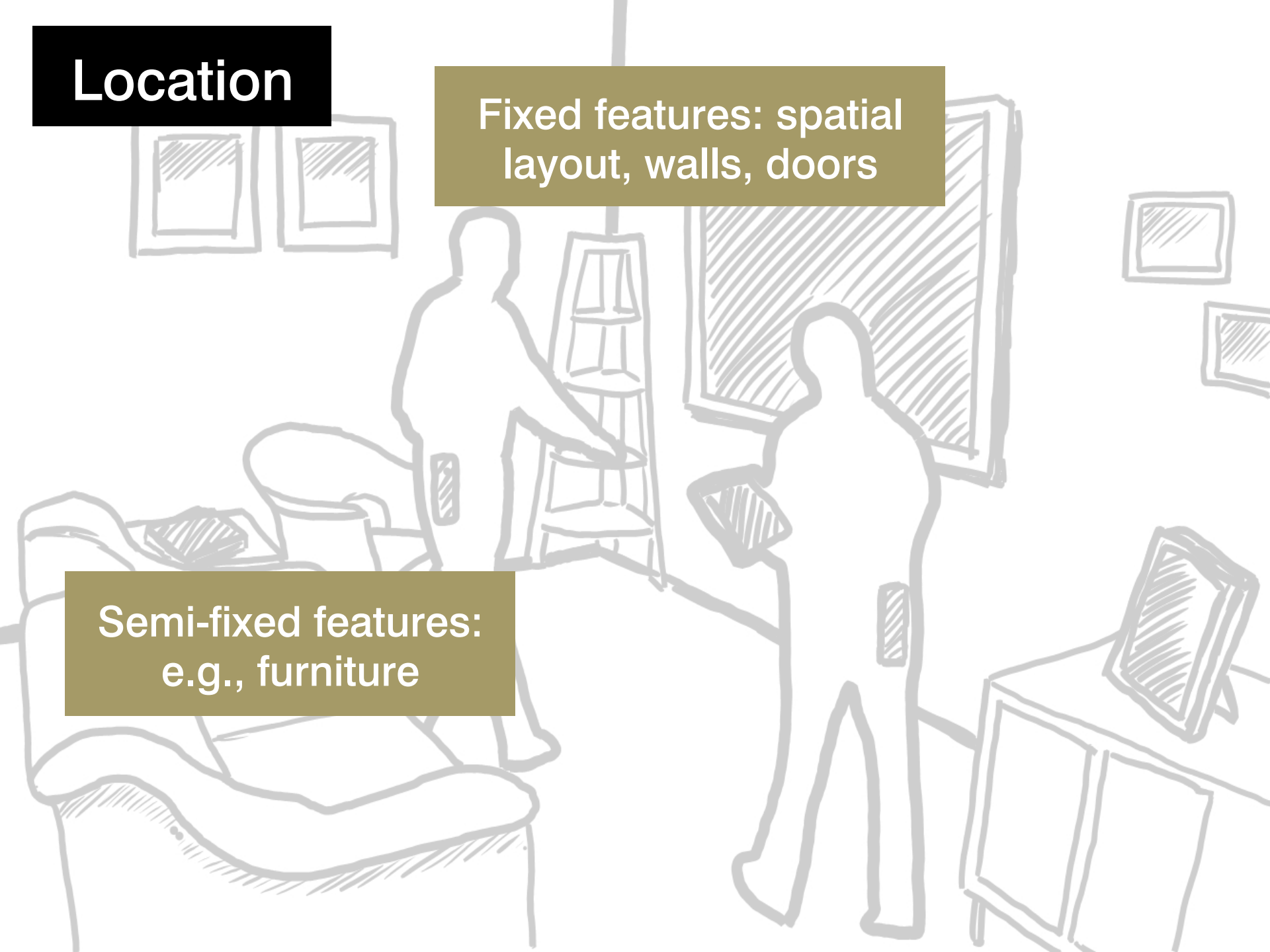
LARGE
INTERACTIVE
SURFACE

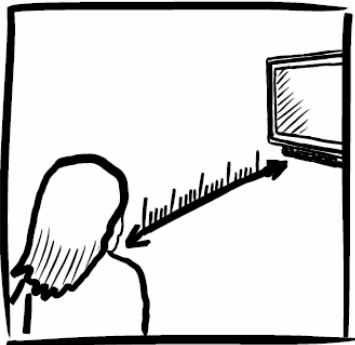


Location

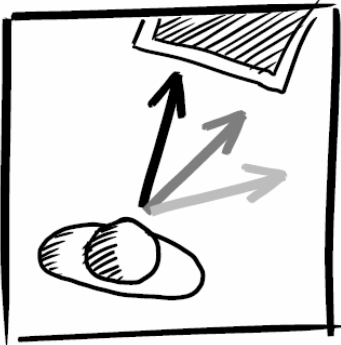
Fixed features: spatial layout, walls, doors

Semi-fixed features:
e.g., furniture

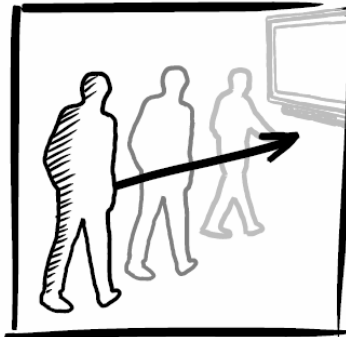




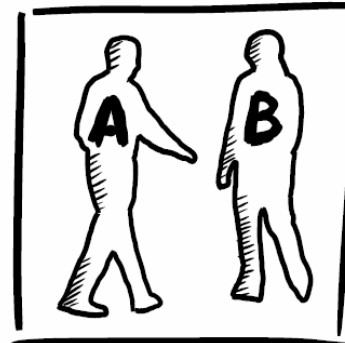
Distance



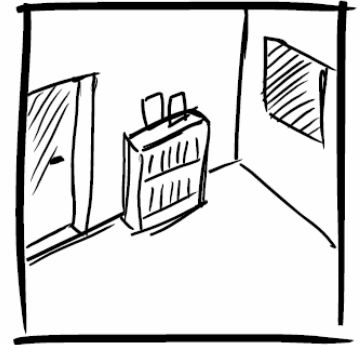
Orientation



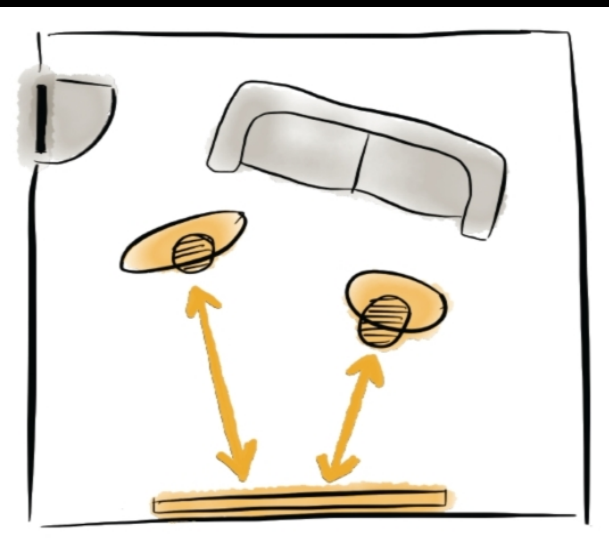
Movement

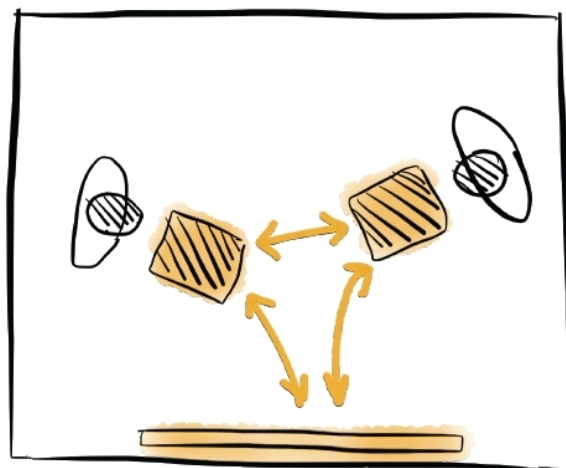
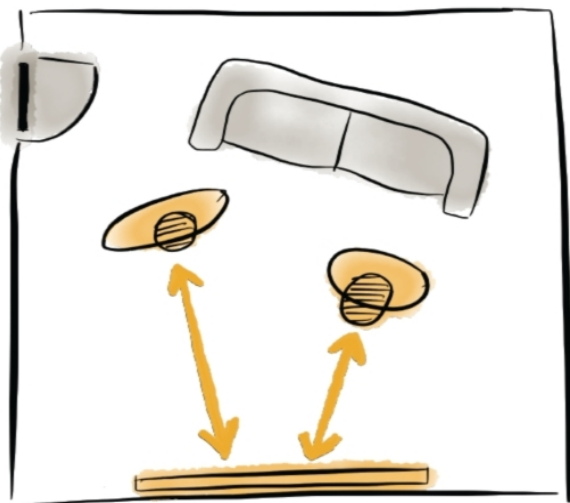


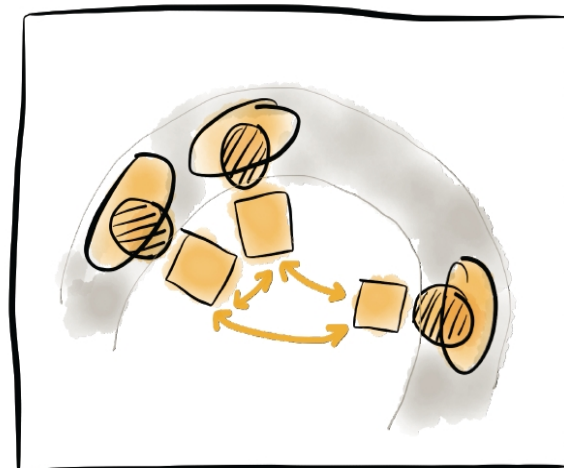
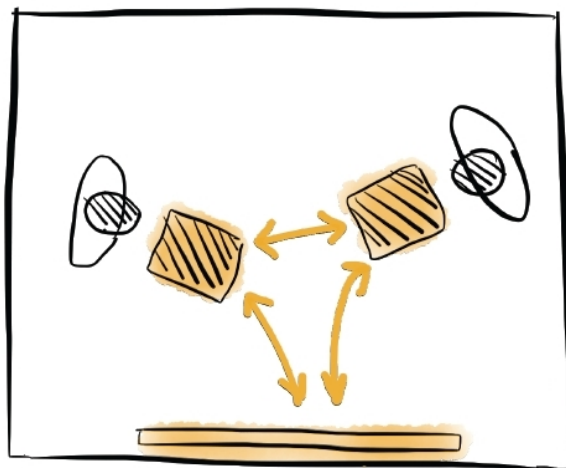
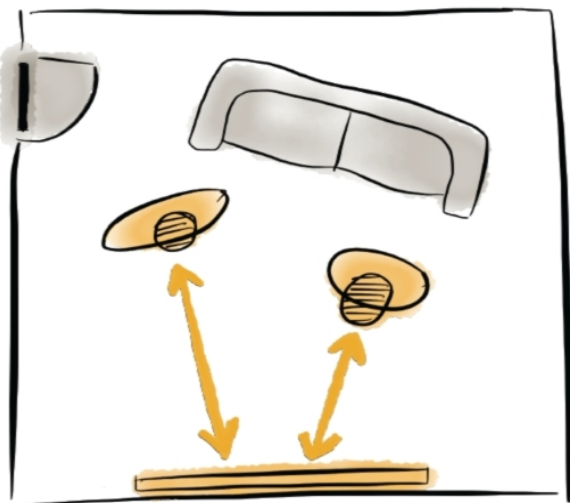
Identity

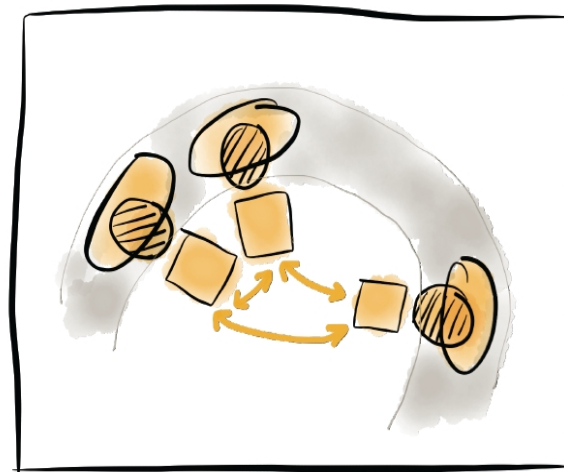
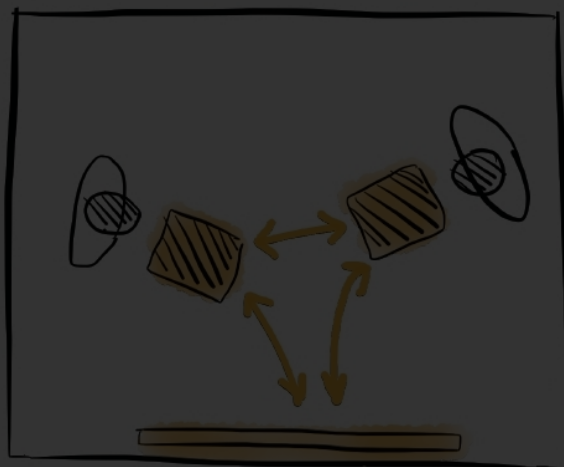
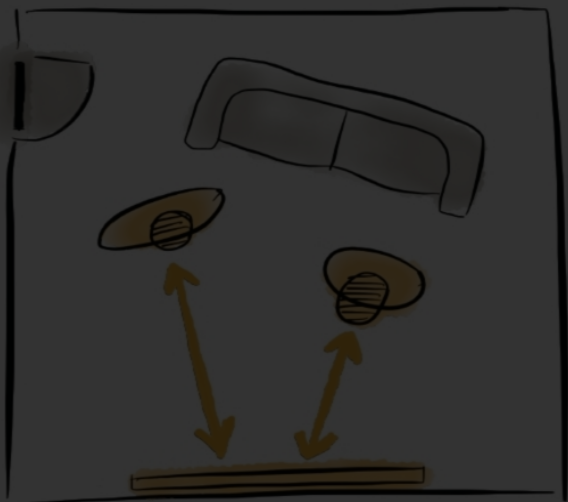


Location



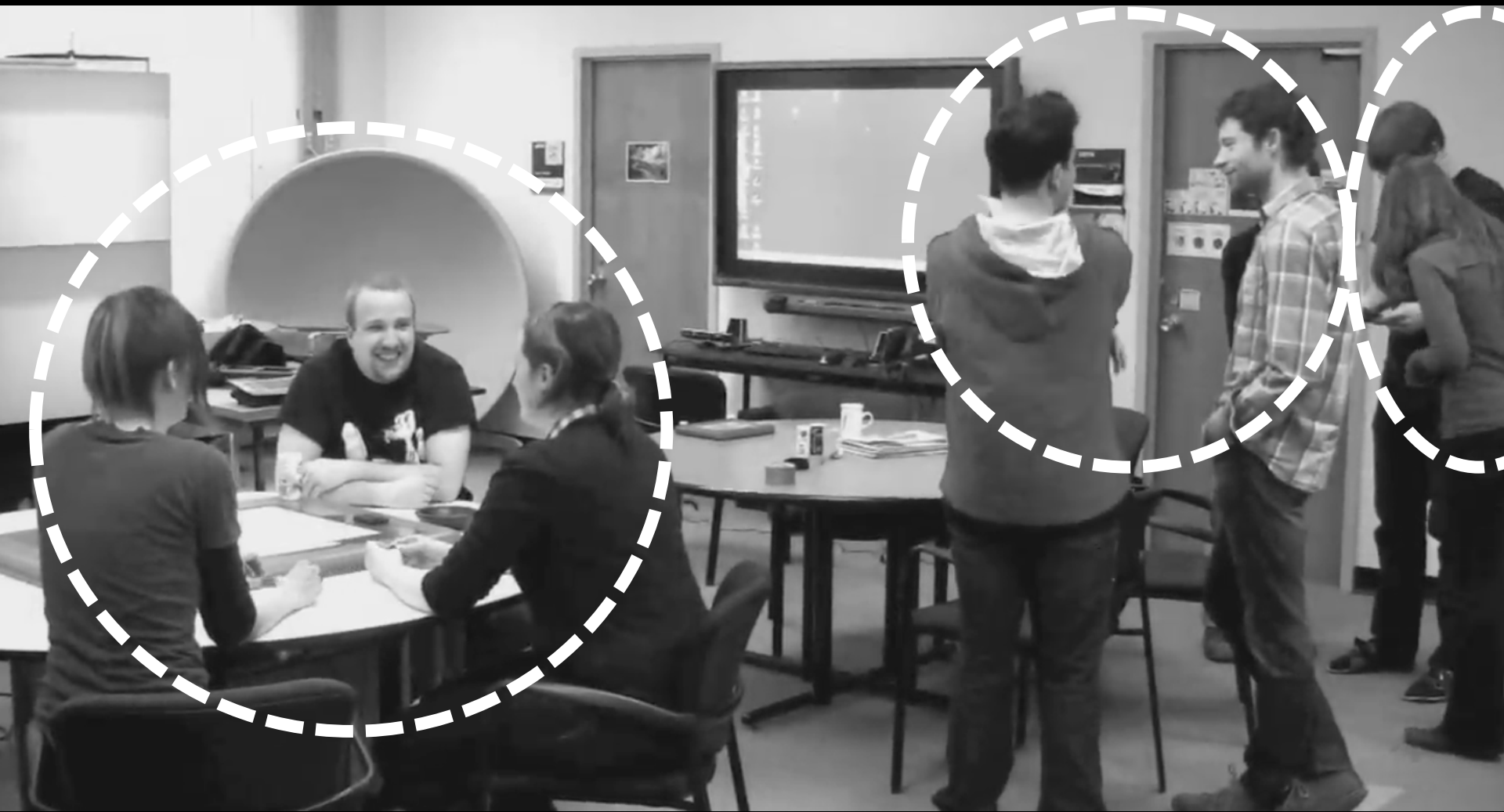






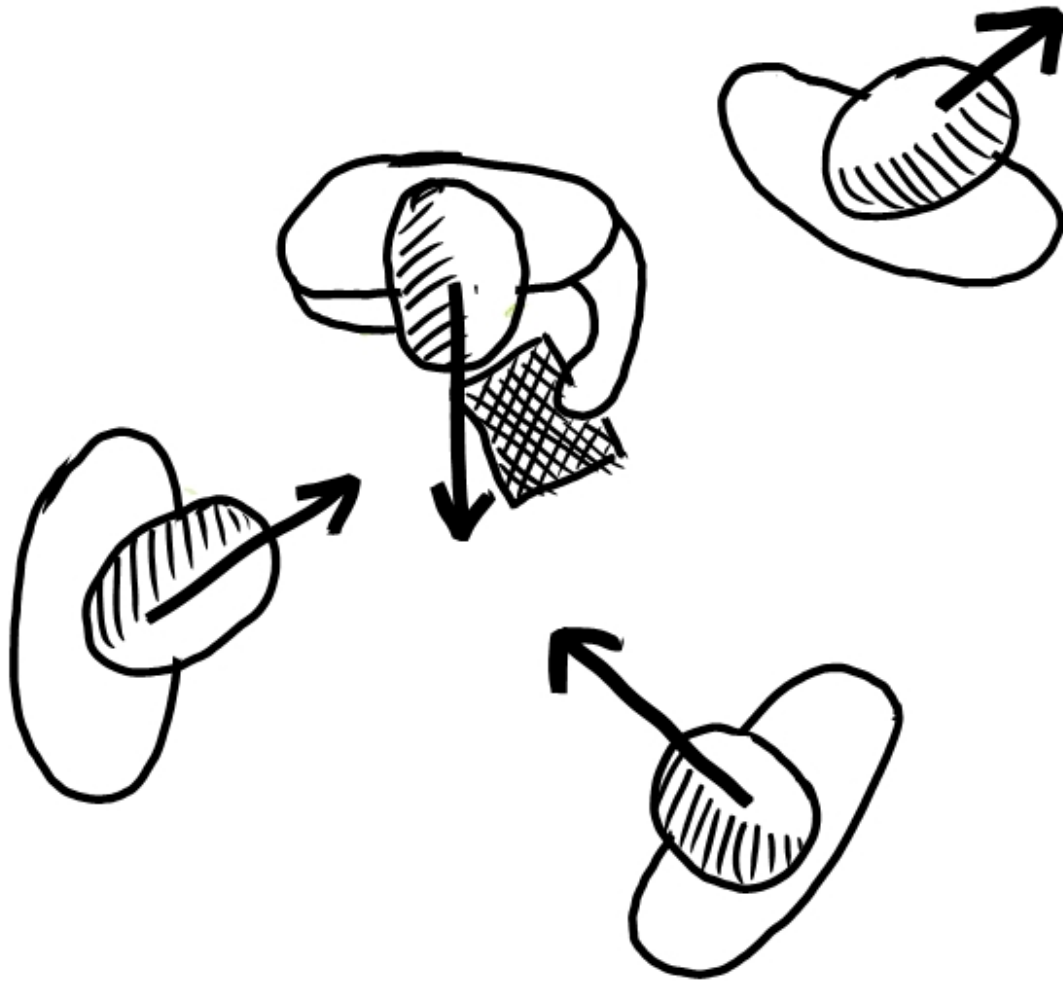
Towards Ad-hoc Collaboration Spaces with Spatially-Aware Devices

Marquardt, N., Hinckley, K. and Greenberg, S. (2012) Cross-Device Interaction via Micro-mobility and F-formations. *In Proceedings of the ACM Symposium on User Interface Software and Technology – ACM UIST 2012*. (Cambridge, MA), ACM, 13-22, October 7-10.

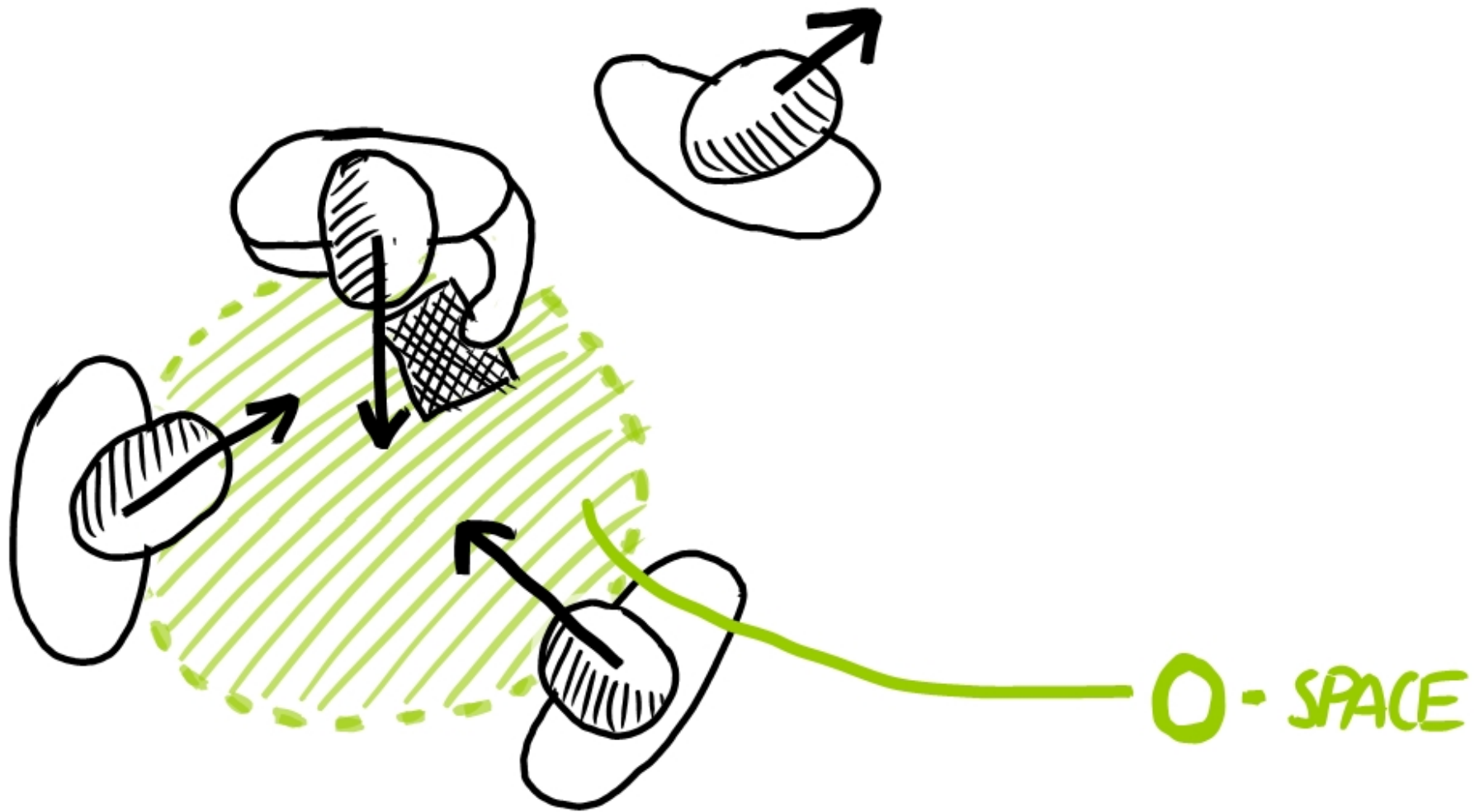




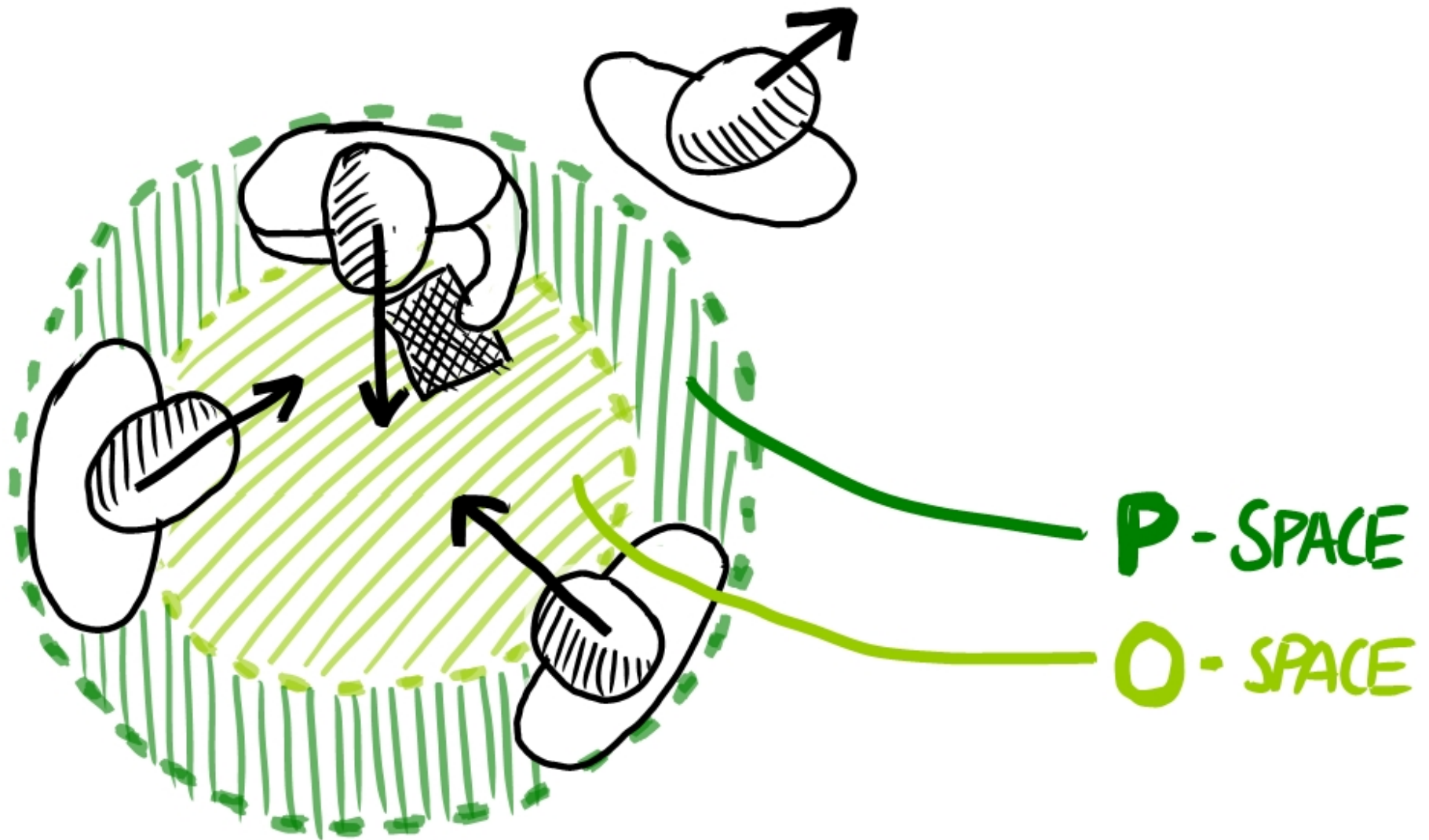
F-formations [Kendon 1990]



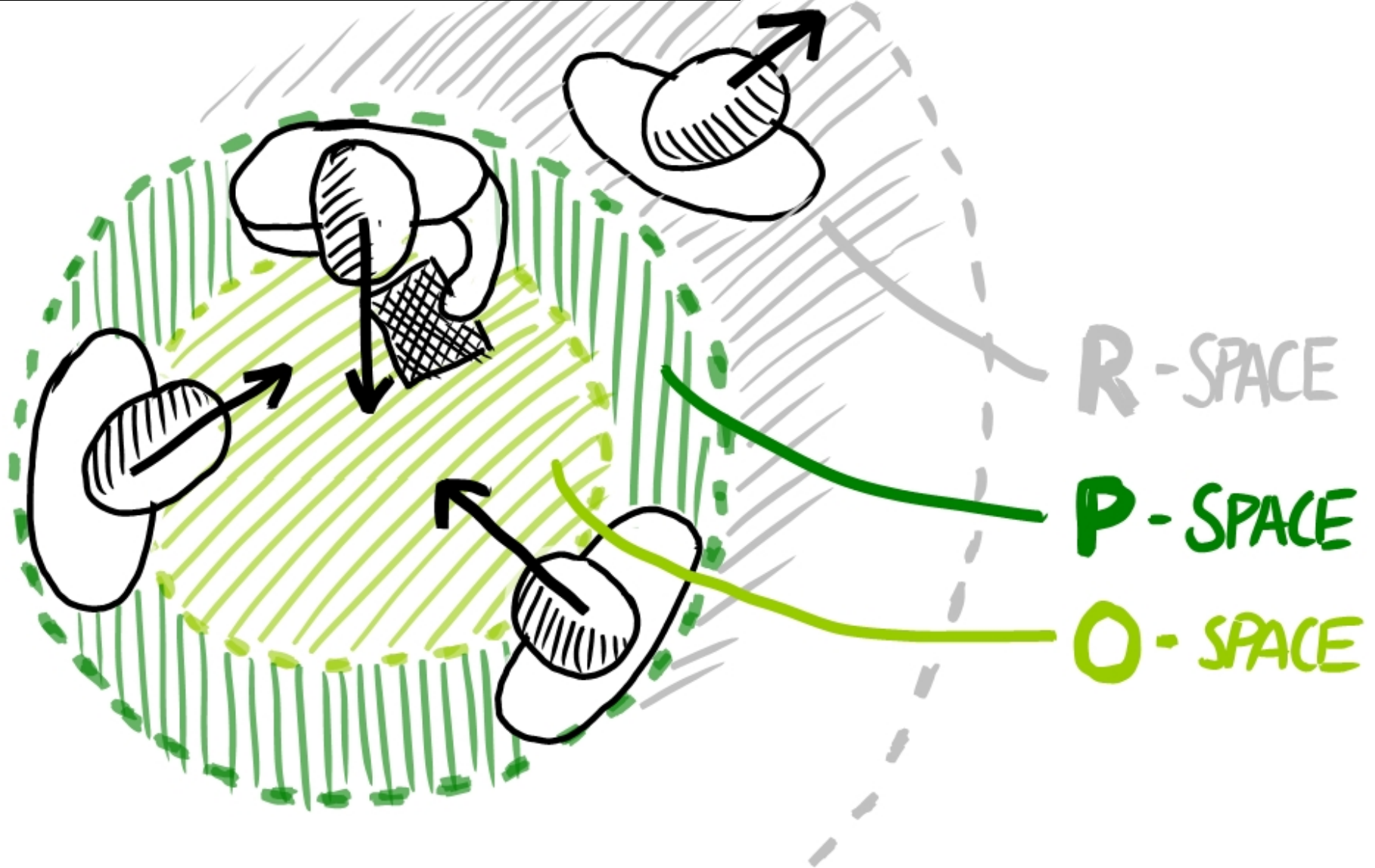
F-formations [Kendon 1990]



F-formations [Kendon 1990]



F-formations [Kendon 1990]



F-formations [Kendon 1990]



Face-to-face



Side-to-side



Corner-to-corner

Micro-mobility [Luff, Heath 1998]





An aerial, black and white photograph of a group of approximately ten people standing in a loose circle on a paved surface. A large, white dashed line forms a circle around the group, framing the scene. The people are dressed in casual clothing, and some are holding papers or bags. The perspective is from directly above, looking down at the group.

Proxemics

Photo source: Janna Wages, 2010

An aerial, black-and-white photograph of a crowd of people. Two concentric dashed white circles are drawn over the crowd. The inner circle encloses a group of people, and the outer circle encloses a larger area. Two white rectangular boxes with black text are overlaid on the image. The first box, labeled 'F-formations', is positioned over the inner dashed circle. The second box, labeled 'Proxemics', is positioned over the outer dashed circle.

F-formations

Proxemics



Micro-mobility

The image is a grayscale aerial photograph of a crowd of people. Three concentric dashed white circles are drawn over the crowd. The innermost circle is centered on a person in the upper left. The middle circle is centered on a person in the upper right. The outermost circle is centered on a person in the lower right. The text labels are placed within or near these circles: 'Micro-mobility' is in the top circle, 'F-formations' is in the middle circle, and 'Proxemics' is in the bottom circle.

F-formations

Proxemics





Design study:

Proxemics of people & devices



**Exploratory study:
10 participants**



**Foam-core mockups
of devices**

Tasks

Tasks

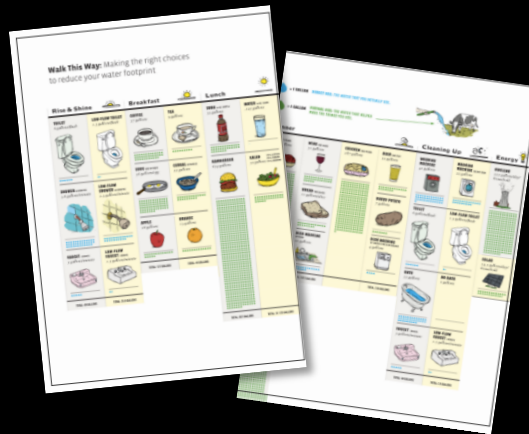
collaborative



Tasks

collaborative

competitive



Tasks

collaborative

competitive

individual



Observed behaviors

B1 | Devices as extension of person

B2 | F-formations vary by task

B3 | Moving devices in/out of focal zone

B4 | Incidental tilting

B5 | Pointing while tilting within the o-space

B6 | Reorientation with gradation in response

B7 | Avoid persistent spatial invasion

B8 | Matching pose while side-by-side

Observed behaviors

B1 | Devices as extension of person

B2 | F-formations vary by task

B3 | Moving devices in/out of focal zone

B4 | Incidental tilting

B5 | Pointing while tilting within the o-space

B6 | Reorientation with gradation in response

B7 | Avoid persistent spatial invasion

B8 | Matching pose while side-by-side

B2 | F-formations vary by task

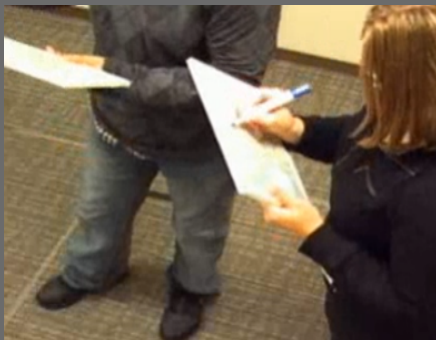


Collaborative

B2 | F-formations vary by task



Collaborative



Individual

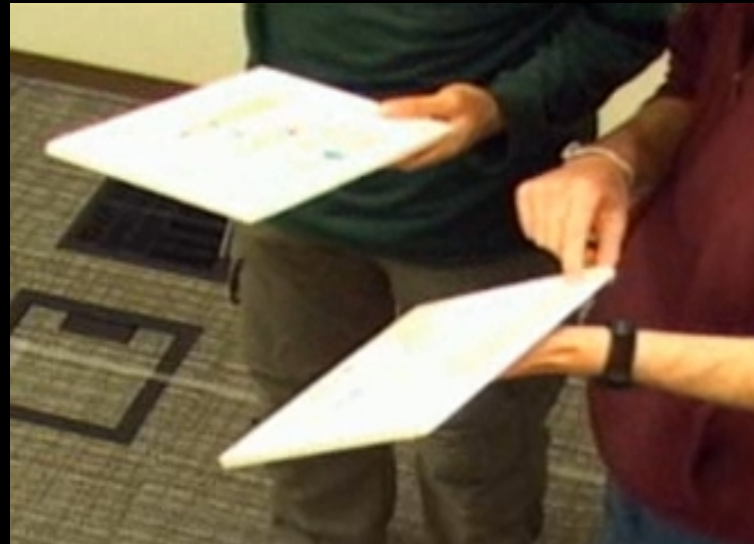


Competitive


B3 | Moving devices in/out of focal zone



B5 | Pointing while tilting within o-space



- B1 | Devices as extension of person**
- B2 | F-formations vary by task**
- B3 | Moving devices in/out of focal zone**
- B4 | Incidental tilting**
- B5 | Pointing while tilting within the o-space**
- B6 | Reorientation with gradation in response**
- B7 | Avoid persistent spatial invasion**
- B8 | Matching pose while side-by-side**

- B1| Devices as extension of person
 - B2| F-formations vary by task
 - B3| Moving devices in/out of focal zone
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 - B6| Reorientation with gradation in response
 - B7| Avoid persistent spatial invasion
 - B8| Matching pose while side-by-side
- 

GroupTogether system

Fluid **cross-device sharing**
techniques for co-located
collaboration by considering
proxemics of people and
proxemics of devices

Tilt-to-preview

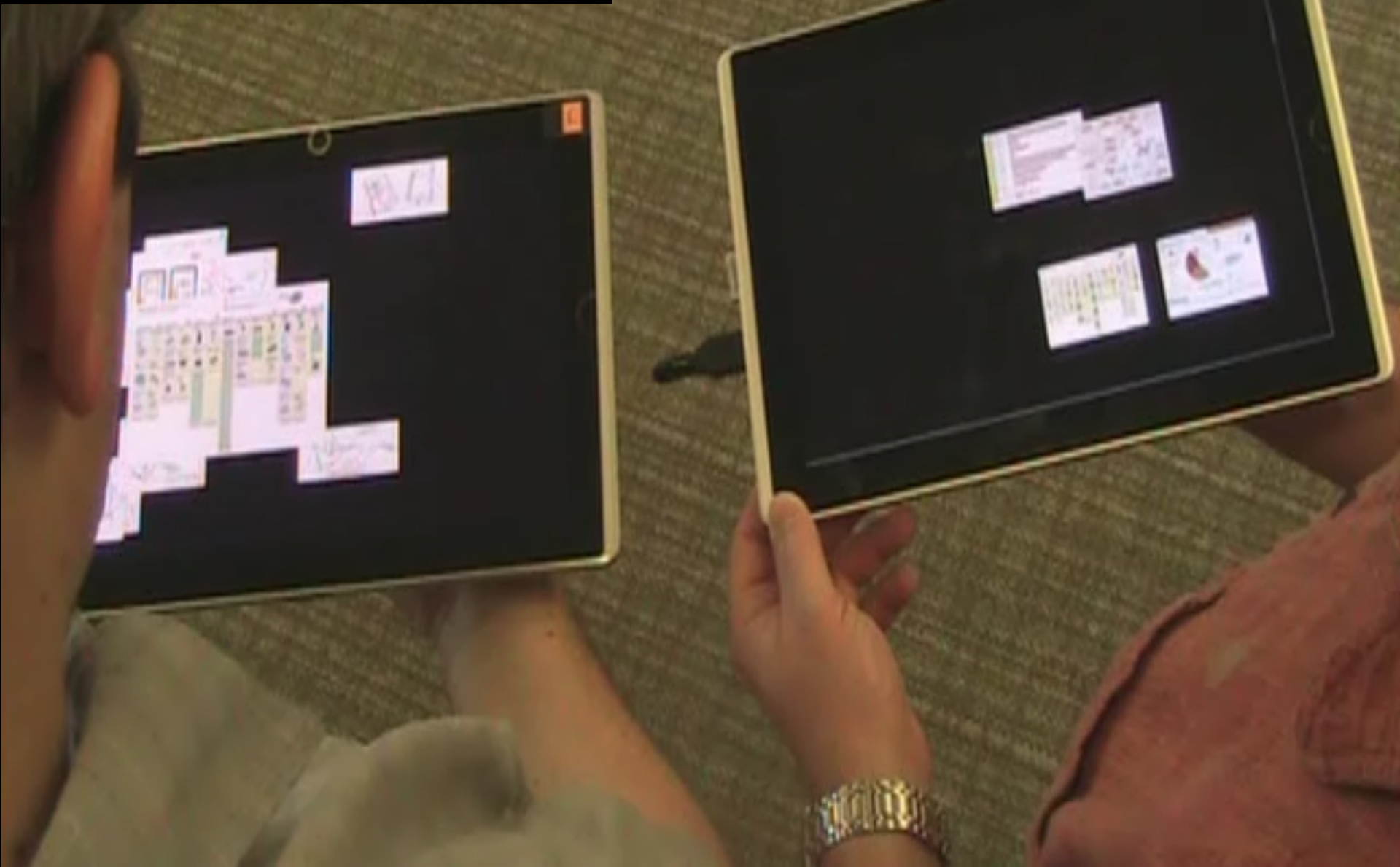




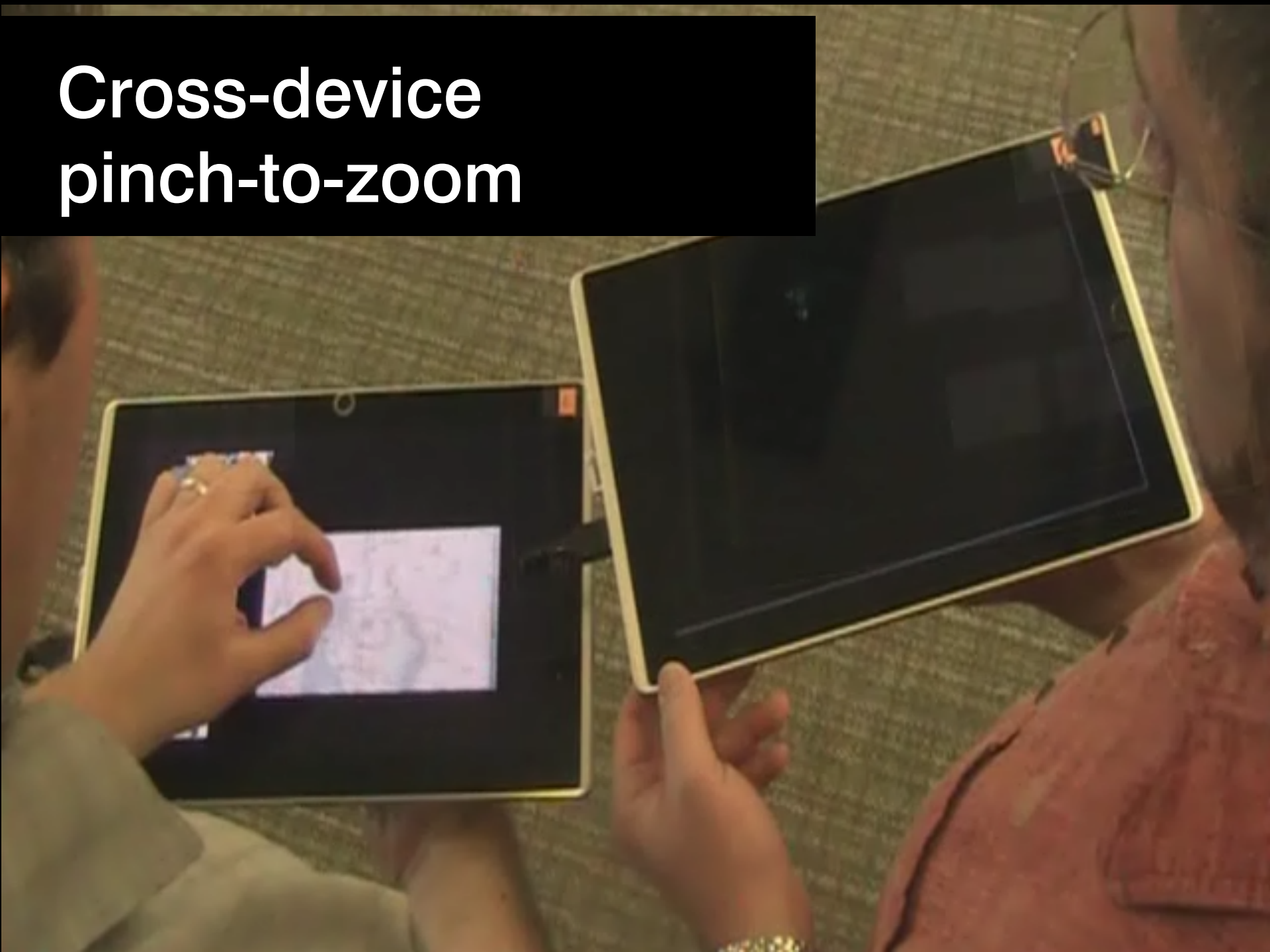
Public devices part of formation



Portals



Cross-device pinch-to-zoom



Implementation

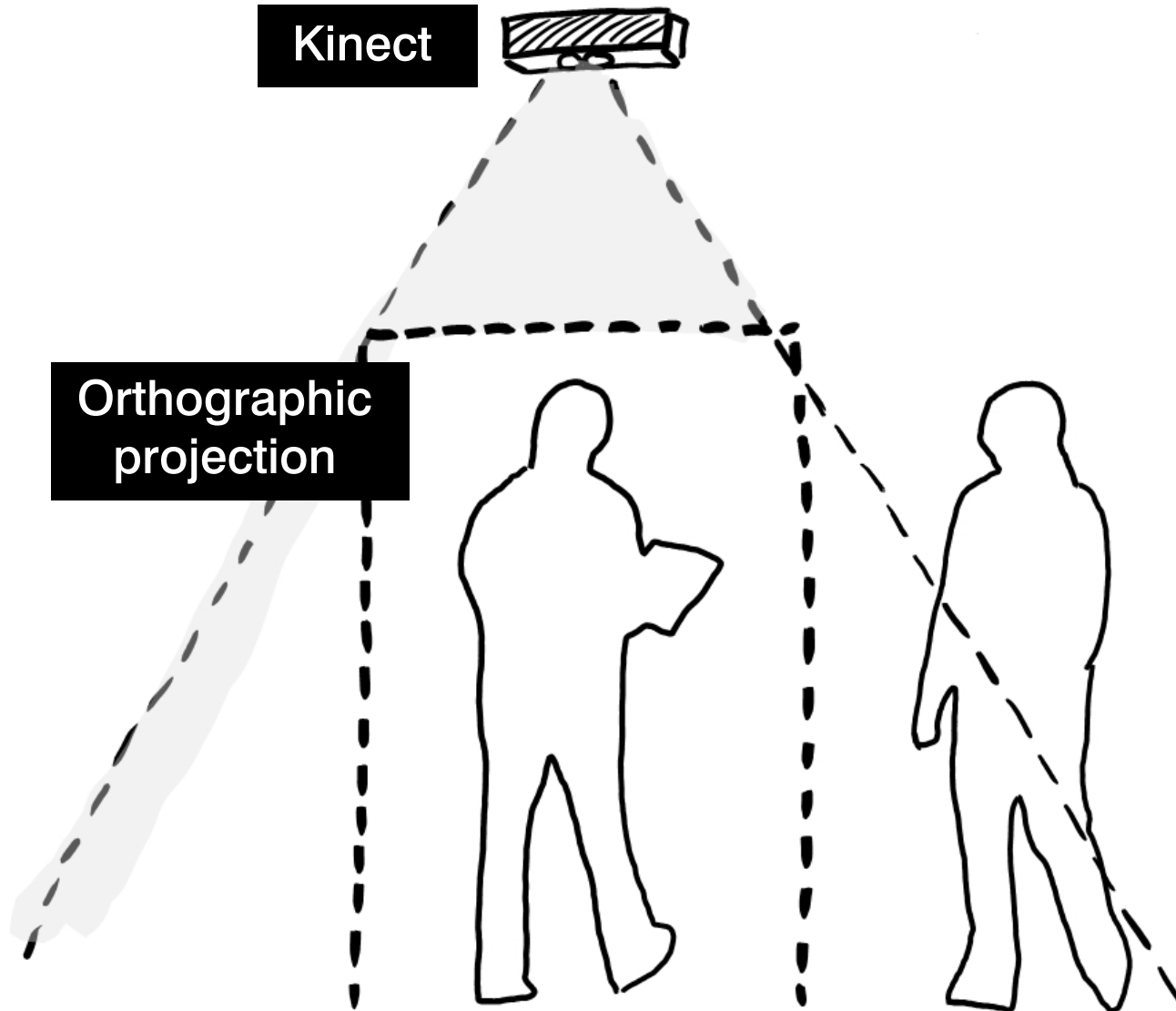
Hybrid sensing approach

Person-to-person
proxemics
and
F-Formations

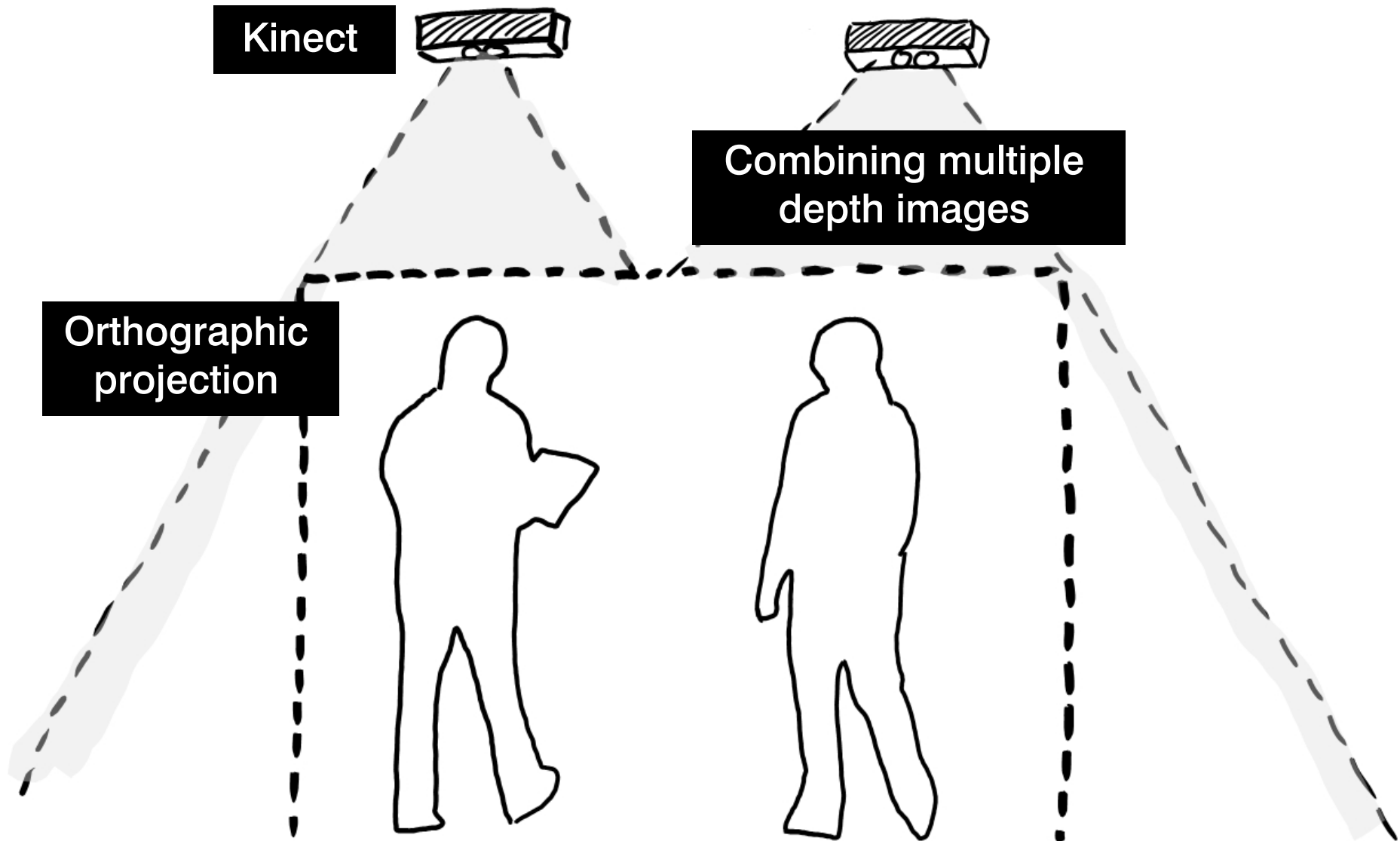
Device-to-device
proxemics

Micro-mobility of
devices

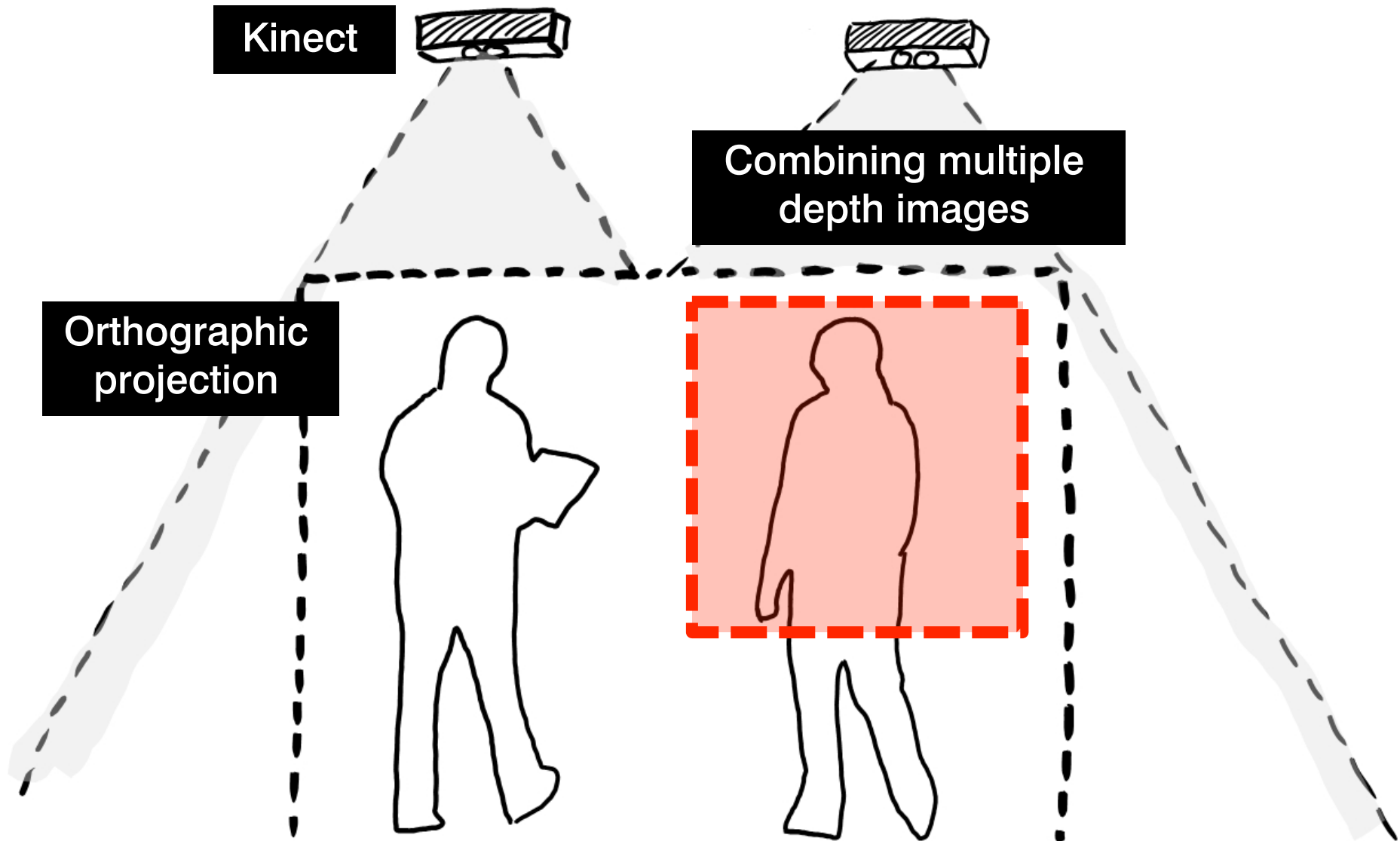
Step 1 | Tracking people's position



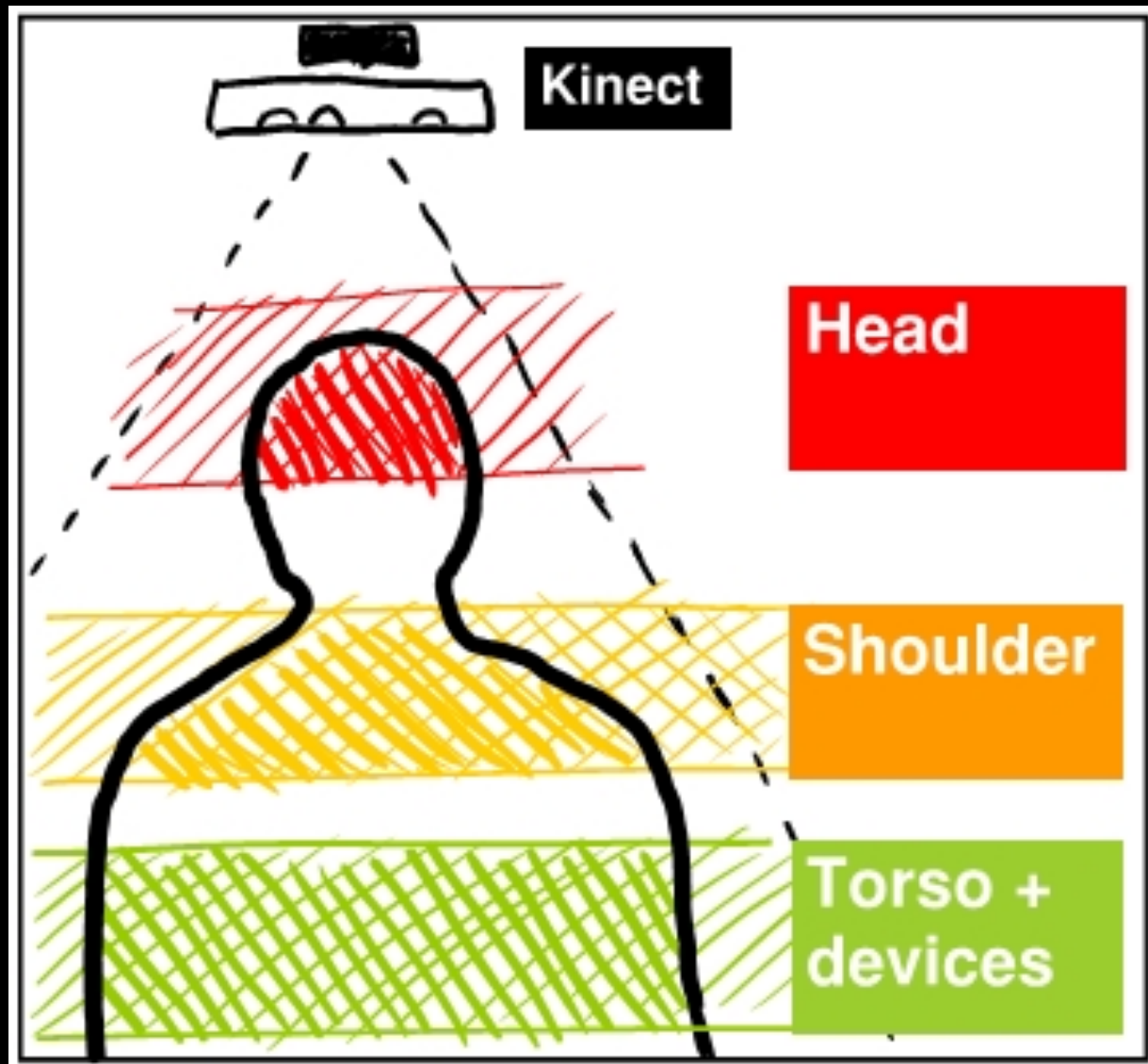
Step 1 | Tracking people's position



Step 1 | Tracking people's position



Step 1 | Tracking people's position



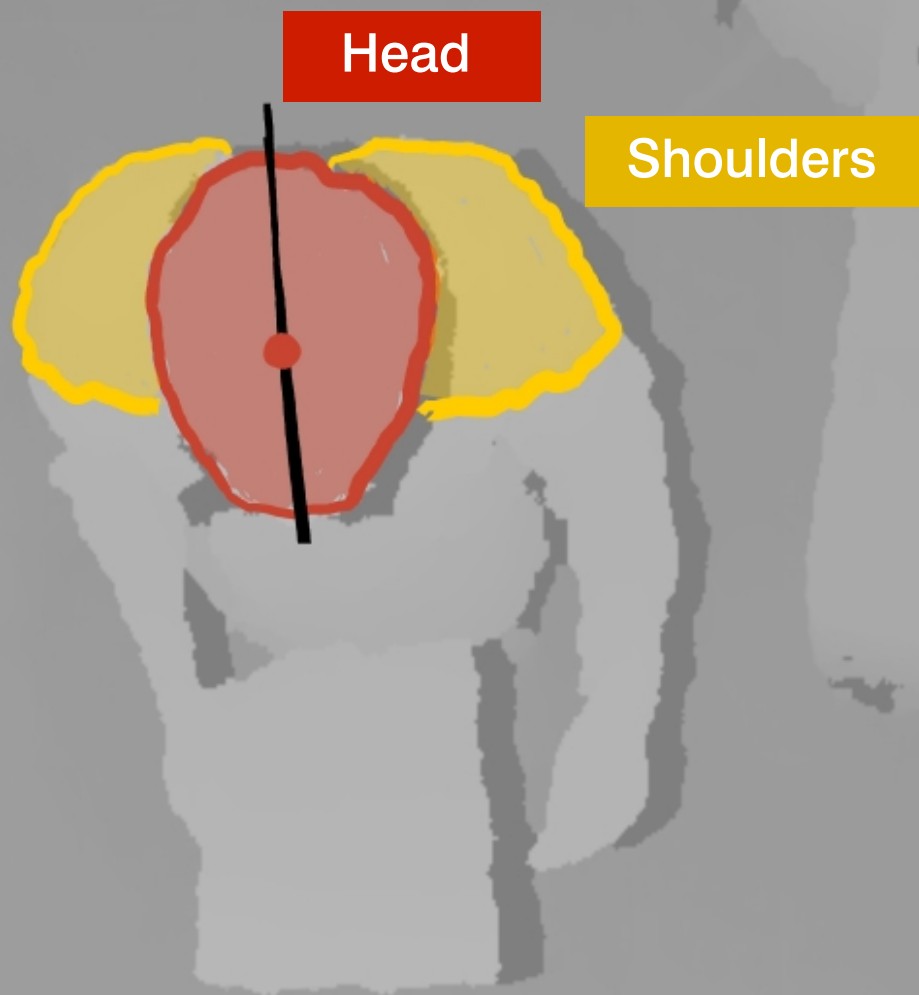


Head



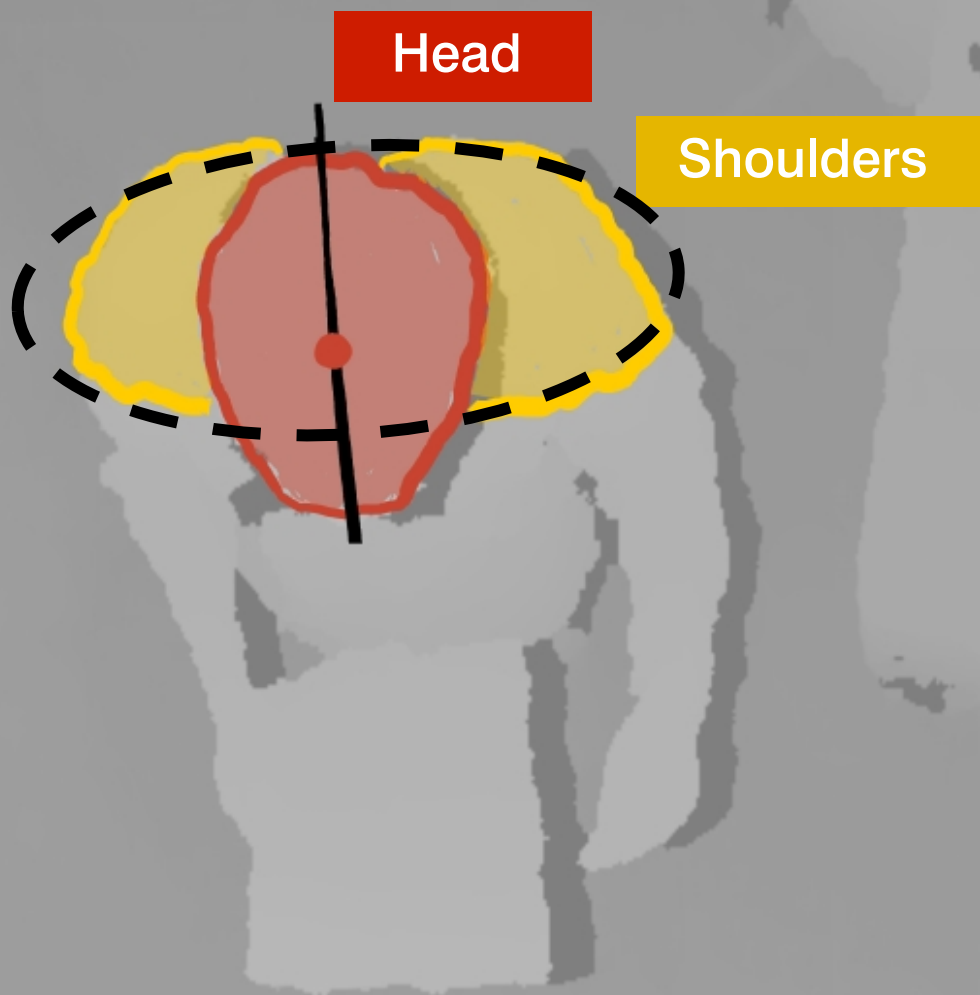


Head



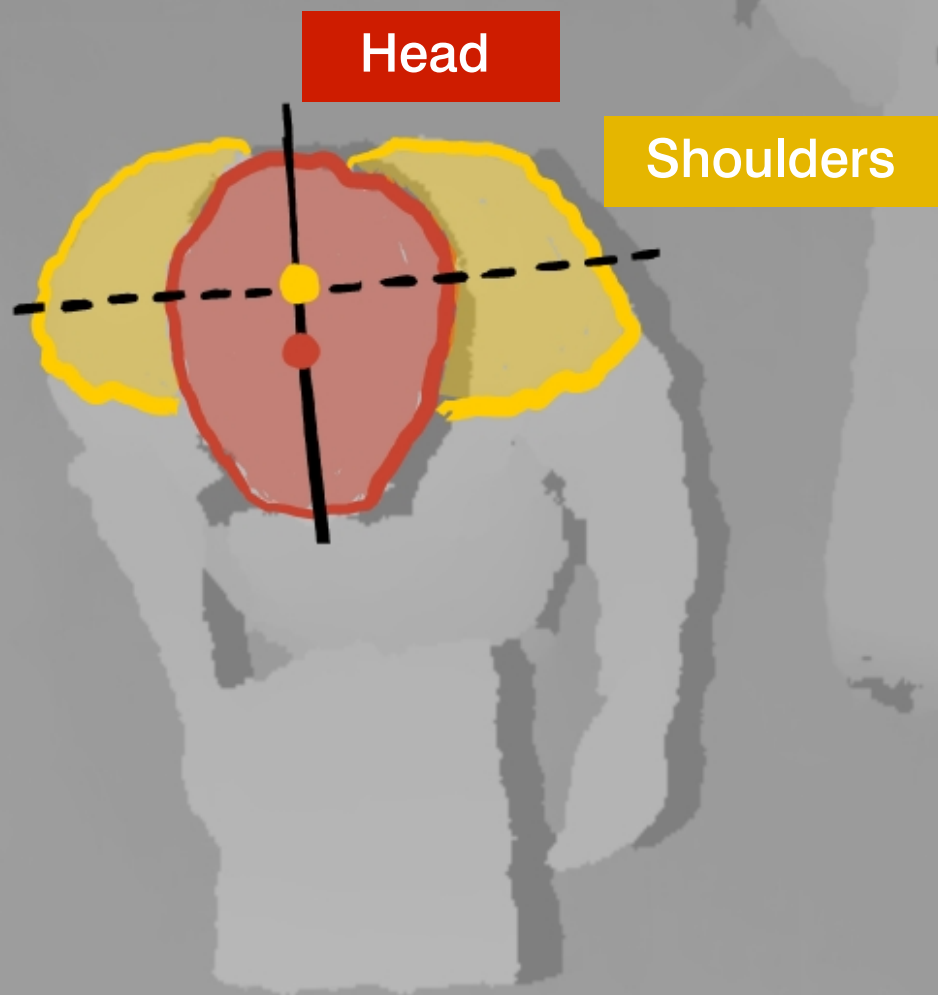
Head

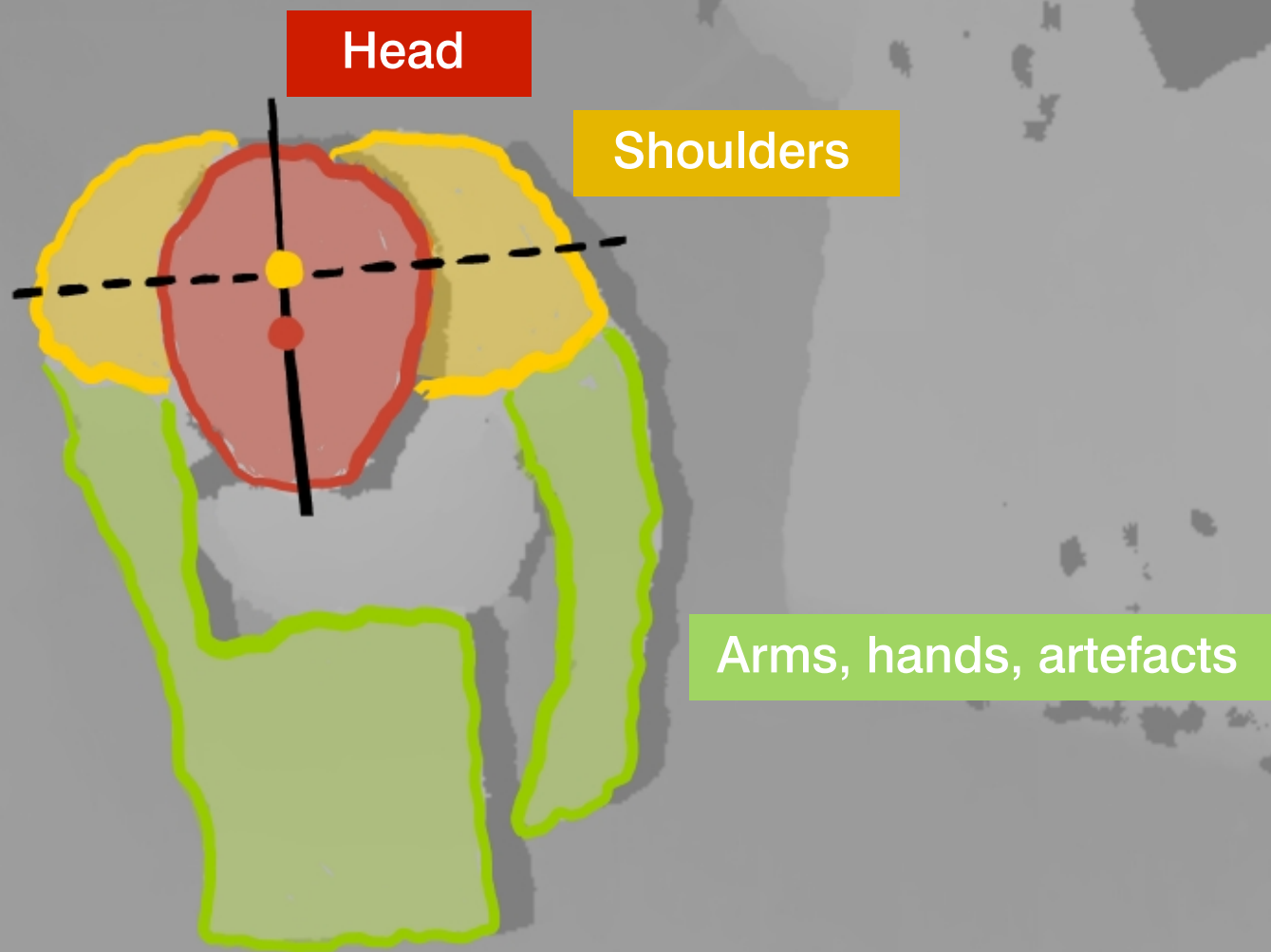
Shoulders

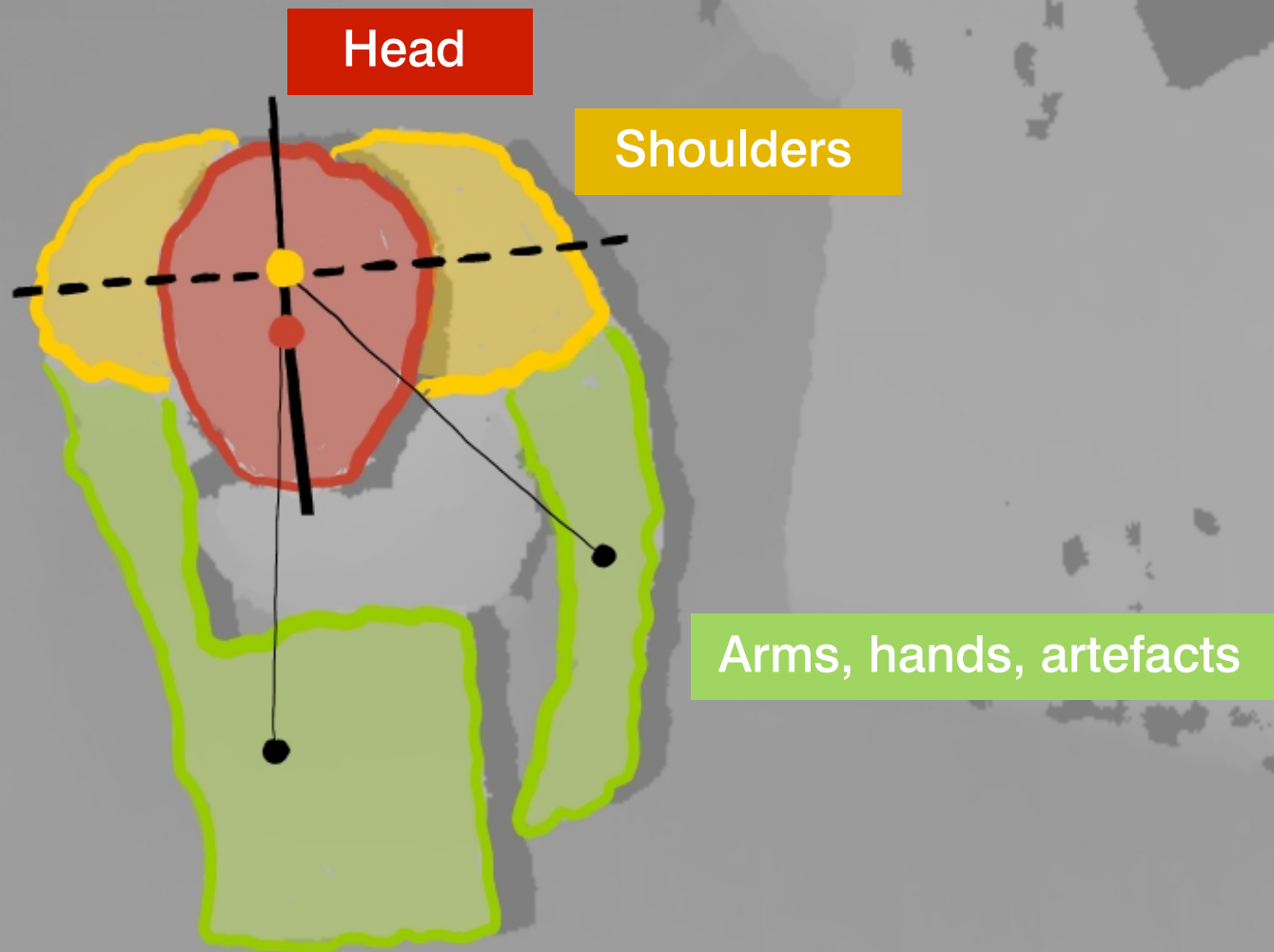


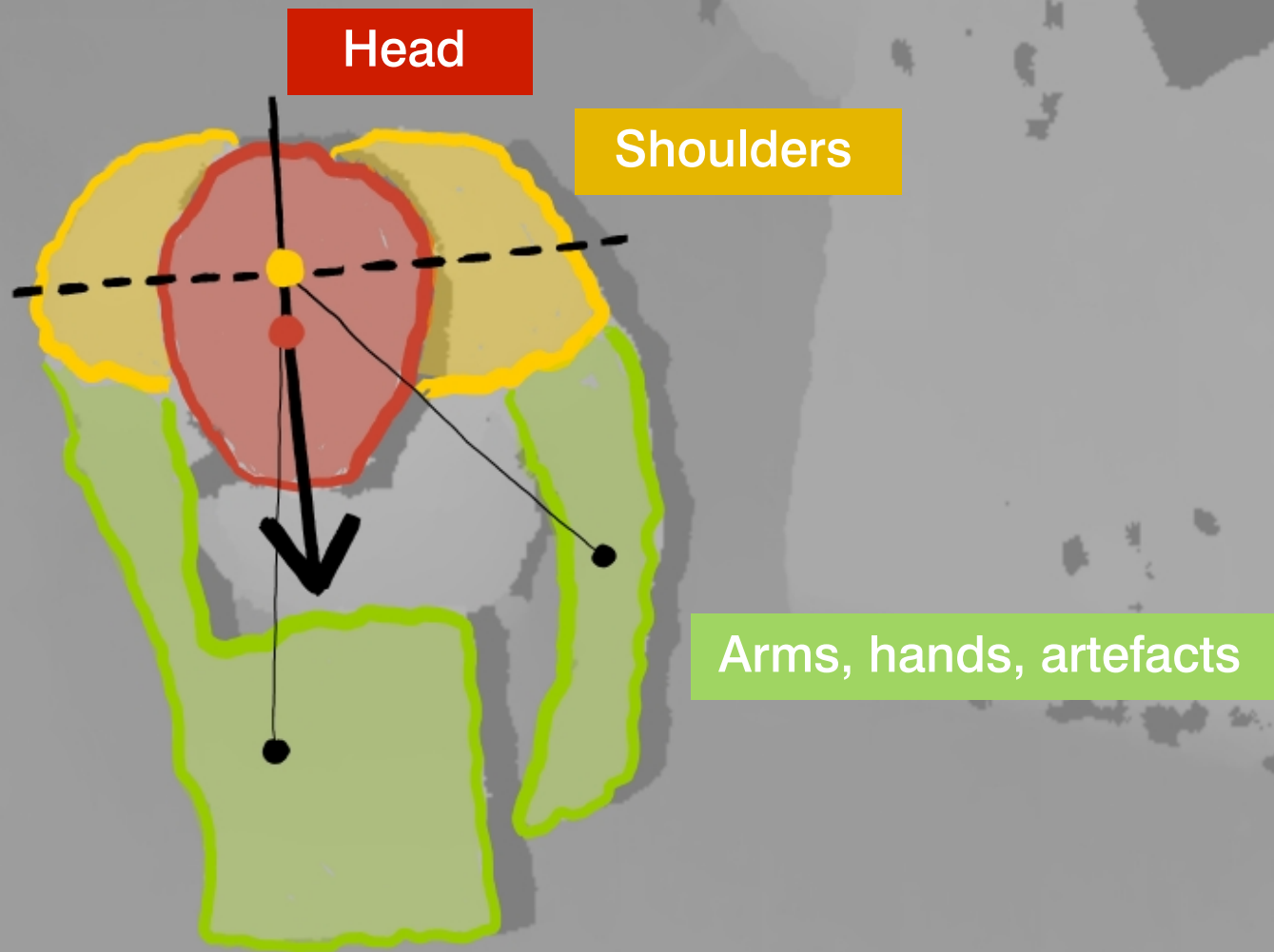
Head

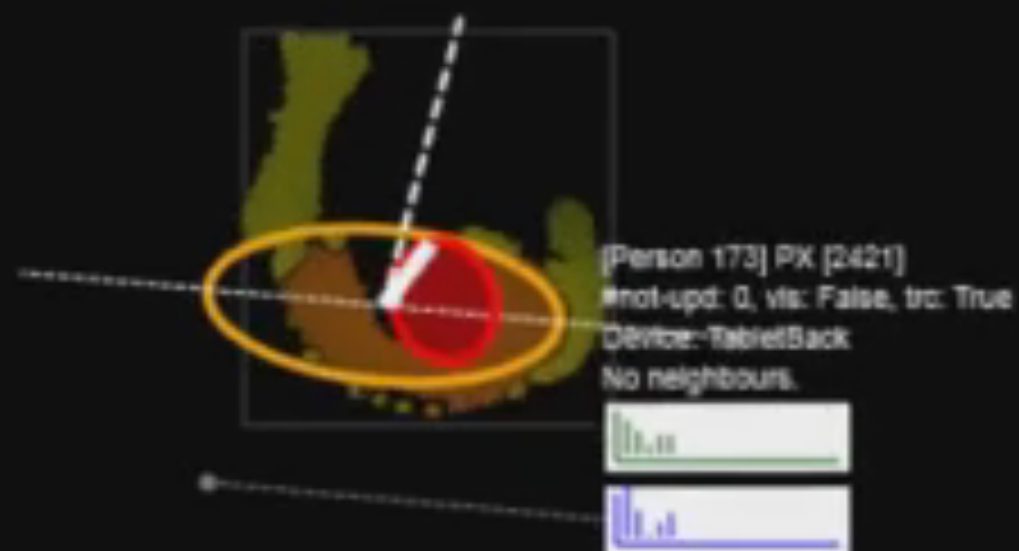
Shoulders

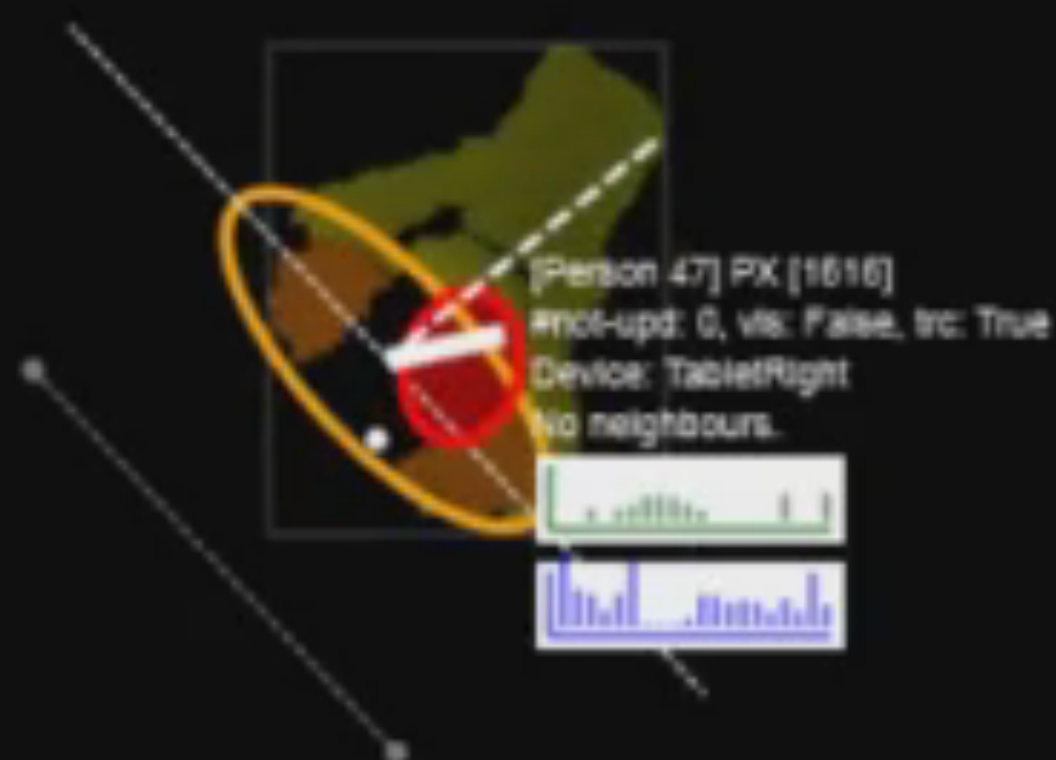






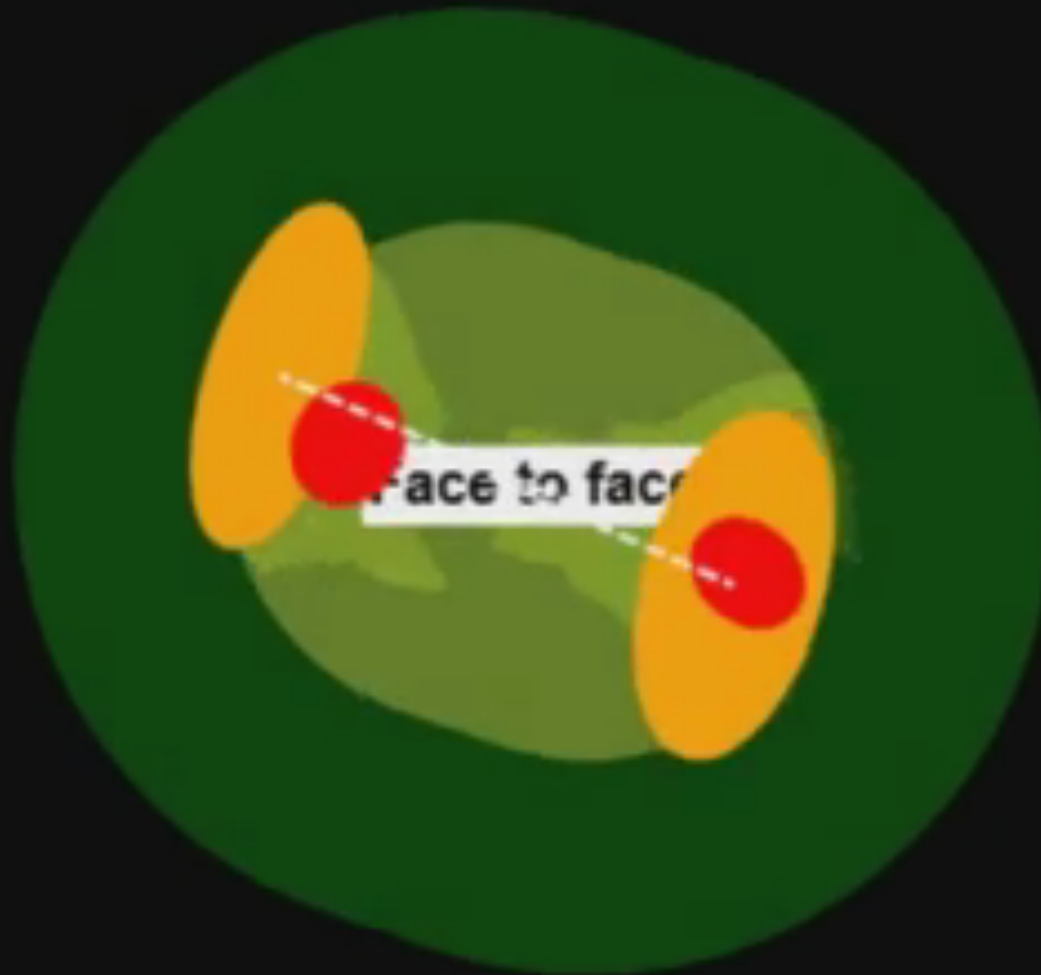




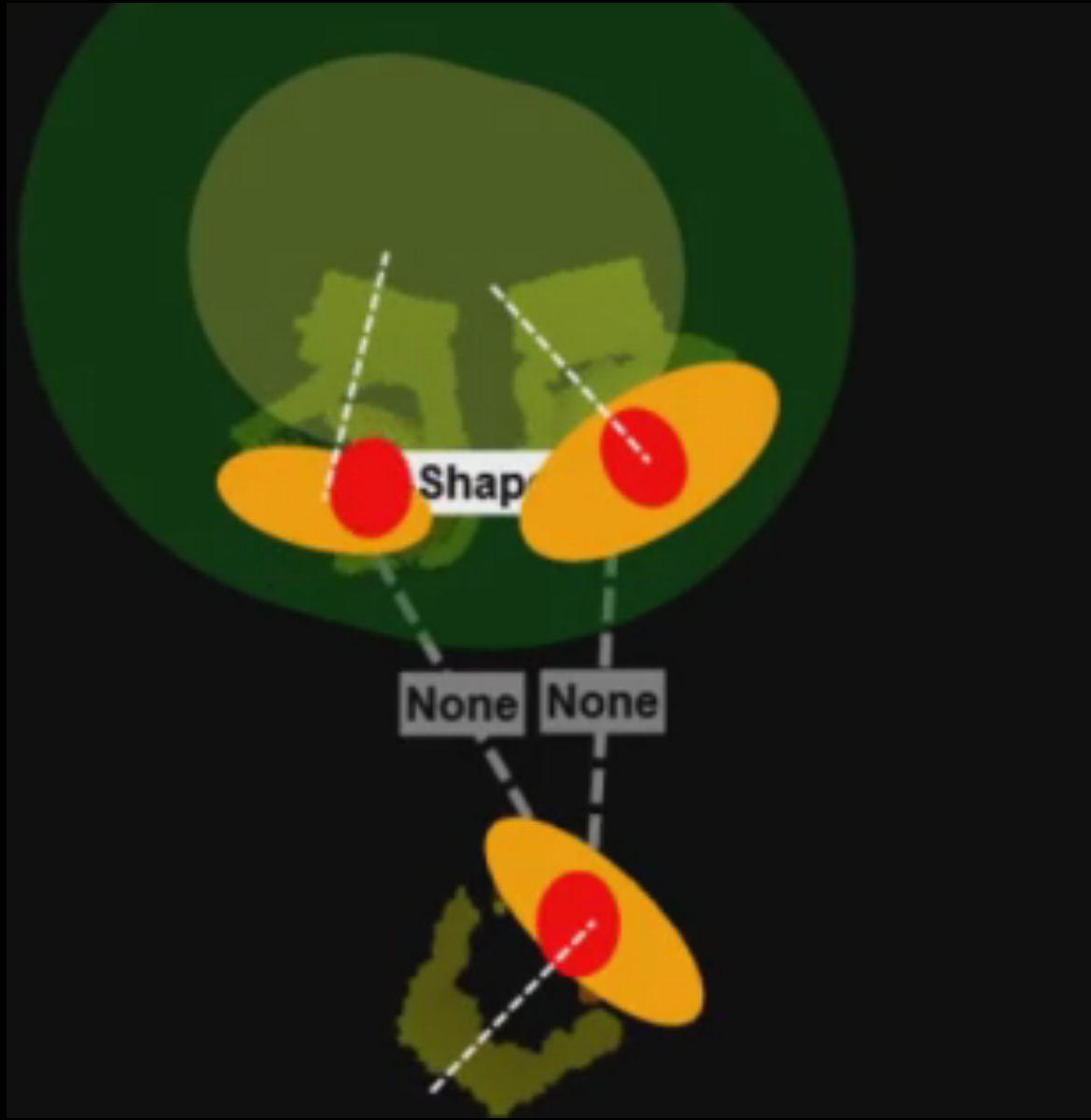


Step 1 | Determining f-formations

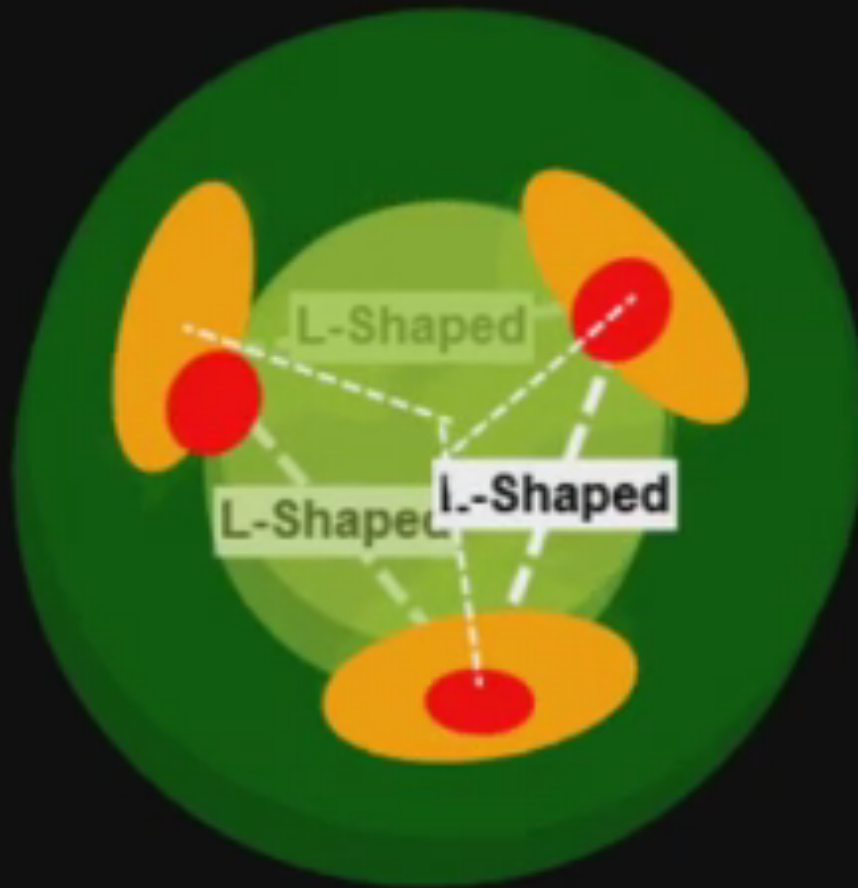
Step 1 | Determining f-formations



Step 1 | Determining f-formations

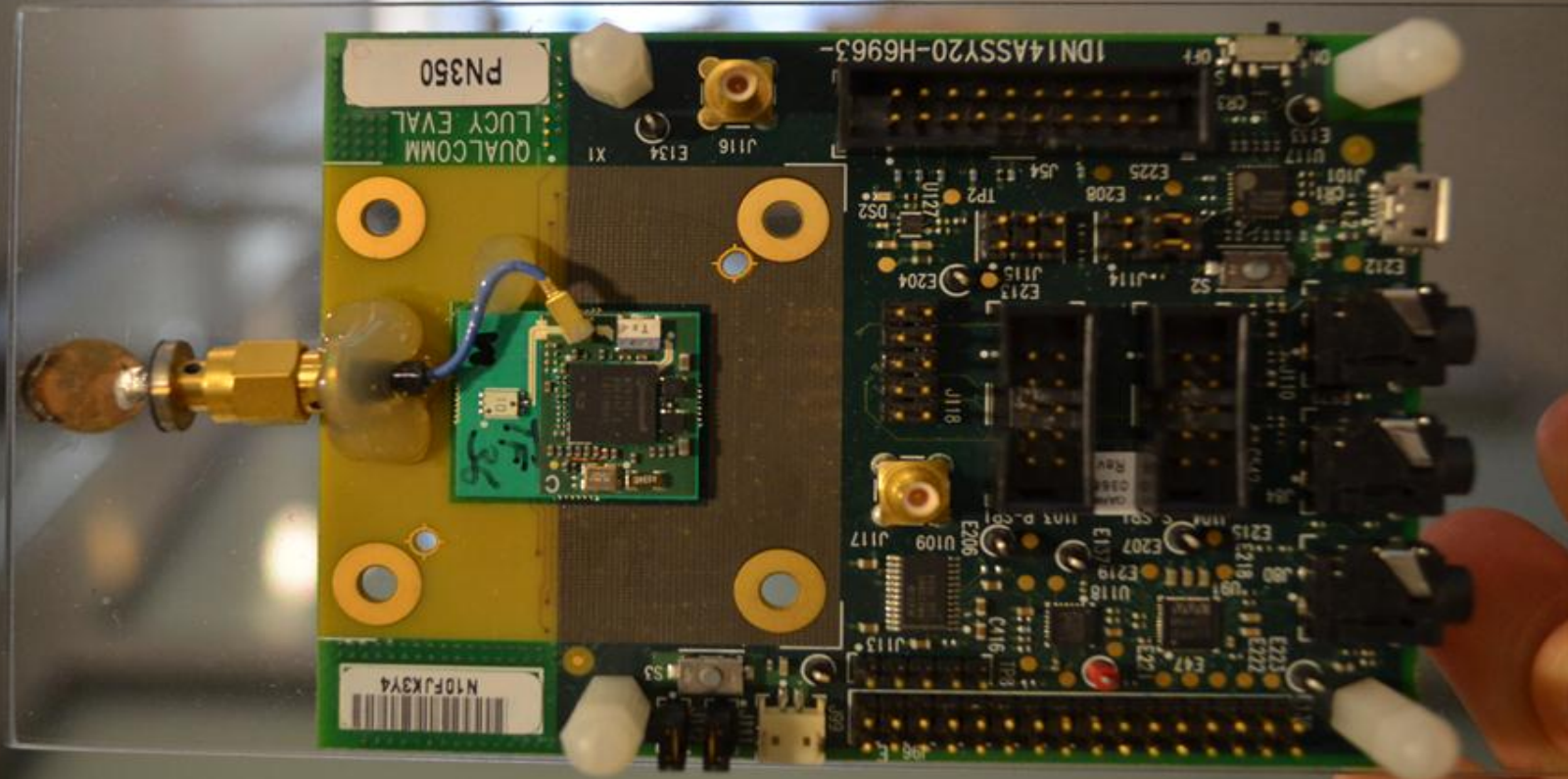


Step 1 | Determining f-formations



Step 2 | Devices' spatial relationships

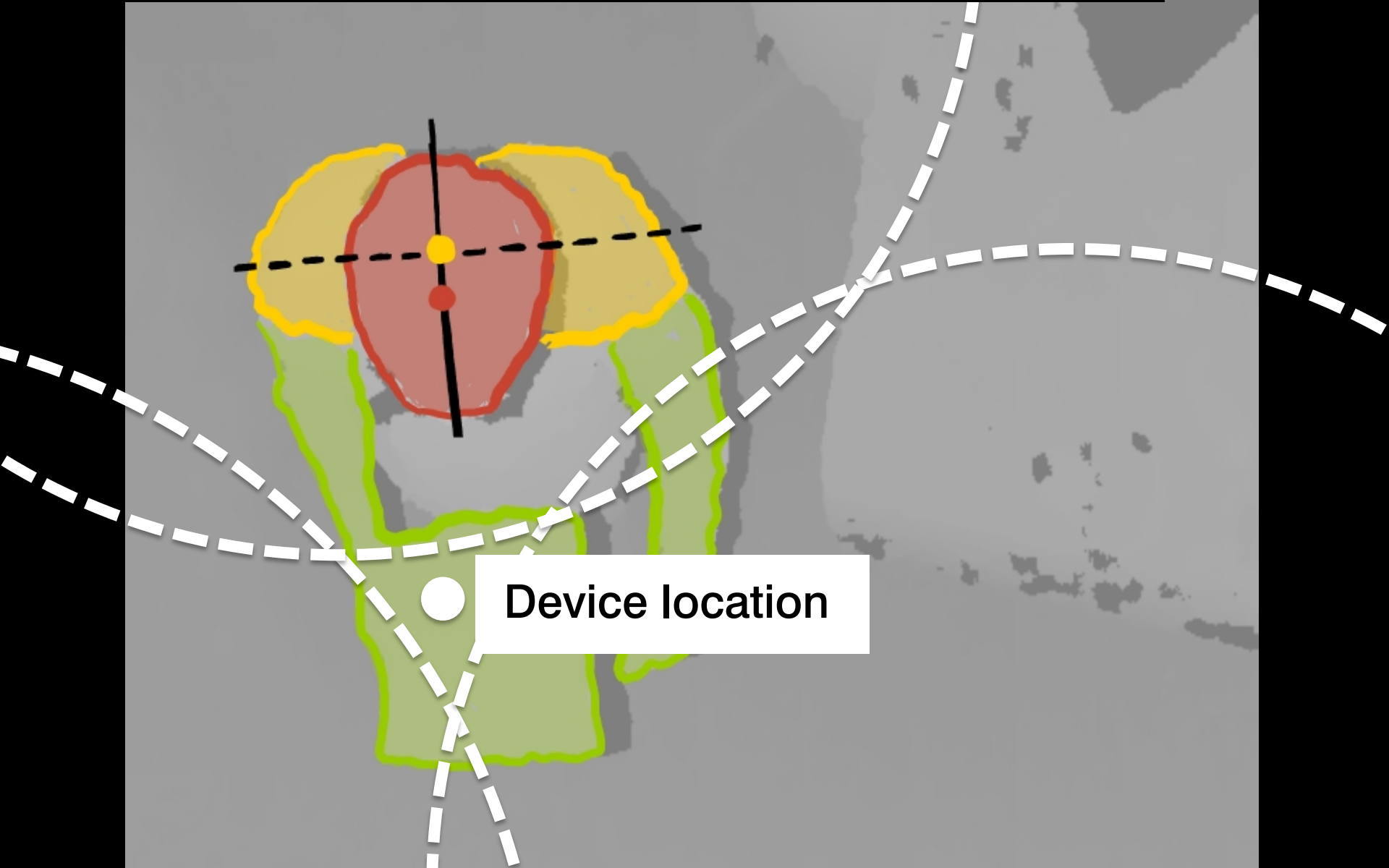
Step 2 | Devices' spatial relationships



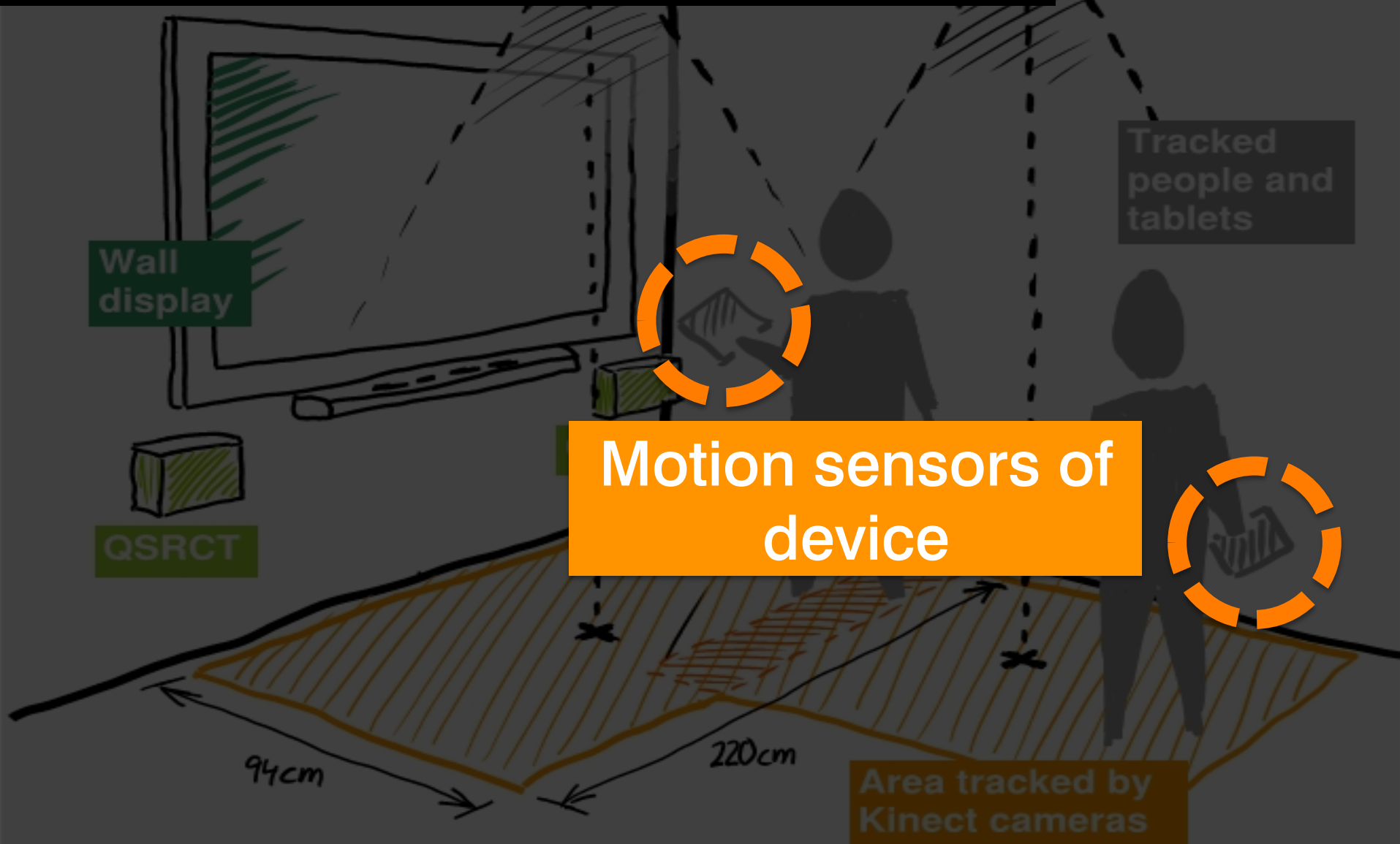
Step 2 | Devices' spatial relationships

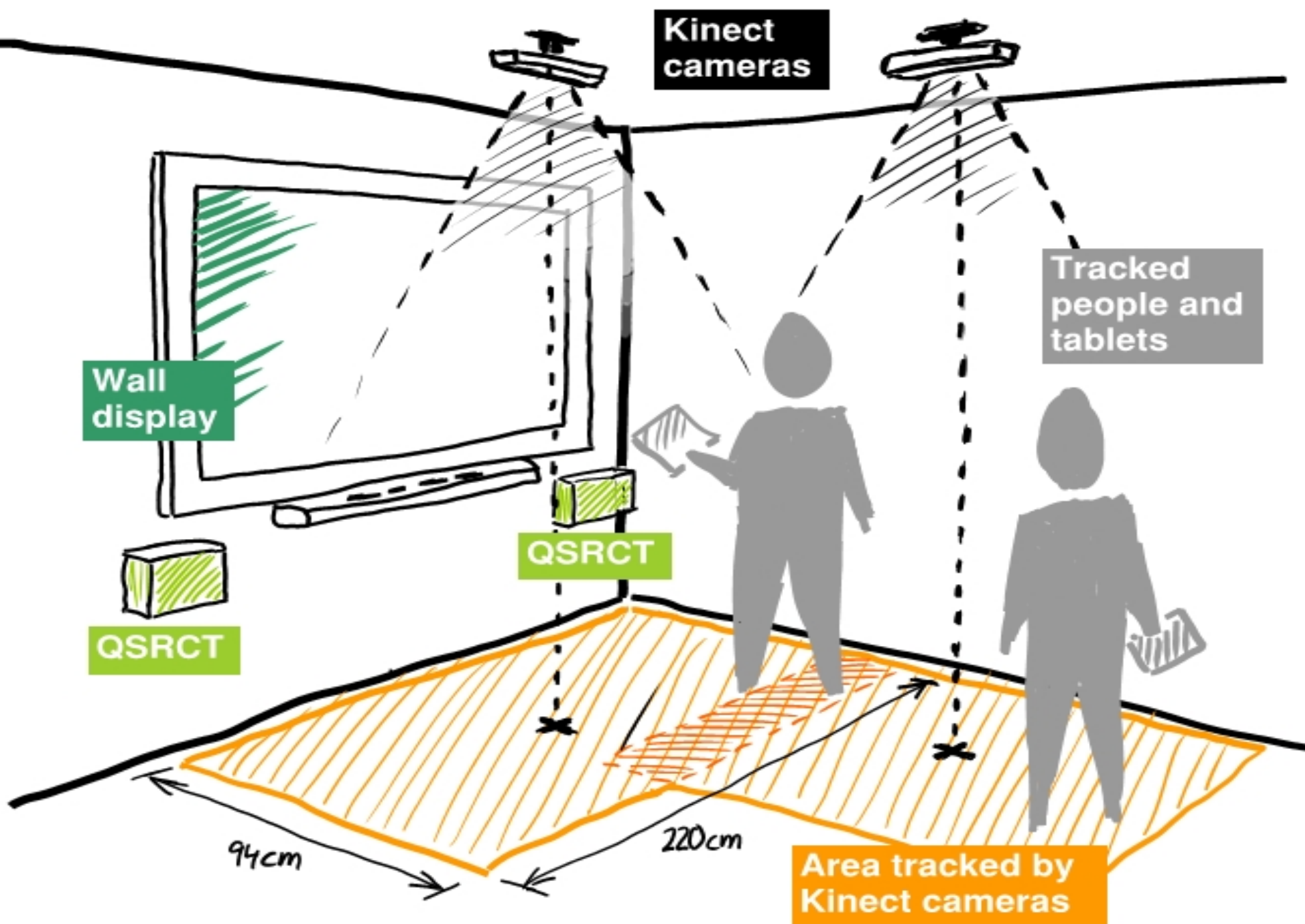


p 2 | Devices' spatial relationships



Step 3 | Sensing micro-mobility







Hybrid sensing approach

1. Person-to-person proxemics and F-Formations

2. Device-to-device proxemics

3. Micro-mobility

Hybrid sensing approach

1. Person-to-person proxemics and F-Formations

Overhead KINECT cameras

+

2. Device-to-device proxemics

Radio signal trilateration

+

3. Micro-mobility

Motion sensors of device

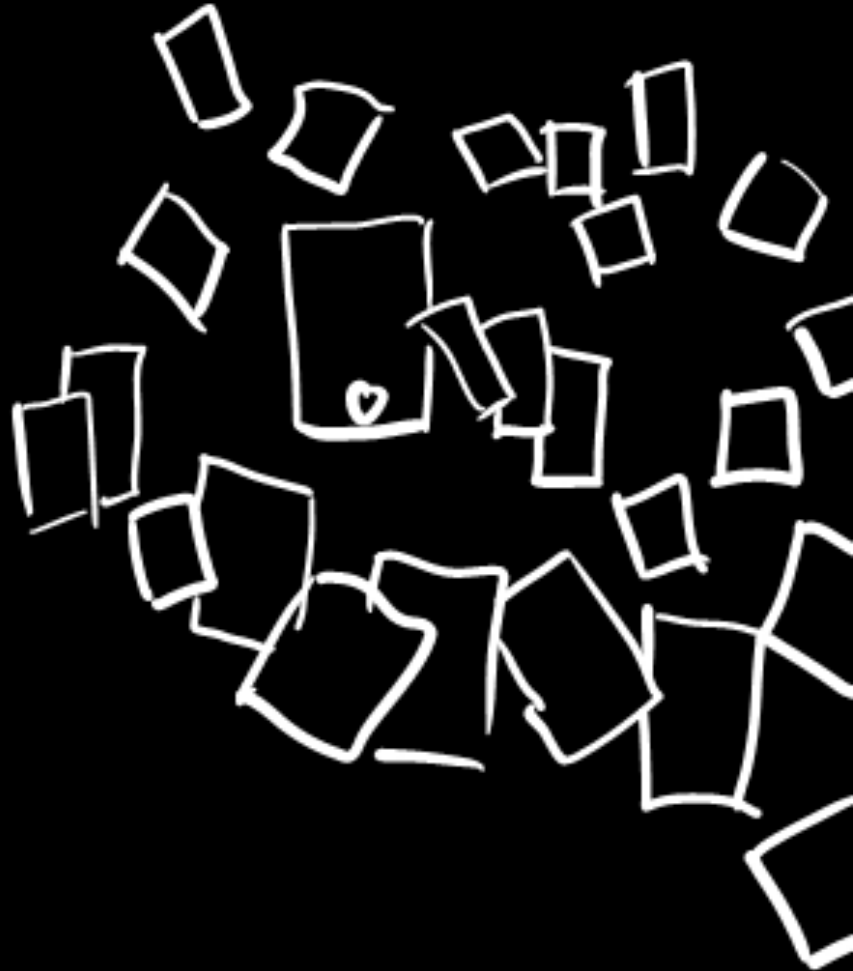
Large Ubicomp Ecologies



Large Ubicomp Ecologies



VS.



Large Ubicomp Ecologies



VS.





HuddleLamp: Spatially-Aware Mobile Displays for Ad-hoc Around-the-Table Collaboration

Rädle, R., Jetter, H.C., Marquardt, N., Reiterer, H., Rogers, Y. (2014) HuddleLamp: Spatially-Aware Mobile Displays for Ad-hoc Around-the-Table Collaboration. In Proceedings at ITS 2014, ACM (to appear).







HuddleLamp

RGB-D camera inside the lamp

PC for processing

**0.8m
HEIGHT**

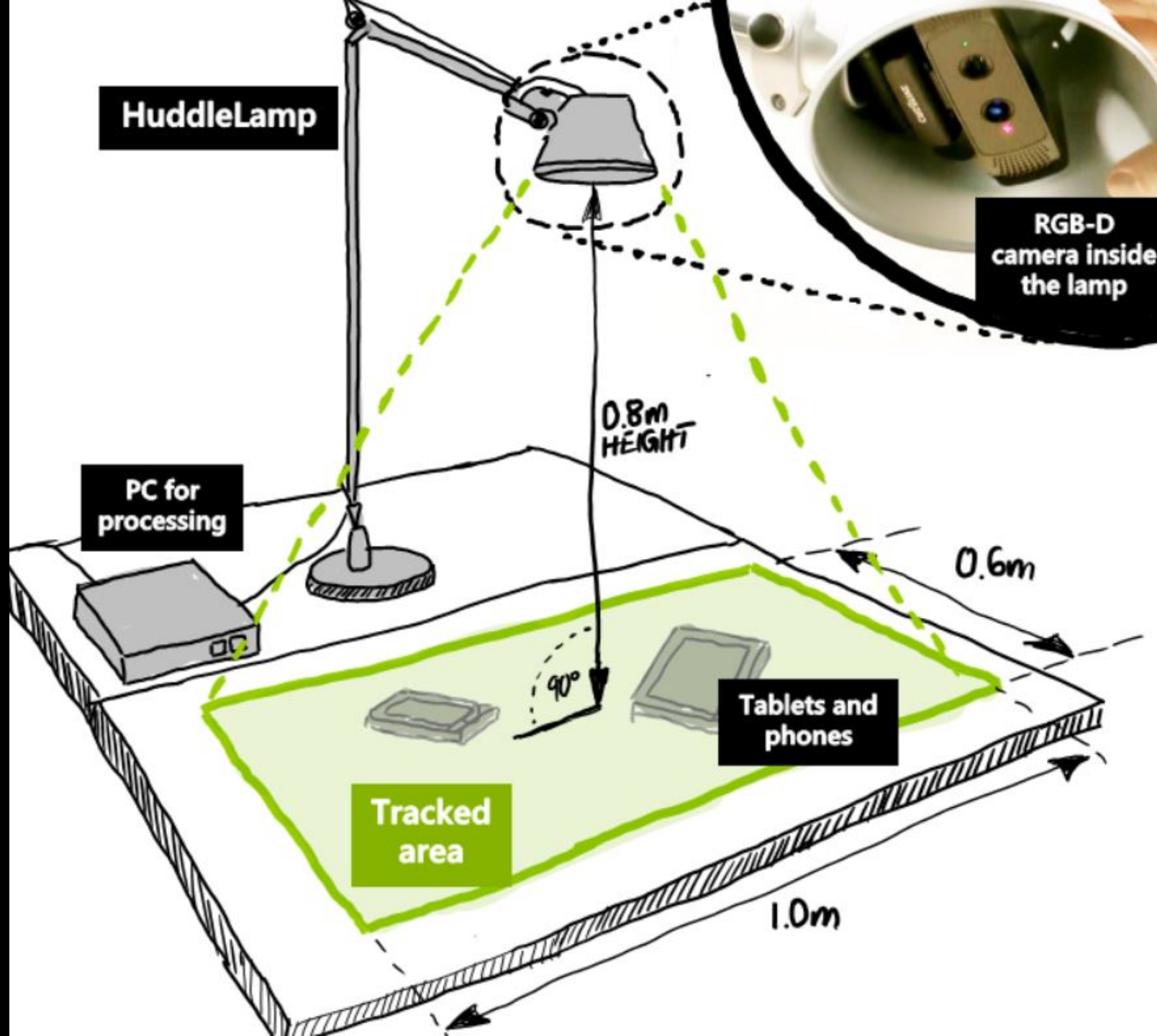
0.6m

Tablets and phones

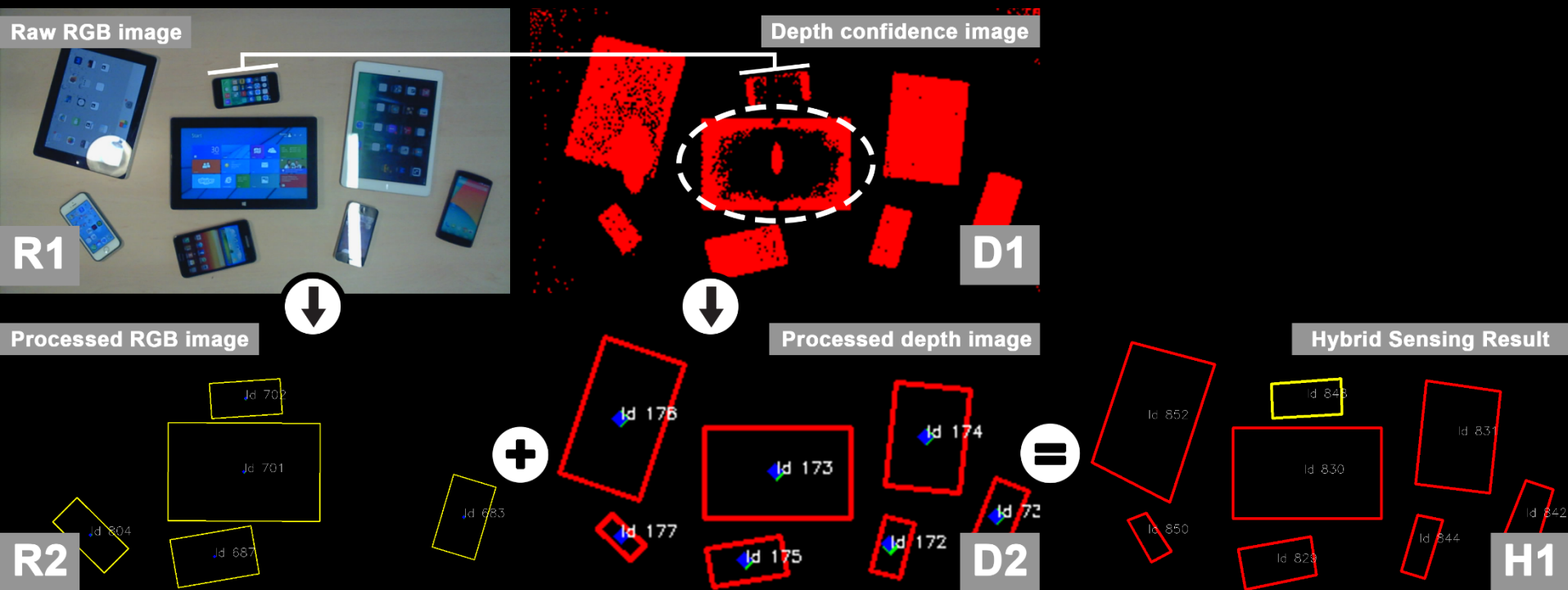
Tracked area

1.0m

90°



Hybrid Sensing – RGB and Depth Tracking

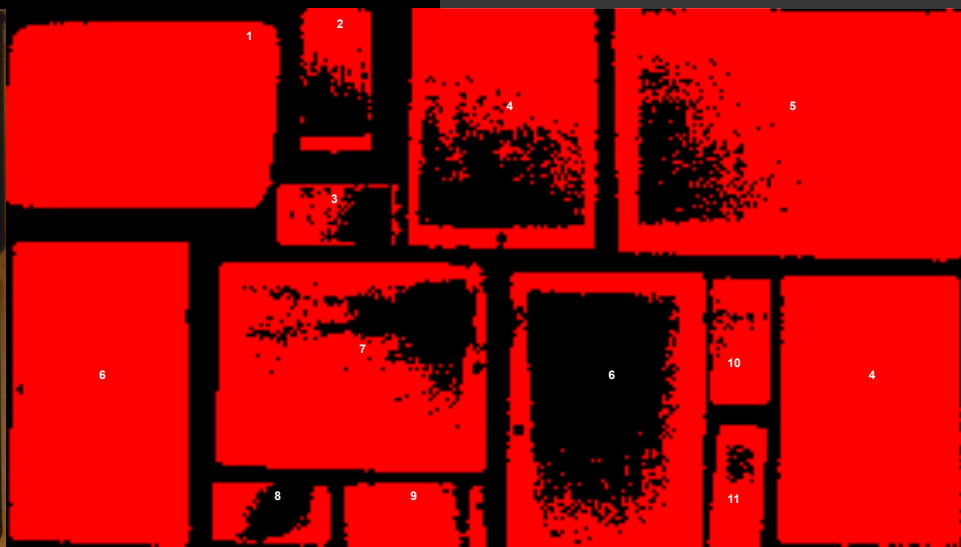


Reflectance Properties

RGB Image



Confidence Image



Technical Evaluation – Results in Brief

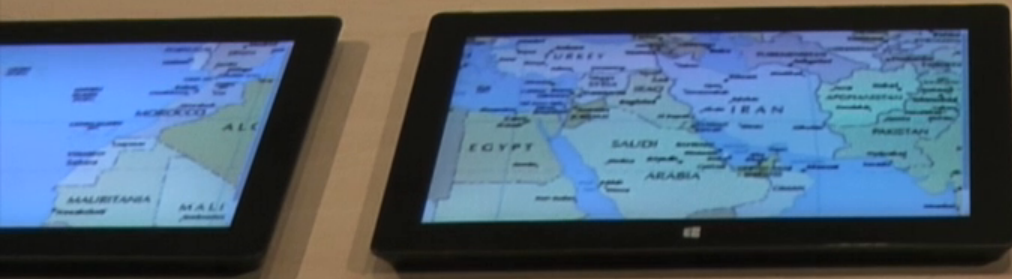
- Accuracy of Hybrid Sensing < 1 cm
- Reliable tracking even when occluded
100% 1 finger, 99.9% 1 hand, and 89.8% 2 hands
- Unaffected by ambient light ranging
10 lux, 1600 lux, and 2200 lux
- Tracking framerate between 25 to 30 fps

HuddleLamp JavaScript API

Example JavaScript on client device

```
1. var huddle = Huddle.client()
2.   .on("devicefound", function() {
3.     console.log("devicefound");
4.   })
5.   .on("devicelost", function() {
6.     console.log("devicelost");
7.   })
8.   .on("proximity", function(data) {
9.     console.log(data);
10.  })
11.  .connect(host, port);
```

HuddleLamp JavaScript API



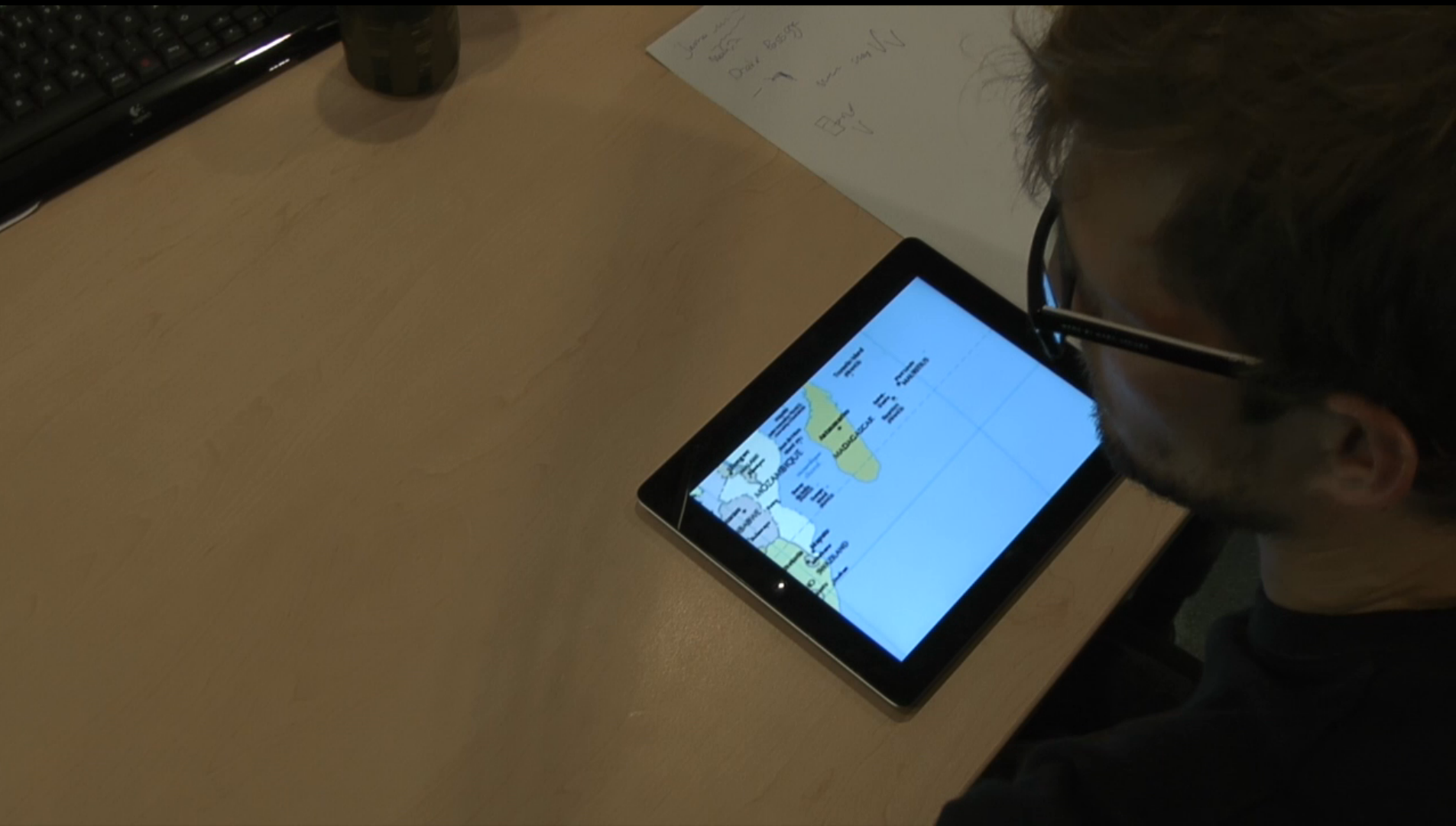
Join the Huddle



Hut Hut Hut!









Proxemic interaction

imagines a world of devices that have

fine-grained knowledge of nearby

people and other devices

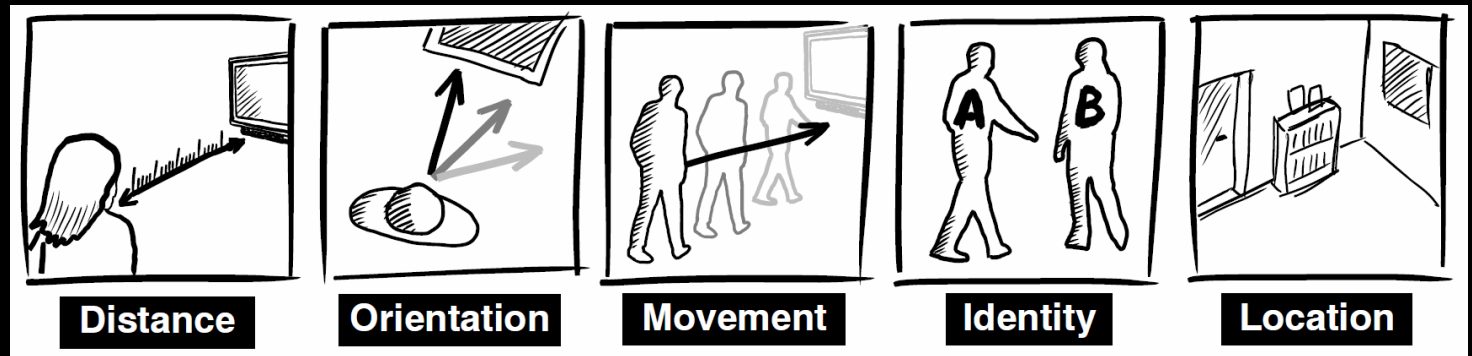
and how such knowledge can be

exploited in ubicomp

interaction design.

**Towards proxemic-aware
ubicomp ecologies?**

Other dimensions that matter?



Only for design of new devices
and interaction techniques?

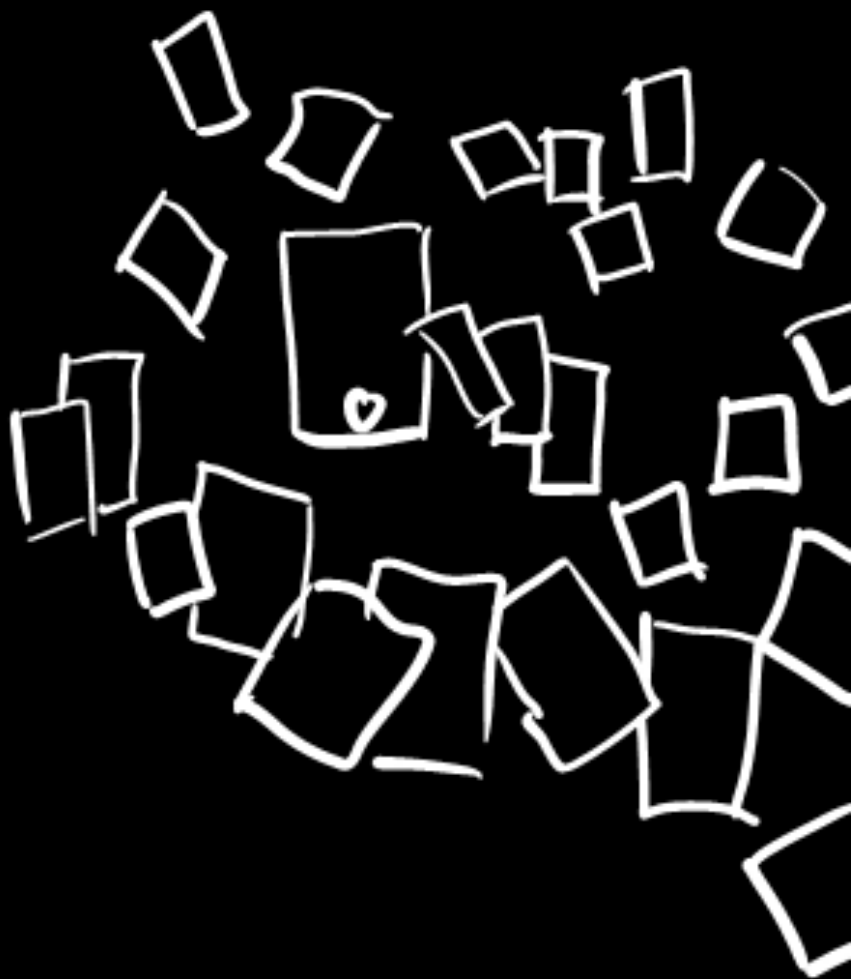
Only for design of new devices
and interaction techniques?

Proxemic Interactions vs.
Interaction Proxemics





VS.



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Greenberg, S., Marquardt, N., Ballendat, T., Diaz-Marino, R. and Wang, M. (2011) Proxemic Interactions: The New Ubicomp? In ACM interactions, 18(1):42-50. ACM, January-February. Invited cover story.

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Proxemic Interactions

From Theory to Practice

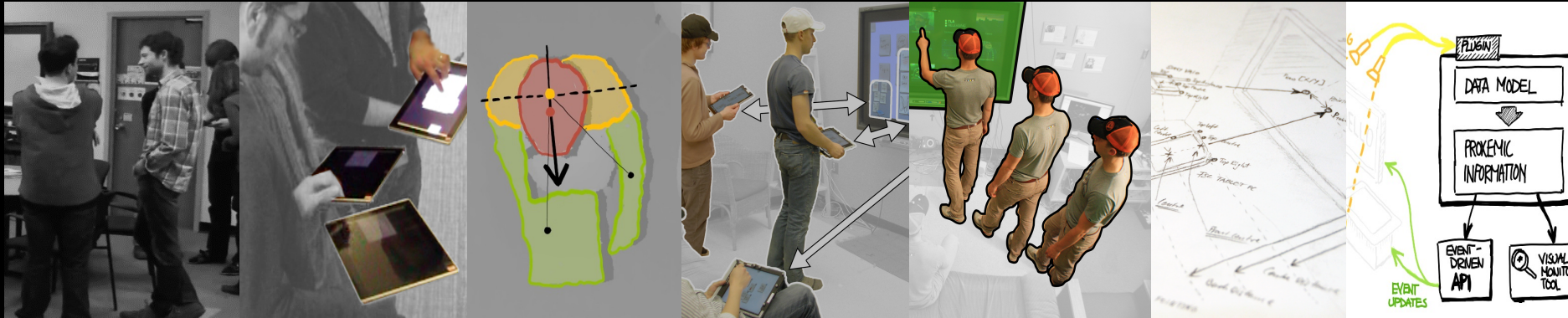
Nicolai Marquardt
Saul Greenberg

*SYNTHESIS LECTURES ON
HUMAN-CENTERED INFORMATICS*

John M. Carroll, *Series Editor*



Microsoft®
Research



Towards Ad-hoc Collaboration Spaces with Cross-Device Interaction Techniques

Nicolai Marquardt
University College London
Invited talk at University of St Andrews