Sasha Jovicic Naomi Friedlander Demetri Terzopoulos
Caroline Houle Jacobo Bibliowicz Marta Wnuczko
Radek Grzeszczuk Jeremy Cooperstock Aaron Uthayagumaran
Cathy Jansen Kevin Forbes Seok-Hyung Bae Syed Rizwan Gilani
Cloud Shao Martin de Lasa Gotham Palaniappan Huixuan Tang
Azam Khan Didier Badouel Candice Lin Nancy Iskander
Vikas Jain James Stewart Seyong Ha Michael Glueck
David Hill Pierre Bénard Sean Sutherland Varun Perumal C
Sherif Ghali Richard Brath
Thomas Diamantis Gerard Baron
Rabia Aslam
John Amanatides
Wael Aboelsaadat
Spencer Beacock Velian Pandeliev Wilson Huang
Rhys Causey Sean Doughty Liviu-Mihai Calin Xuan Dam
Diba Bot Ying Han Rorik Henrikson Ryan Schmidt
David Abrams Nicole Sultanum Fanny Chevalier
Alexis Angelidis
Patrick Coleman Ravin Balakrishnan
Aakar Gupta Daniel Wigdor
Haijun Xia
Brain To Chris Landreth
Andy Chow Bruno De Araujo
Pif Edwards Annette Mayer
Chris De Paoli Steve Tsourounis
Xia Liu Pan Zhang Mazen Al Borno
Zhicong Lu Peter Hamilton
Janis Libeks Mark Sheinin Noah Lockwood
Jian Zhao Alecia Fowler Samuel Boivin
Gene Golovchinksy Parsa Mirdehghan
Beverly Harrison Leslie Mezei Issey Roquet
George Fitzmaurice Marilyn Mantei
Tovi Grossman Matthew Carroll
Dustin Freeman
John Zhou

Marge Coahran Richard Guy
Michiel van de Panne Gary Hardock
Alina Gvozdik Anand Agarawala Kent Fenwick
Yusheng Wu Alain Fournier Tyler De Witt
Qiuying Xu Jiang Yue Gerry Chu
Zhen Li Vicky Bilbily John Buchanan Jia Sheng
Mian Wei Ken Xu Andrew Tan Nikola Banovic
Jonathan Deber Garry Ing Rachel Franz Meng Lei Maria Raso
Hubert Hu Robert Kevin Gibson Tom Bellman Mark Green Ricardo Jota
Jos Stam Tom Nadas Michelle Annett Chris Arnold William Hunt
Marie-Claire Forgue Hanieh Bastani Sam Hasinoff
Brad Myers Norman Badler Todd Goodwin
Karan Singh Michael Chen Joe Laszlo
David Levin Jason Chang Justin Ho
Alec Jacobson Xiang Cao Ralph Hill
Ron Baecker George Drettakis
Eugene Fiume Cosmin Munteanu Nick Kim
Kyros Kutulakos Zhijun Ding
Khai Truong Mags Ngo Aaron Hertzmann Patrick Dubroy
Clifton Forlines Alex Tessier Xiaojun Bi Petros Faloutsos
Jin Li Rhona Charron Luiz Velho
John Hancock Rahul Arora Iva Lu Tristan Campbell
Jaisie Sin Rinat Abdrashitov Mira Rawady Brodie Champion
Christian Beermann Michael Tao Anastasia Bezerianos Tira Cohene Mohit Jain
Yichen Dang Matthew O'Toole Gery Casiez Sangah Han T. De Weese Alison Lee
Anuruddha Hettiarachchi Bill Buxton David Dearman
Yupeng Zhang Parastoo Abtahi Jeremy Birnholtz Chris Gonterman
Mingming Fan mc schraefel Rajat Dhariwal Hiroshi Ishii
Alejo Hausner Jessica David Edy Garfinkiel
Simon Breslav George ElKoura Anna Lipka
Pierre Dragicevic
Liang Chen Anuj Gujar
Michawl Daum Hong Qin
David Fono
John Funge

Dynamic Graphics Project
EST. 1967
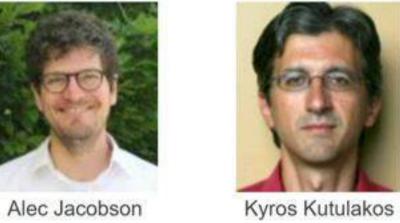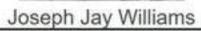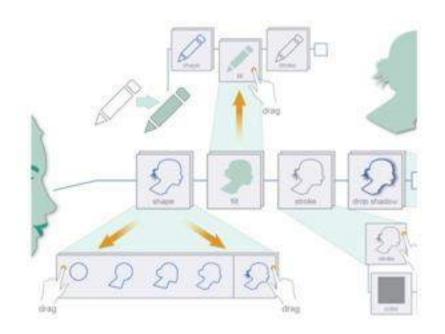
Ishtiaque Ahmed

Ron Baecker

Ravin Balakrishnan

Fanny Chevalier

Eugene Fiume

Tovi Grossman

Alec Jacobson

Kyros Kutulakos

David Levin

Cosmin Munteanu

Karan Singh

Khai Truong

Daniel Wigdor

Joseph Jay Williams

Post-WIMP UX

Symphony of Devices

Digital Fab

Immersive Haptics

Zero Latency UI
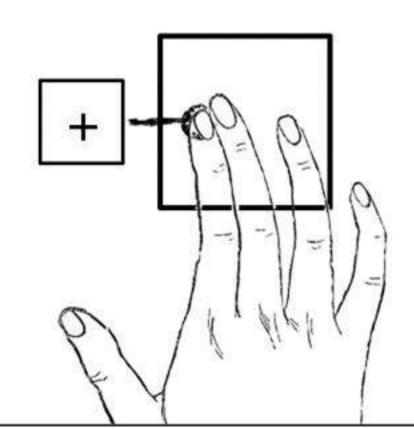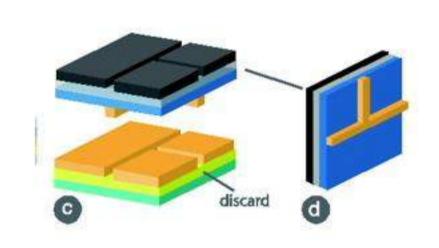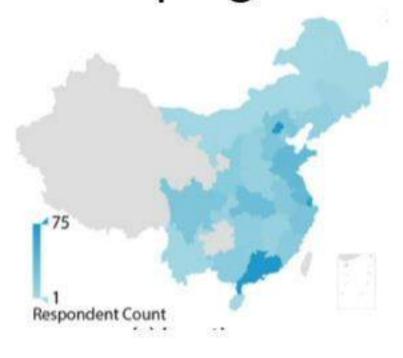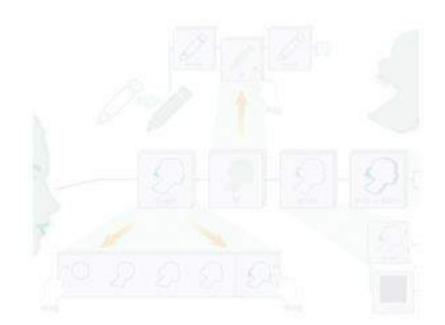
Developing Nations

Post-WIMP UX
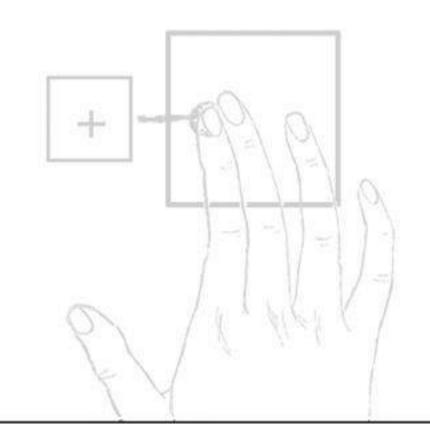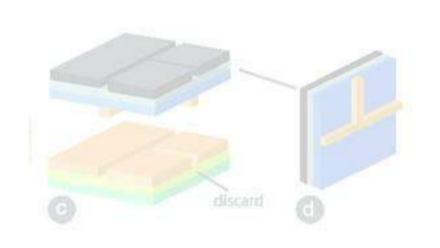
Symphony of Devices

Digital Fab

Immersive Haptics

Zero Latency UI

Developing Nations

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HoloDoc: Enabling Mixed Reality Workspaces that Harness Physical and Digital Content

Zhen Li, Michelle Annett, Ken Hinckley, Karan Singh, Daniel Wigdor. 2019. HoloDoc: Enabling Mixed Reality Workspaces that Harness Physical and Digital Content. Conditionally accepted for *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems* (CHI '19). ACM, New York, NY, USA.

SMAC: A Simplified Model of Attention and Capture in Multi-Device Desk-Centric Environments

Zhen Li, Michelle Annett, Ken Hinckley, Daniel Wigdor. 2019 (in press). SMAC: A Simplified Model of Attention and Capture in Multi-Device Desk-Centric Environments. To appear in *Proc. ACM Hum.-Comput. Interact.* 3, EICS. (to be Presented at EICS 2019).

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Perumal Varun Chadalavada, Goutham Palaniappan, Vimal Kumar Chandran, Khai Truong, and Daniel Wigdor. 2018. ID'em: Inductive Sensing for Embedding and Extracting Information in Robust Materials. *Proc. ACM Interact. Mob. Wearable Ubiquitous Technol.* 2, 3, Article 97 (September 2018), 28 pages. Presented at UBICOMP 2018.

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Michelle Annett, Matthew Lakier, Franklin Li, Daniel Wigdor, Tovi Grossman, and George Fitzmaurice. 2016. The Living Room: Exploring the Haunted and Paranormal to Transform Design and Interaction. In *Proceedings of the 2016 ACM Conference on Designing Interactive Systems* (DIS '16). ACM, New York, NY, USA, 1328-1340.

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Fraser Anderson, Tovi Grossman, Daniel Wigdor, and George Fitzmaurice (2015). Supporting Subtlety with Deceptive Devices and Illusory Interactions. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems* (CHI '15). ACM, New York, NY, USA, 1489-1498.

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Xiang 'Anthony' Chen, Tovi Grossman, Daniel Wigdor, and George Fitzmaurice. 2014. Duet: exploring joint interactions on a smart phone and a smart watch. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '14). ACM, New York, NY, USA, 159-168.

Conductor: Enabling and understanding cross-device interaction

Peter Hamilton and Daniel Wigdor. 2014. Conductor: enabling and understanding cross-device interaction. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '14). ACM, New York, NY, USA, 2773-2782.

Panelrama: Enabling easy specification of cross-device web applications

Jishuo Yang and Daniel Wigdor. 2014. Panelrama: enabling easy specification of cross-device web applications. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '14). ACM, New York, NY, USA, 2783-2792.

A field study of multi-device workflows in distributed workspaces

Stephanie Santosa and Daniel Wigdor. 2013. A field study of multi-device workflows in distributed workspaces. In *Proceedings of the 2013 ACM international joint conference on Pervasive and ubiquitous computing* (UbiComp '13). ACM, New York, NY, USA, 63-72.

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Prof. Karan Singh

Stephanie Santosa

Peter Hamilton

Jishuo Yang

Michelle Annett

Zhen Li

Microsoft

Ken Hinckley

AUTODESK. RESEARCH

George Fitzmaurice

Prof. Tovi Grossman
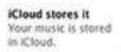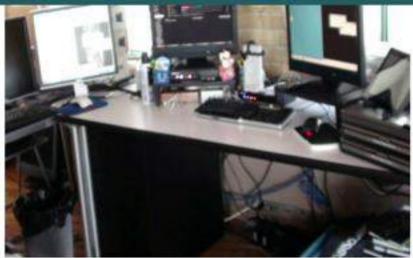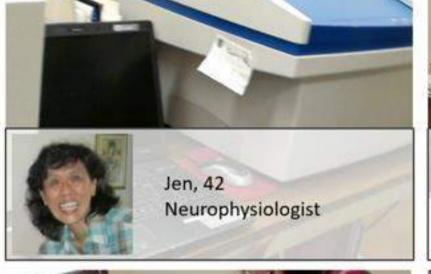
Carnegie Mellon University

Prof. Anthony Chen

2005

Luca Bruno /

in future we will carry not just one but many smart devices

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Towards Symphonies of Devices

Computer Science
UNIVERSITY OF TORONTO

dgp
dynamic graphics project

How can we enable users to dynamically form ad hoc arrangements of devices to suit their current needs?

Buy music
Download music from
iTunes on any device.

iCloud stores it
Your music is stored
in iCloud.

And pushes it to your devices
Your music automatically appears
on your iPad, iPhone, iPod touch,
Mac, and PC.
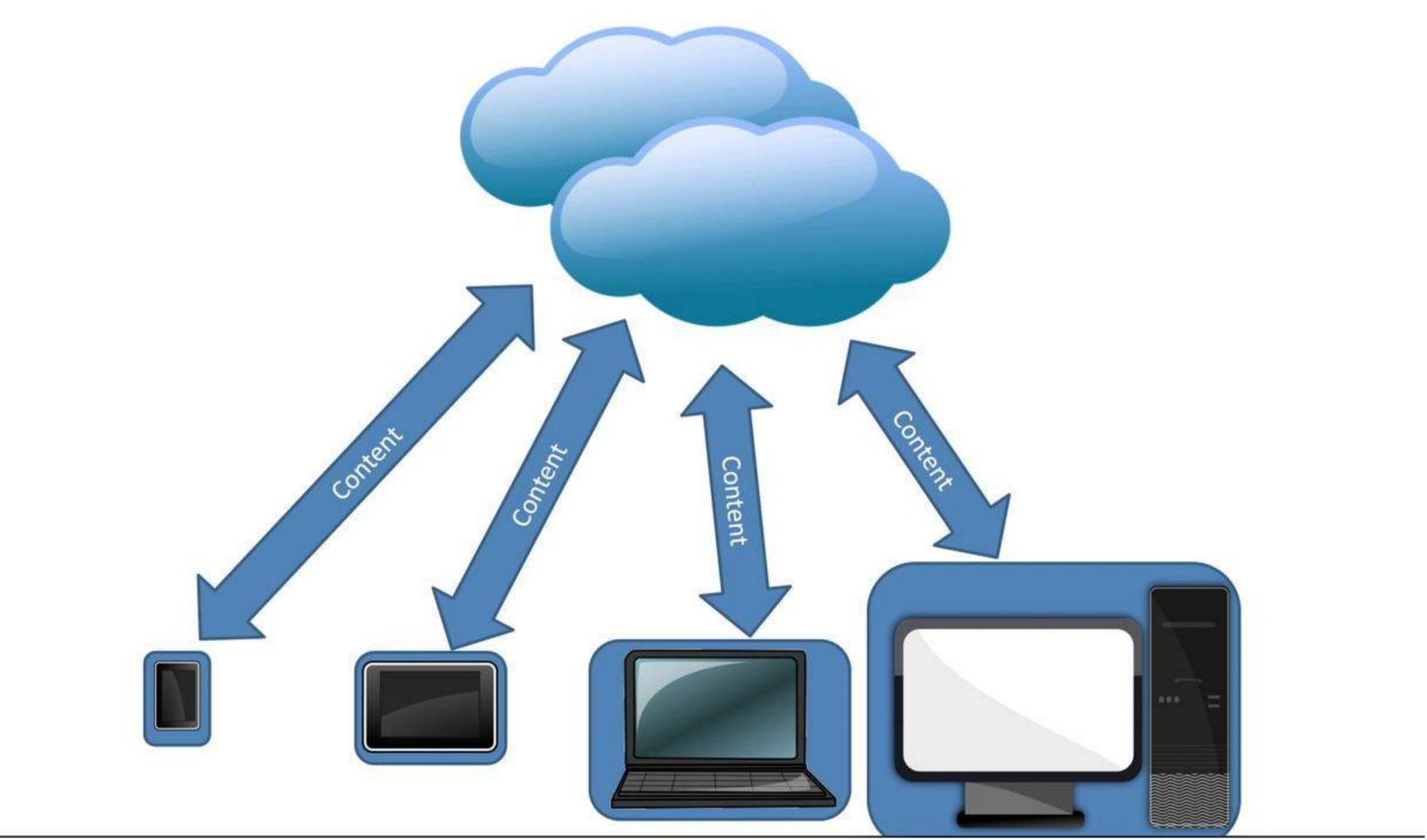
Welcome to SkyDrive
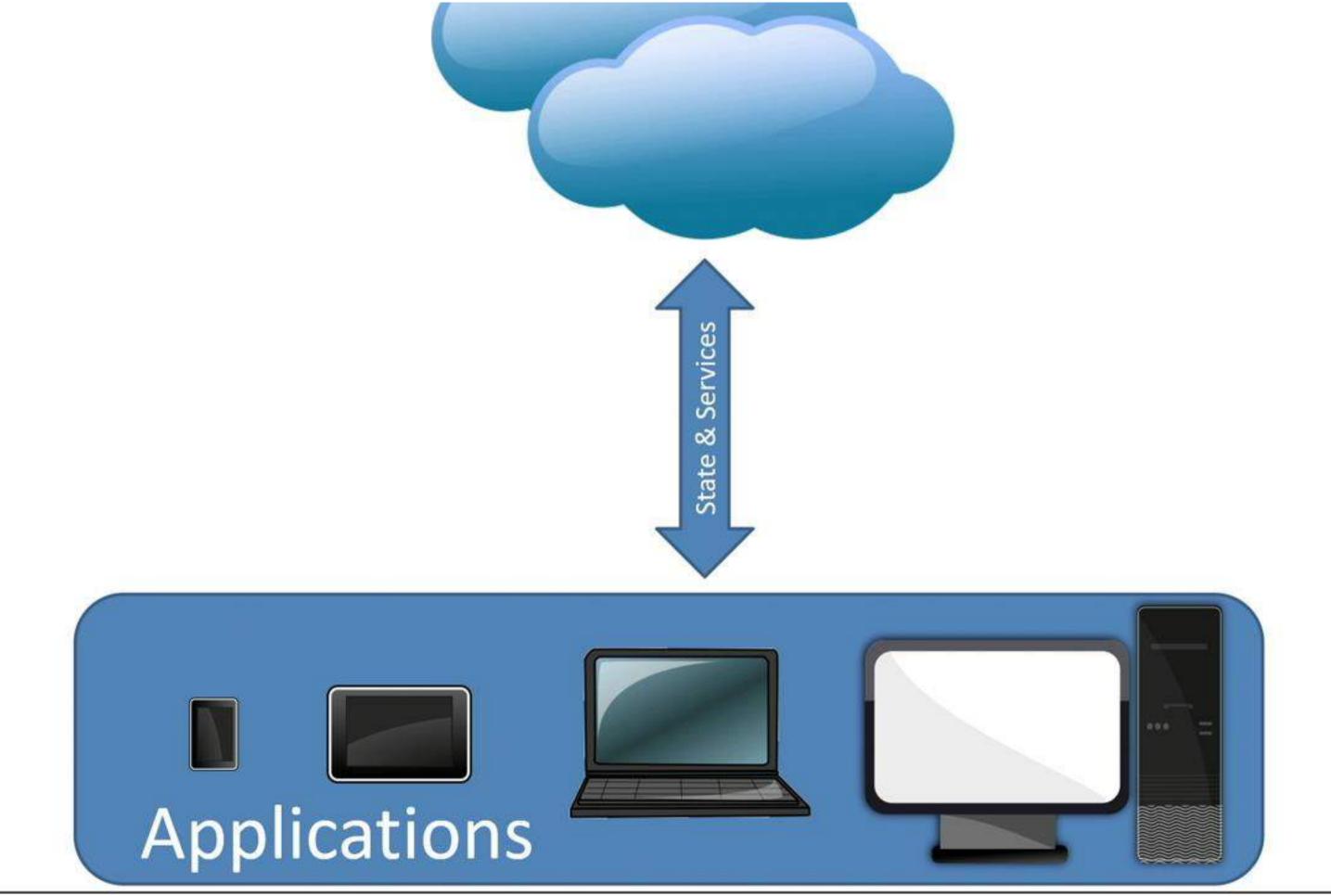
Your most important files are with you wherever you go, on any device.

Kindle
for PC

Kindle for
Android

Kindle for
BlackBerry

Kindle
for iPad

Kindle
for iPhone

Kindle
for Mac

Kindle for
Windows Phone 7

Content
Content
Content
Content

State & Services

Applications

Towards Symphonies of Devices

Computer Science
UNIVERSITY OF TORONTO

dgp
dynamic graphics project
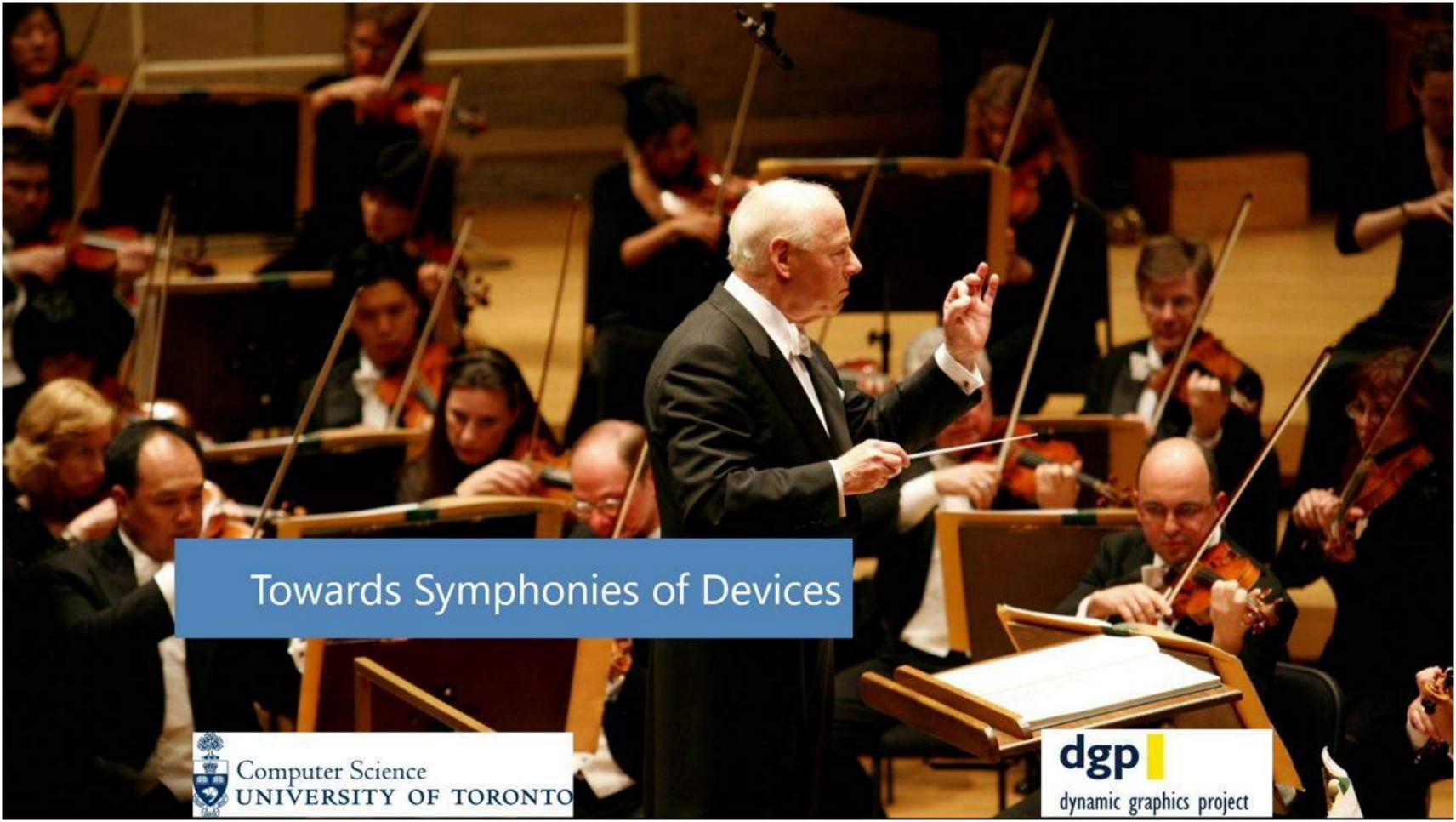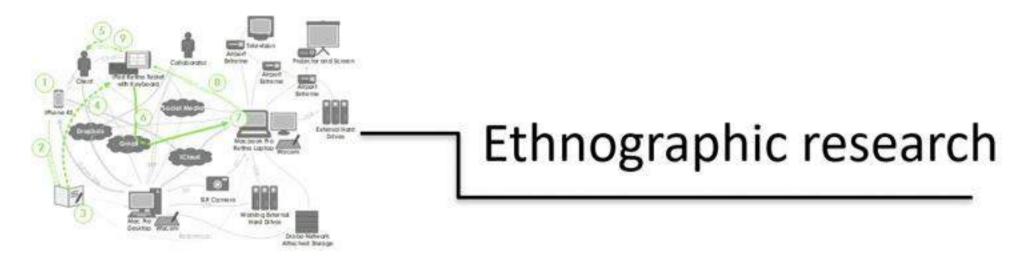
What arrangements of devices provide useful, usable, desirable experiences?

How can content producers target unknown device combinations?

Project Components

Ethnographic research

Interaction design
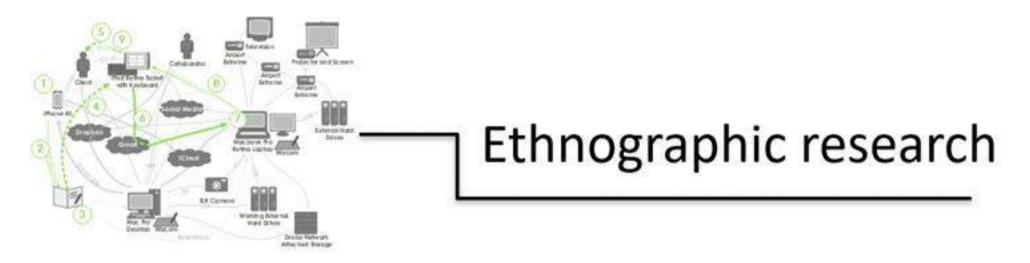
Development tools

Project Components

Ethnographic research

Interaction design

Development tools

A field study of multi-device workflows in distributed workspaces

Stephanie Santosa and Daniel Wigdor. 2013. A field study of multi-device workflows in distributed workspaces. In *Proceedings of the 2013 ACM international joint conference on Pervasive and ubiquitous computing* (UbiComp '13). ACM, New York, NY, USA, 63-72.

The Distributed Workspace

Mike, 38
Motion Designer &
Interior Designer

Jen, 42
Neurophysiologist

Eric, 35
Hospital Pharmacist in
Internal Medicine

Bill, 37
Management Consultant

Elaine, 34
Architect

Glen, 45
Design Consultant

Rick, 34
Illustrator &
Graphic Designer
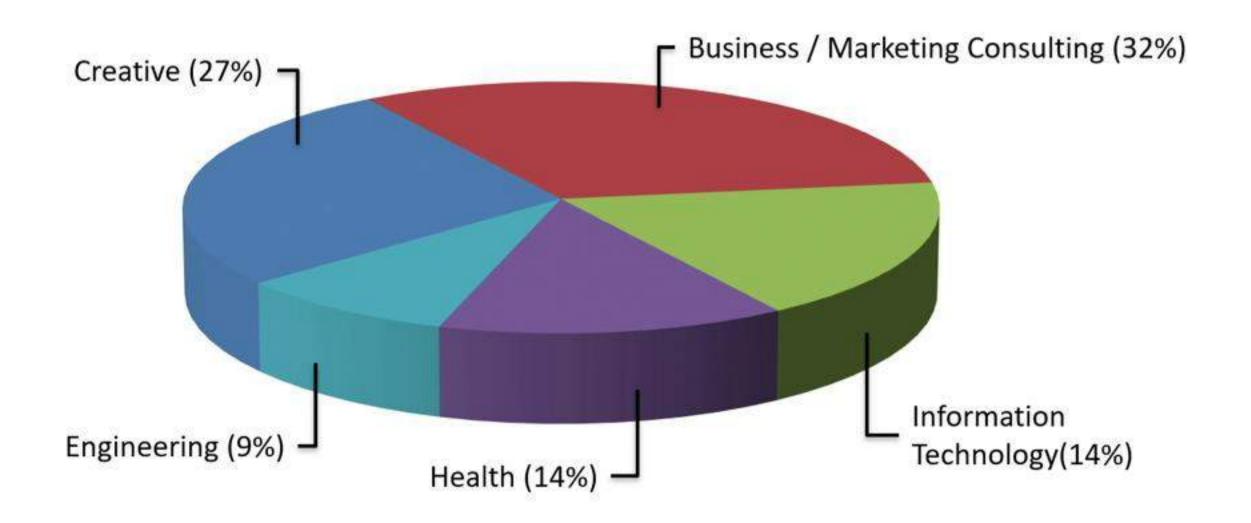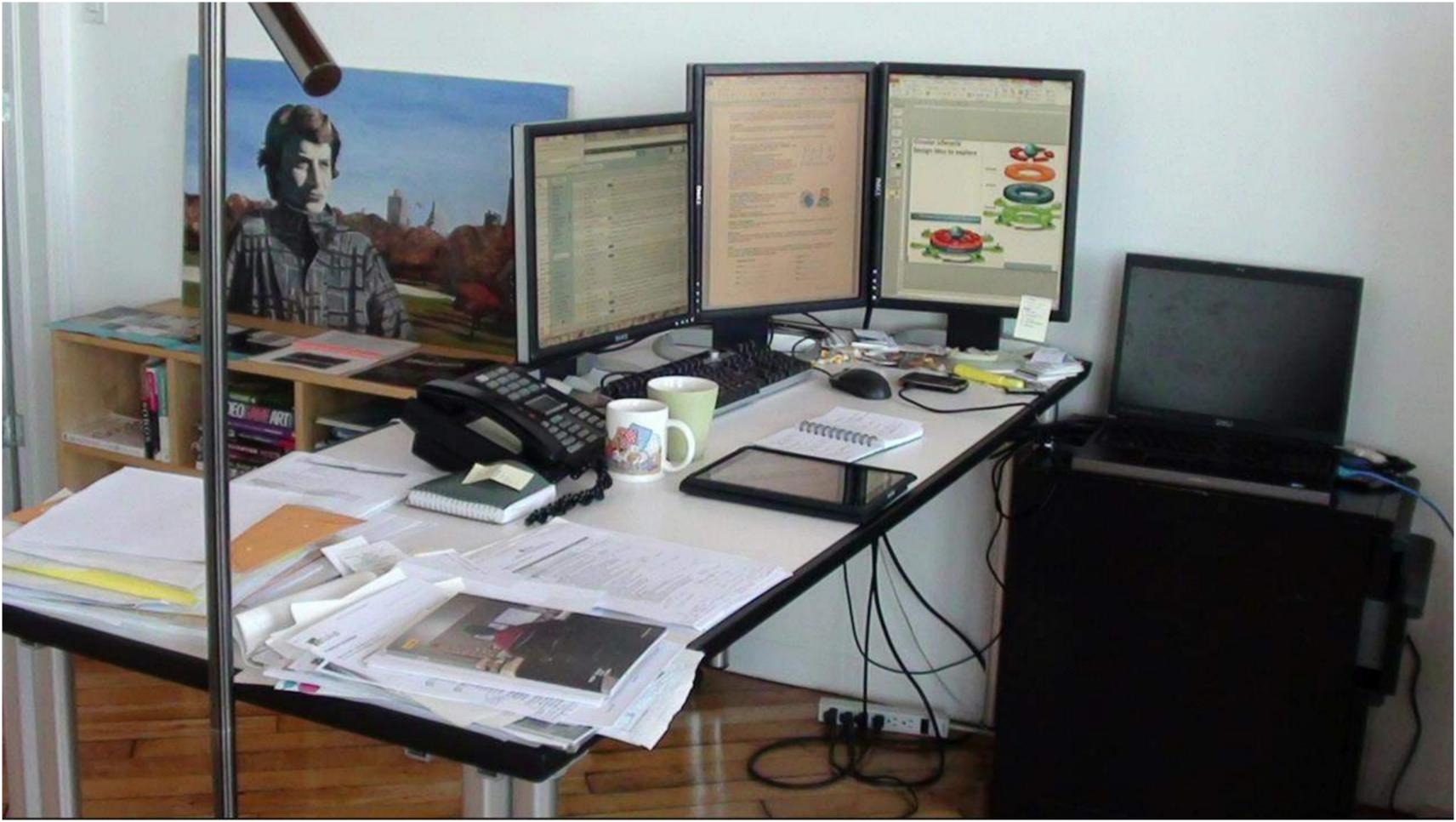
Doug, 32
Geospatial Engineer
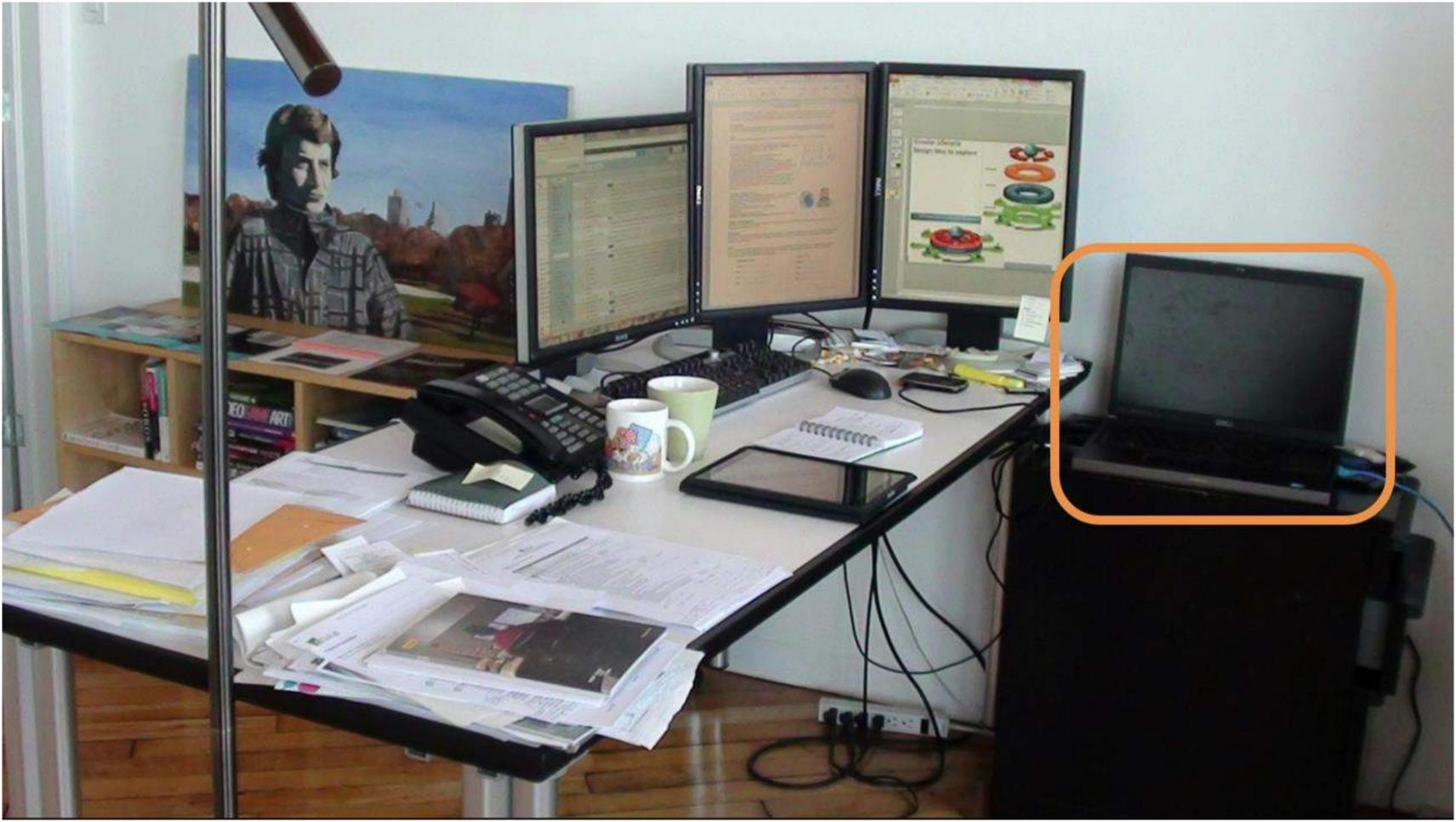
Liz, 36
Marketing Manager
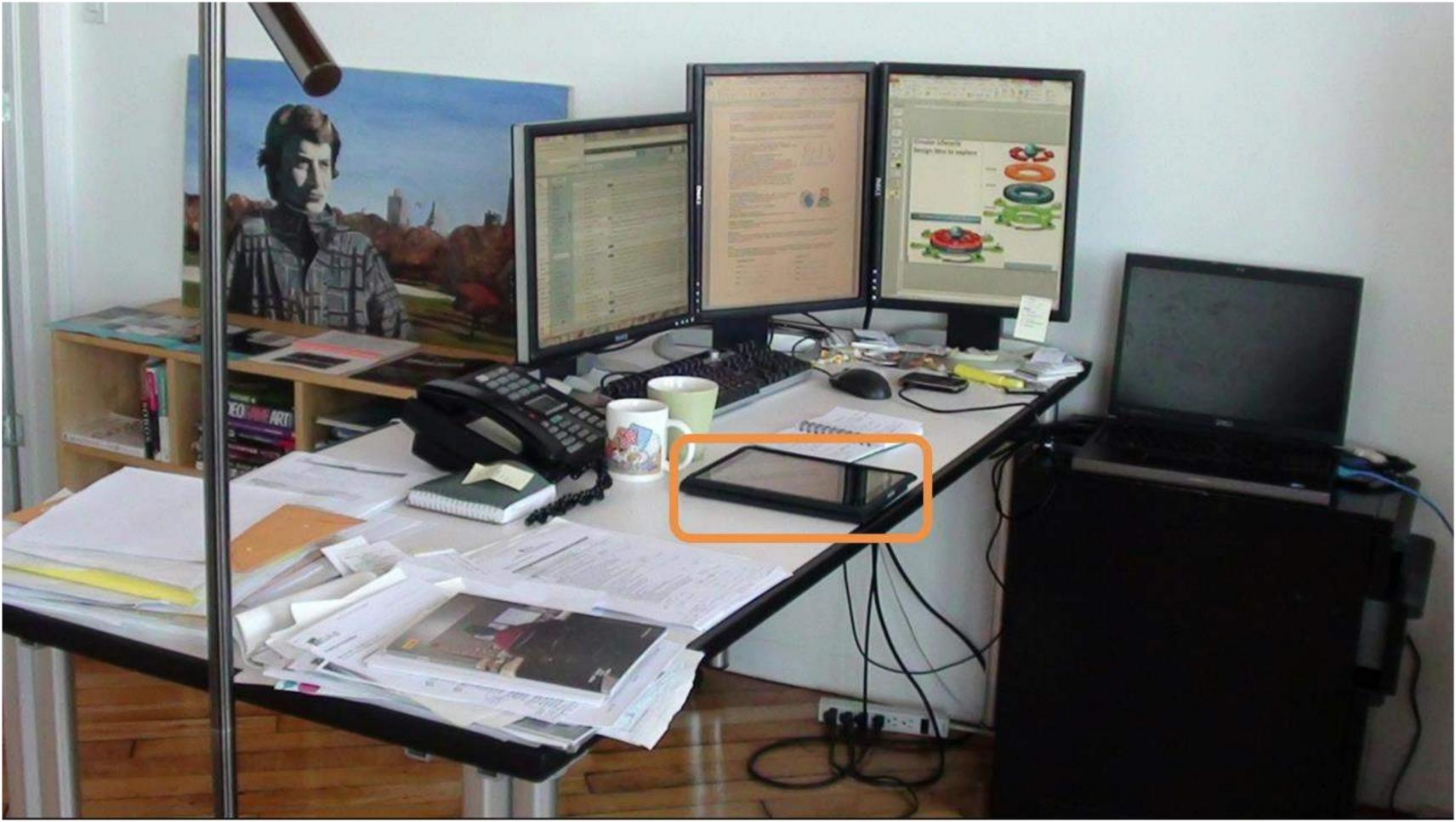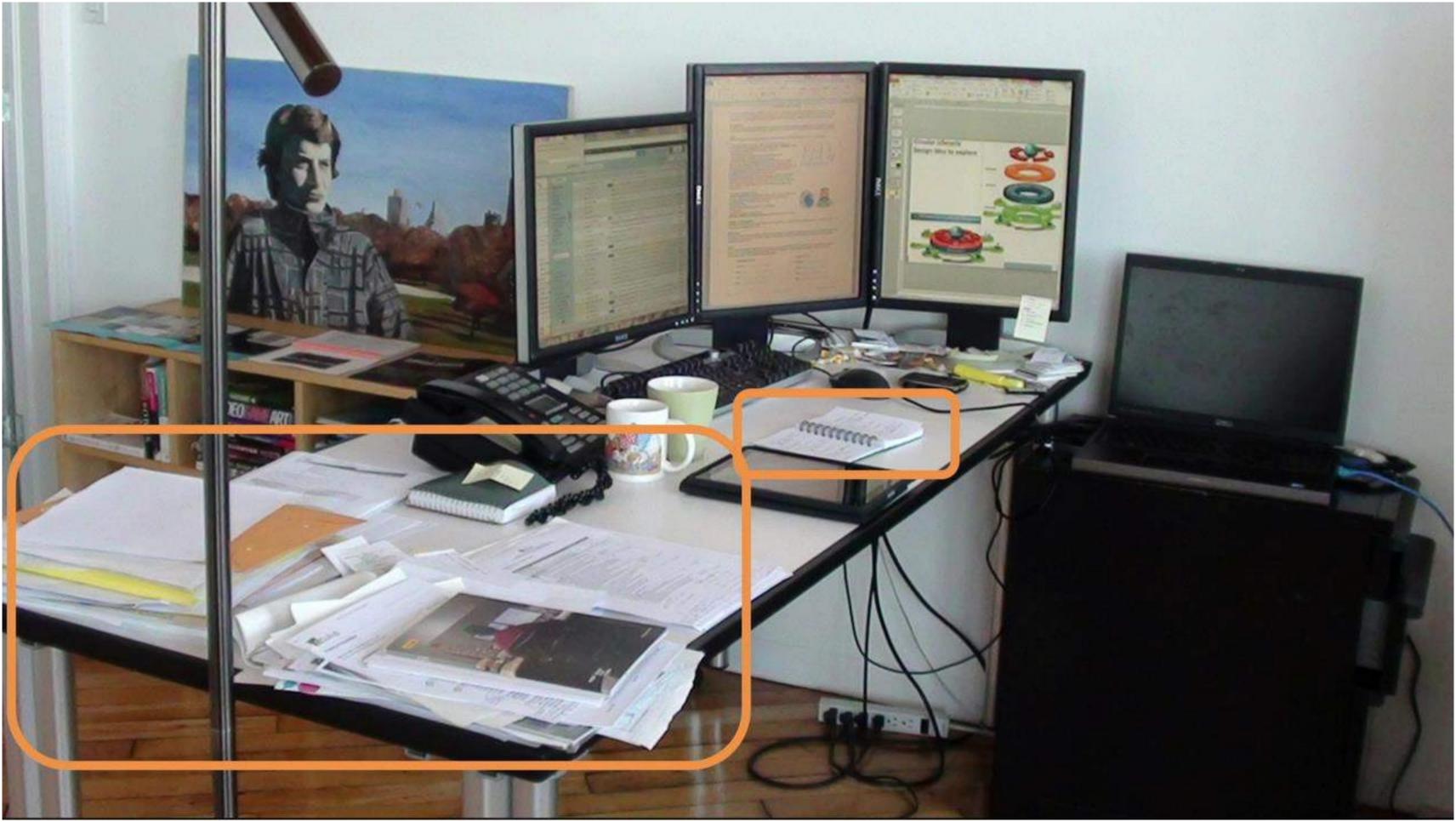
Participants' Industries
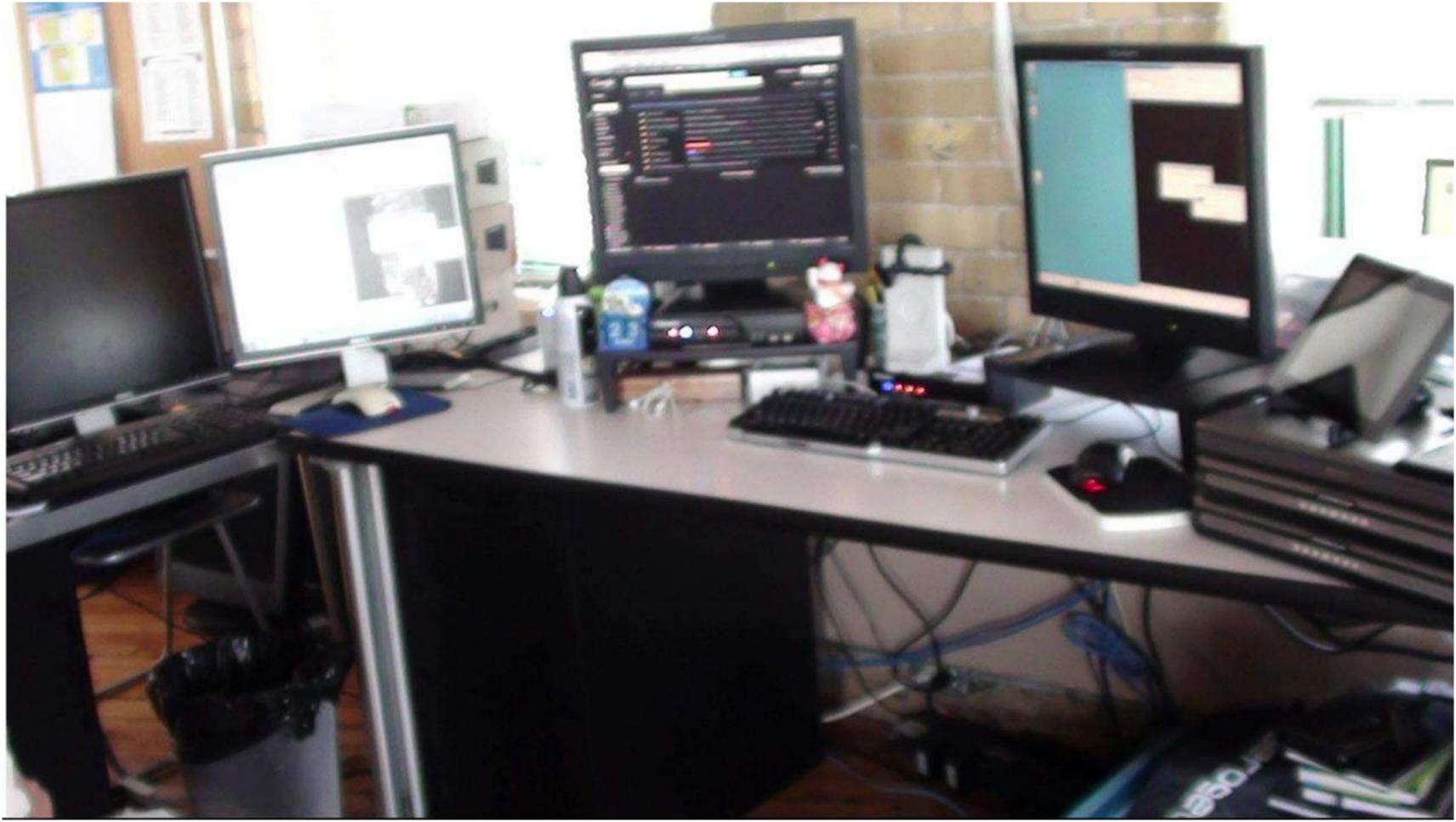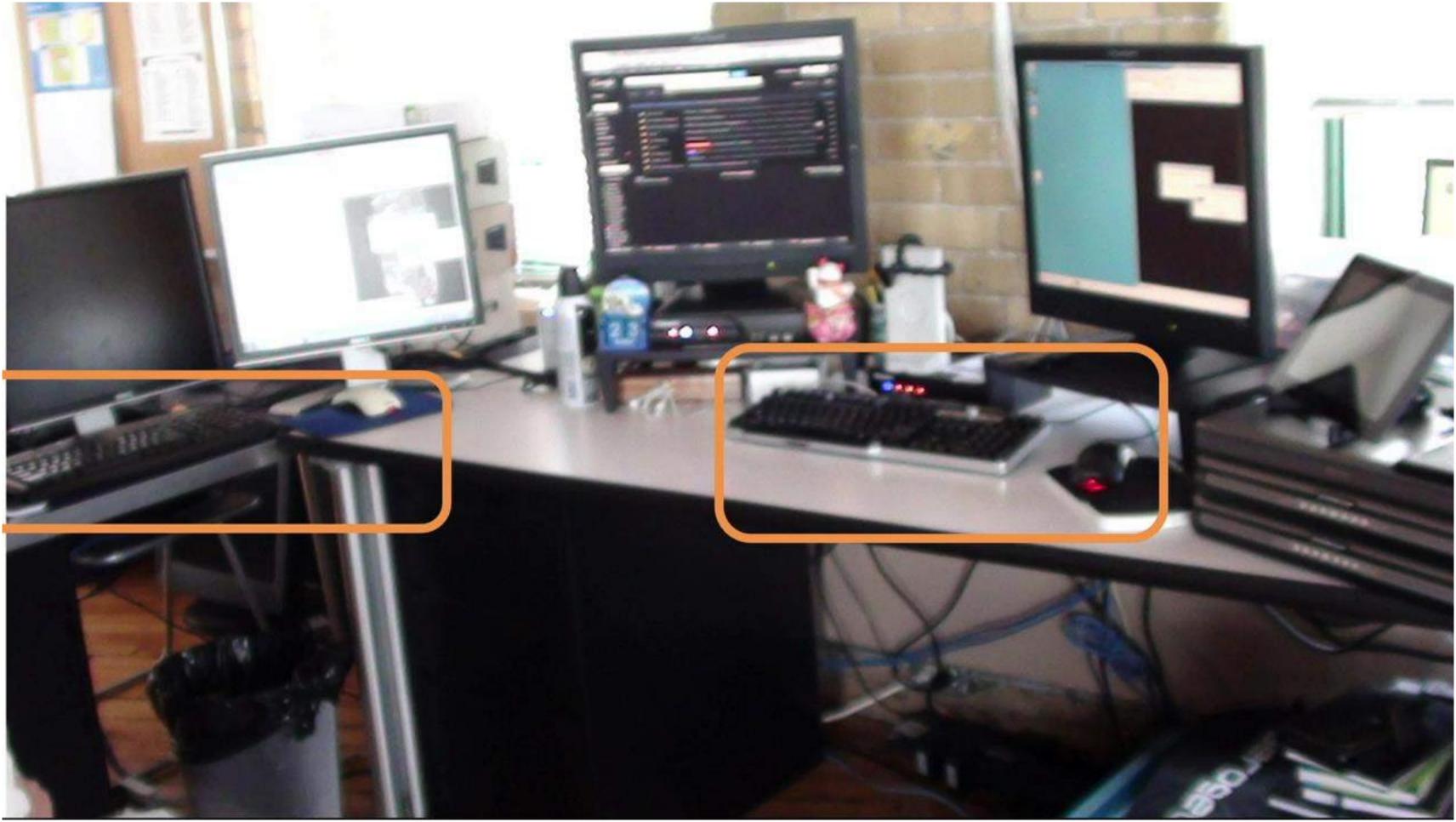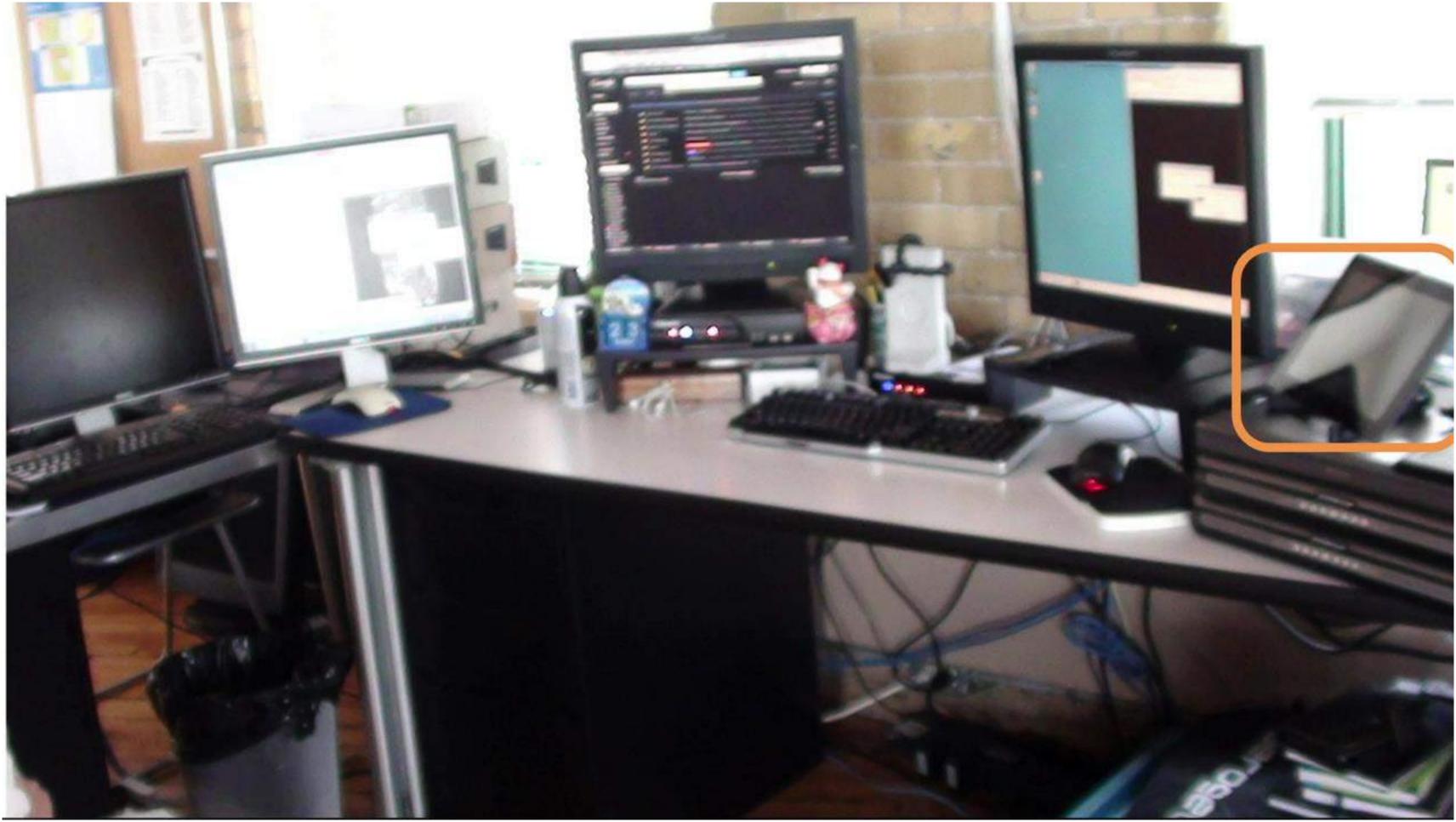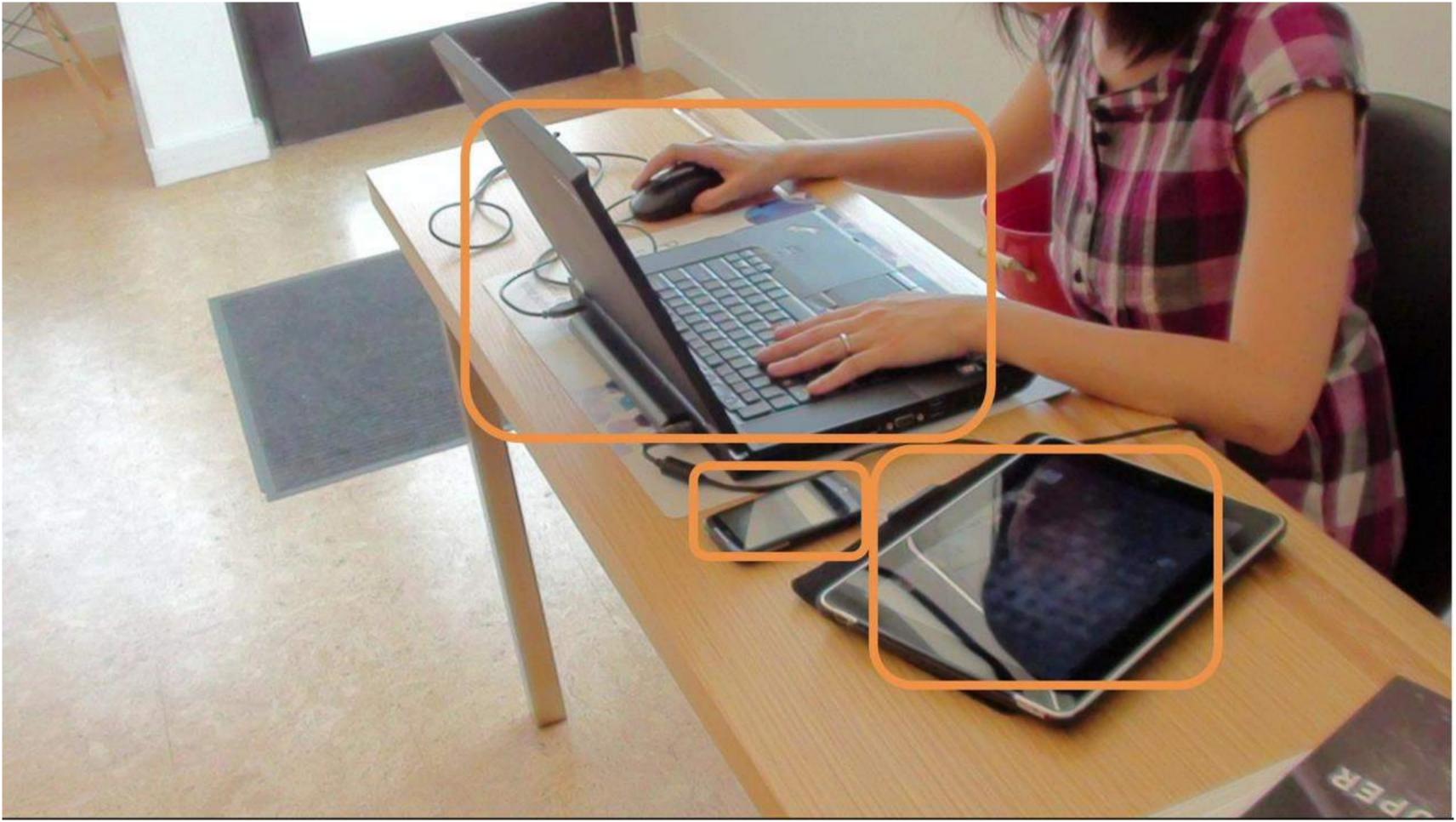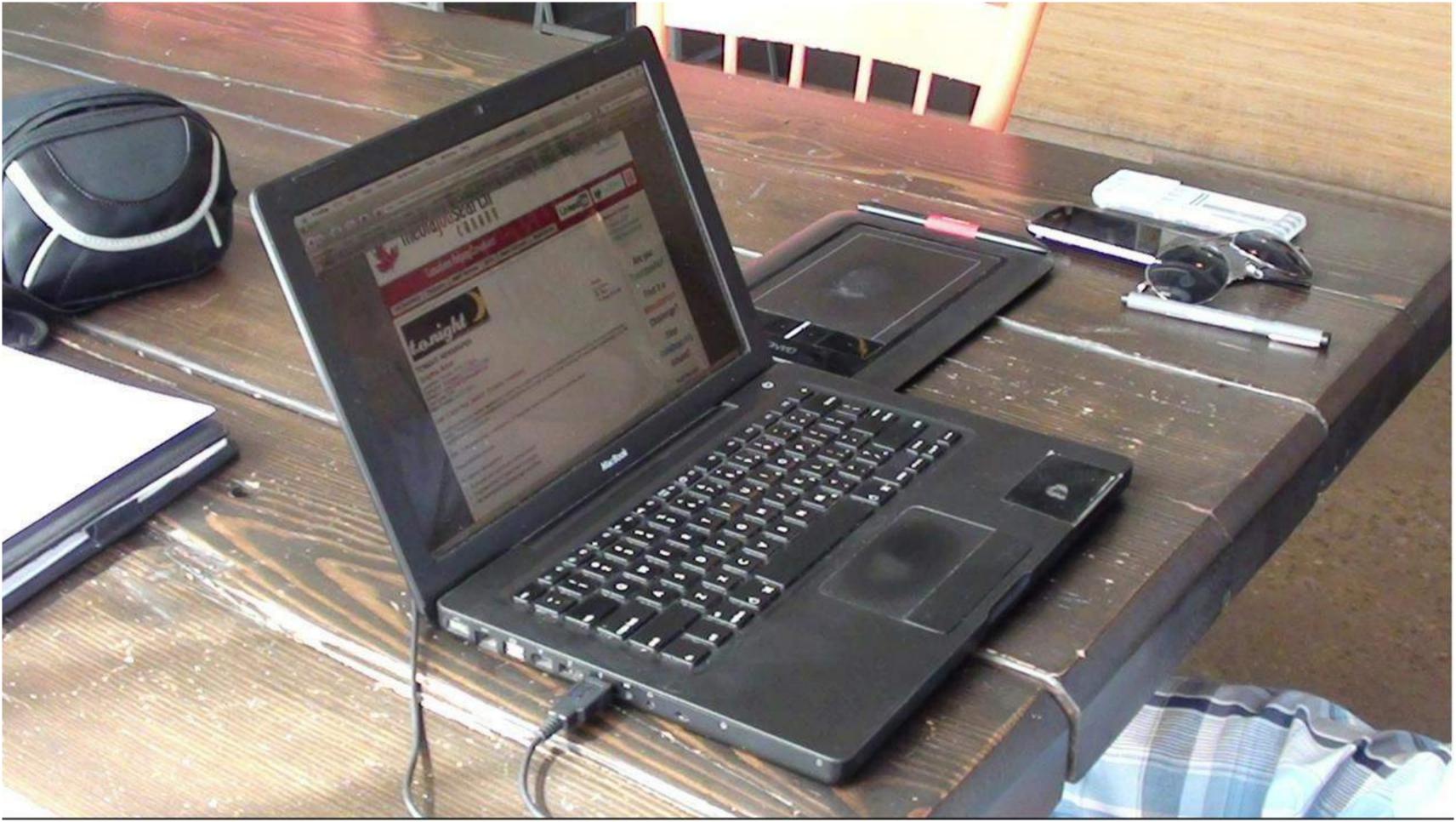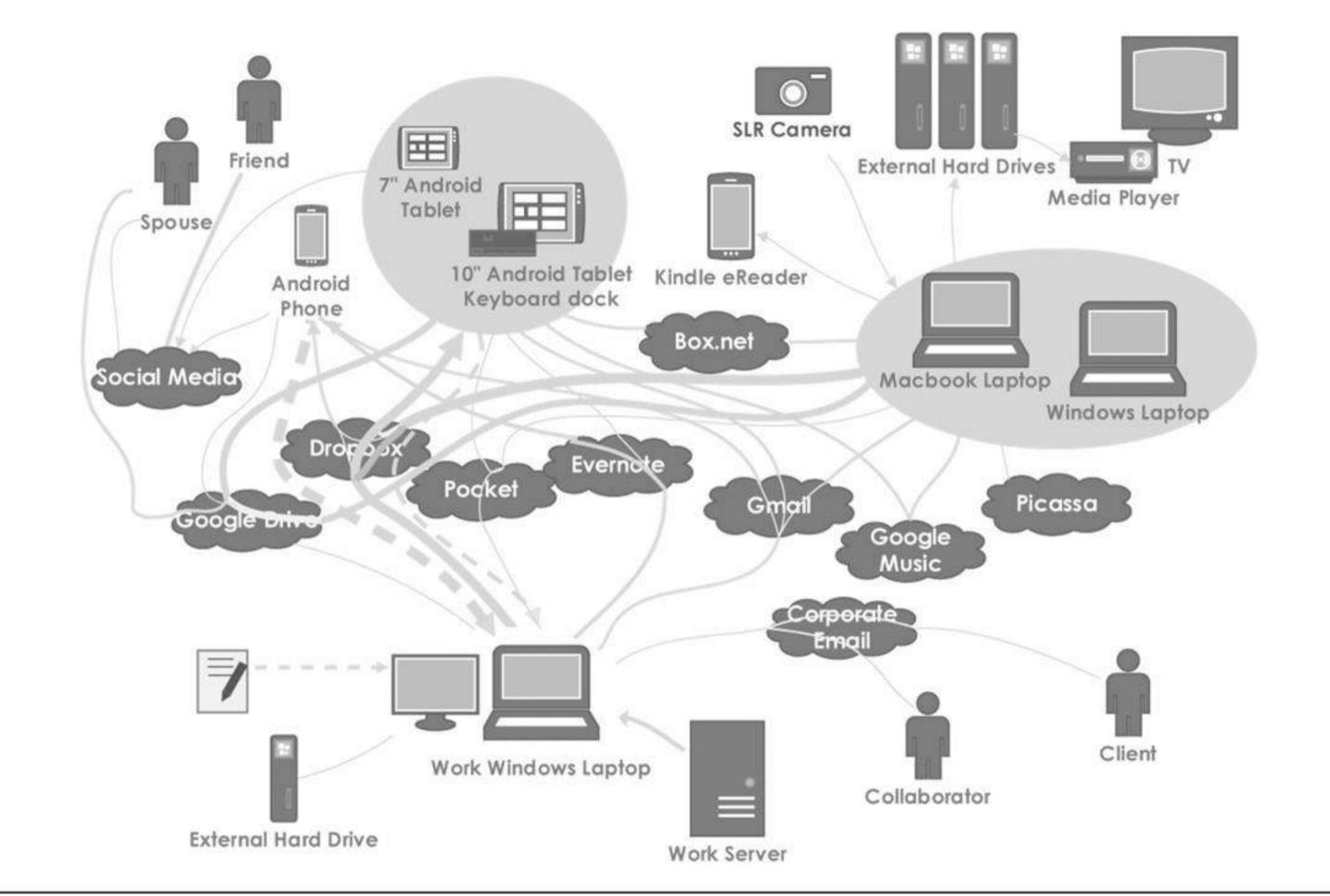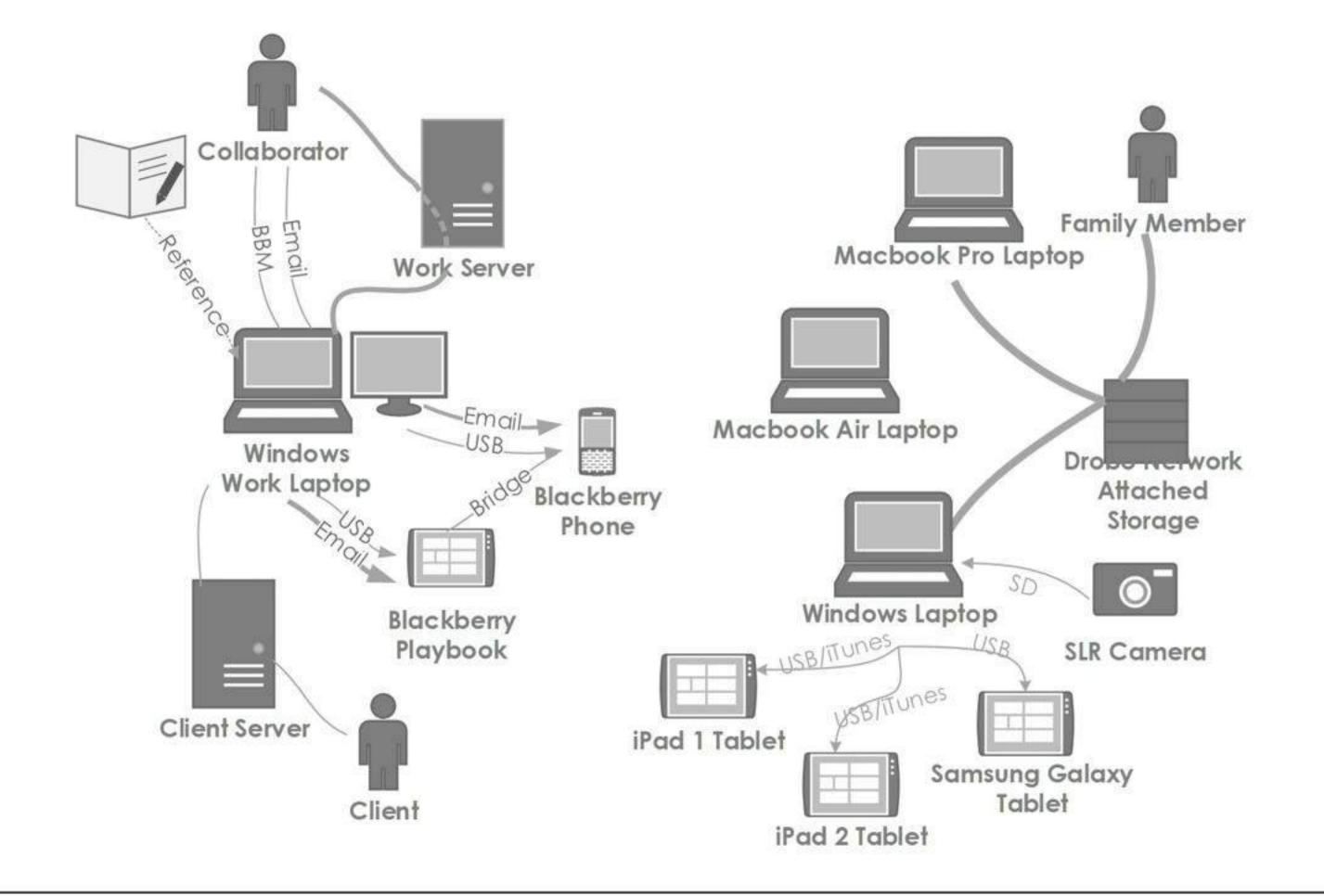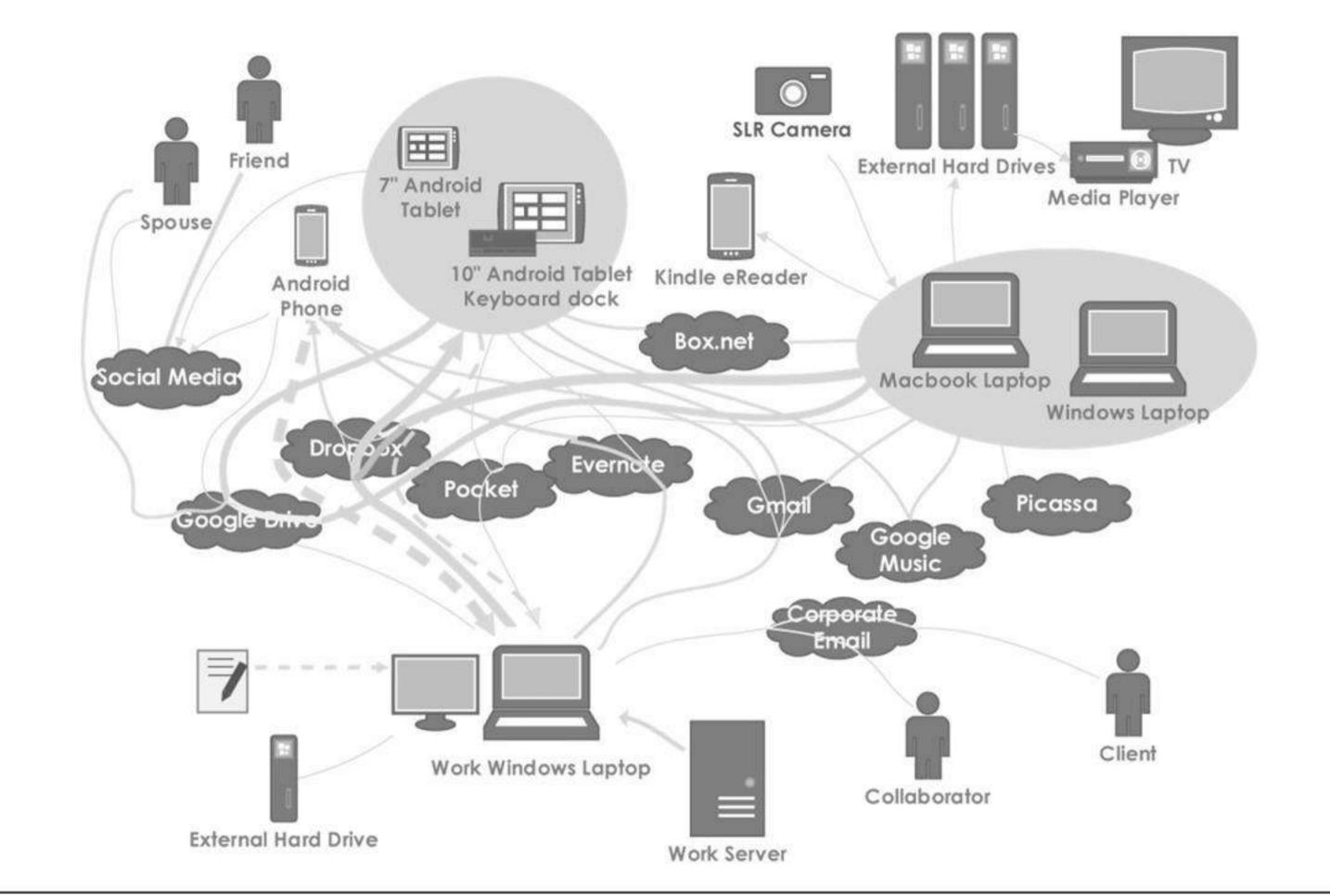
Analysis
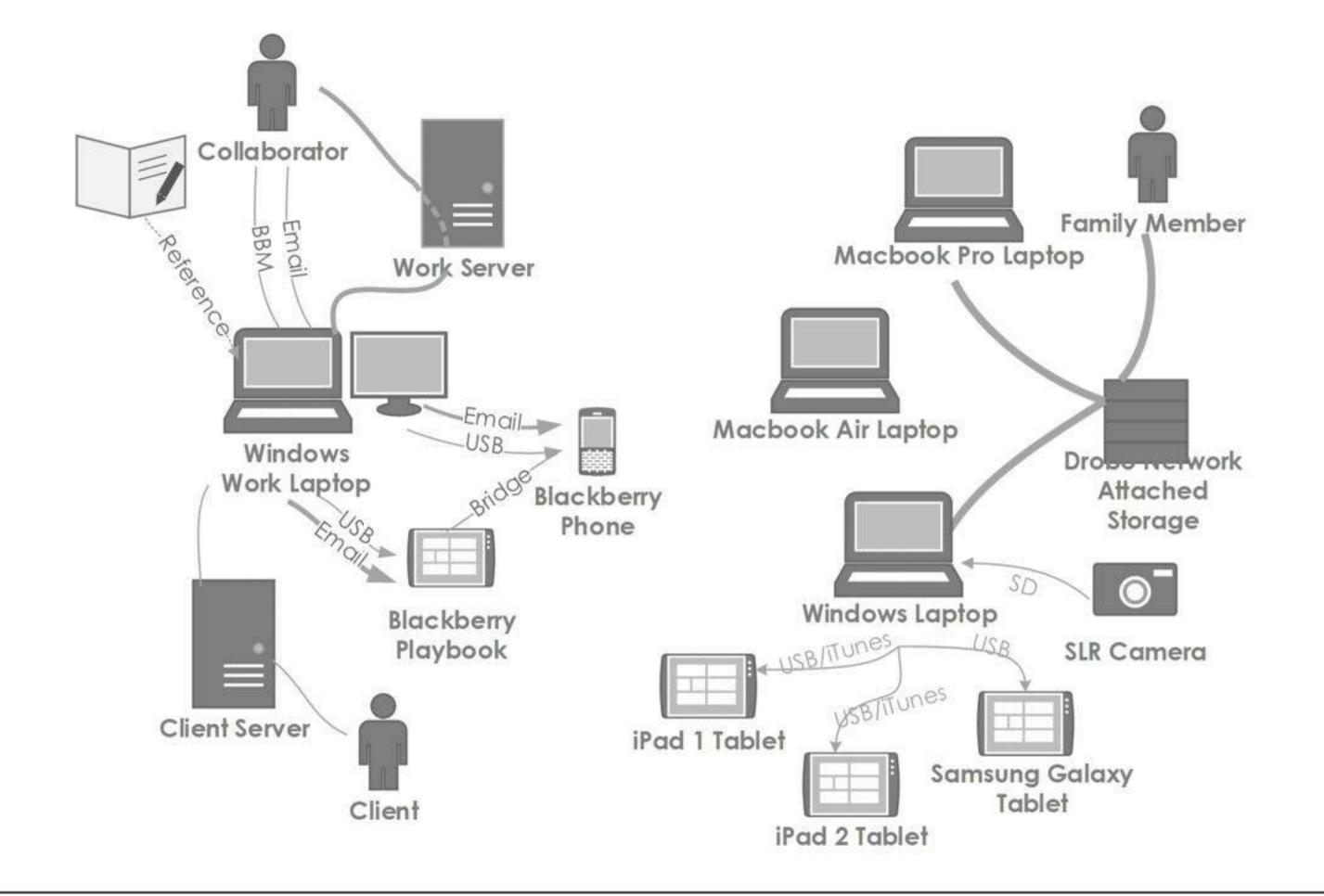
1. Artifact analysis matrix
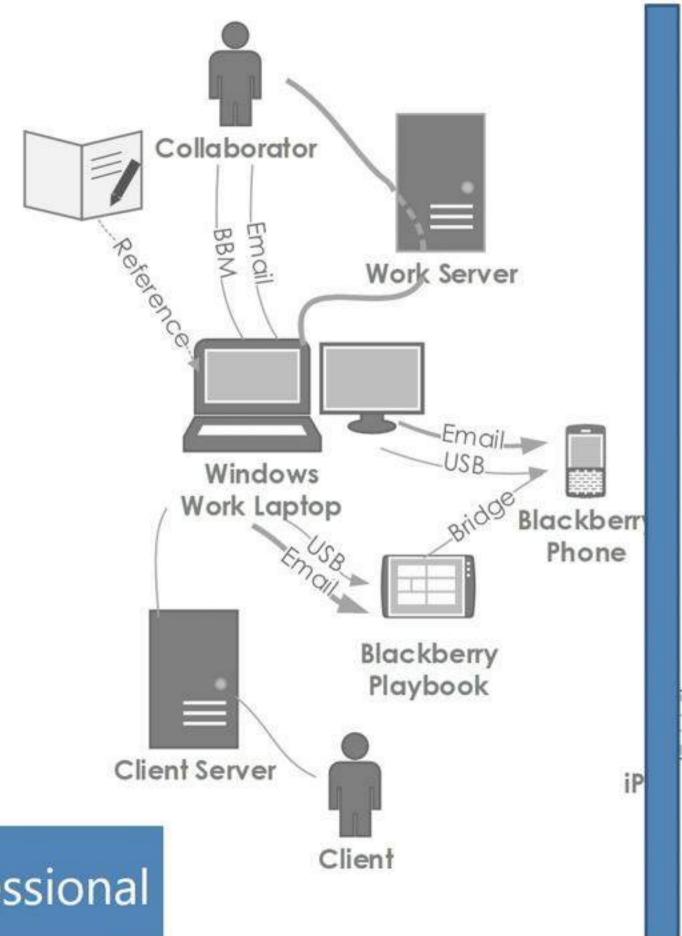
Artifact	Stake-holder (who)	Tasks (what)	Applications (what)	Info transfer out (how)	Info transfer in (how)	Input	Local Info (what + where)	External Info (what + where)	Where	Context of use (when)	Why/Notes	work provided
Laptop (Dell Inspiron, Windows), Work provided	User, Collaborator, Client	Preparing reports, research, data processing, browsing the web, running models	Microsoft Office, Chrome Browser, pdf reader, Engineering modelling software	To tablet/ phone: Dropbox; email or USB to others	From tablet/ phone: Dropbox; USB from others	Mouse, Keyboard	(below)	Current docs temporarily on Dropbox for transfer only (doesn't leave on Dropbox permanently for security)	Work (always), Home (sometimes)	Primary device for work	Content production; production is on the laptop and reading is on the tablet (not much back and forth). The laptop is easier to edit with. Editing applications are better (tablet is too slow). Some docs benefit from more screen space.	yes
Task details	User, Collaborator, Client	Preparing reports	Microsoft Word	To tablet/ phone: Dropbox; email to others	From tablet/ phone: Dropbox; email from others		Documents (e.g. reports)	Docs to be transferred (Dropbox)				
	User	Preparing presentations	Microsoft ppt	To tablet/ phone: Dropbox	From tablet/ phone: Dropbox		Slide presentations	Docs to be transferred (Dropbox)				
	User	Research	Chrome Browser, pdf reader	Pocket, Dropbox			Documents	Docs to be transferred (Dropbox)				
HP Tablet Laptop, personal	User, Family	Creating graphics; occasional streaming of movies/music	Photoshop; VLC, Google Music	Dropbox	Dropbox, USB	Mouse, Keyboard Stylus	Image files	shared files and others on Dropbox and Box.net, Music on	Home	Personal design projects	Stylus input for generating drawings; infrequent usage	no

Spouse

Friend

7" Android Tablet

10" Android Tablet Keyboard dock

Android Phone

SLR Camera

External Hard Drives

TV

Media Player

Kindle eReader

Social Media

Box.net

Macbook Laptop

Windows Laptop

Dropbox

Evernote

Pocket

Gmail

Picassa

Google Drive

Google Music

Corporate Email

External Hard Drive

Work Windows Laptop

Work Server

Collaborator

Client

Collaborator

Work Server

Reference

BBM

Email

Windows
Work Laptop

Email

USB

Bridge

Blackberry
Phone

USB

Email

Blackberry
Playbook

Client Server

Client

Macbook Pro Laptop

Family Member

Macbook Air Laptop

Drobo Network
Attached
Storage

Windows Laptop

SD

SLR Camera

USB/iTunes

USB

iPad 1 Tablet

USB/iTunes

iPad 2 Tablet

Samsung Galaxy
Tablet

Spouse

Friend

Android Phone

7" Android Tablet

10" Android Tablet
Keyboard dock

Kindle eReader

SLR Camera

External Hard Drives

TV

Media Player

Social Media

Box.net

Macbook Laptop

Windows Laptop

Dropbox

Pocket

Evernote

Gmail

Picassa

Google Drive

Google Music

Corporate Email

External Hard Drive

Work Windows Laptop

Work Server

Collaborator

Client

Professional

Collaborator

Work Server

Reference

BBM

Email

Windows Work Laptop

Email

USB

Bridge

Blackberry Phone

USB

Email

Blackberry Playbook

Client Server

Client

Personal

Macbook Pro Laptop

Family Member

Macbook Air Laptop

Drobo Network Attached Storage

Windows Laptop

SD

SLR Camera

USB/iTunes

USB

iP 1 Tablet

USB/iTunes

iPad 2 Tablet

Samsung Galaxy Tablet

Findings

Serial and Parallel Patterns

Specialization of Devices & Tools

Data Fragmentation

Project Components

Ethnographic research

Interaction design

Development tools

Conductor: Enabling and understanding cross-device interaction

Peter Hamilton and Daniel Wigdor. 2014. Conductor: enabling and understanding cross-device interaction. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '14). ACM, New York, NY, USA, 2773-2782.
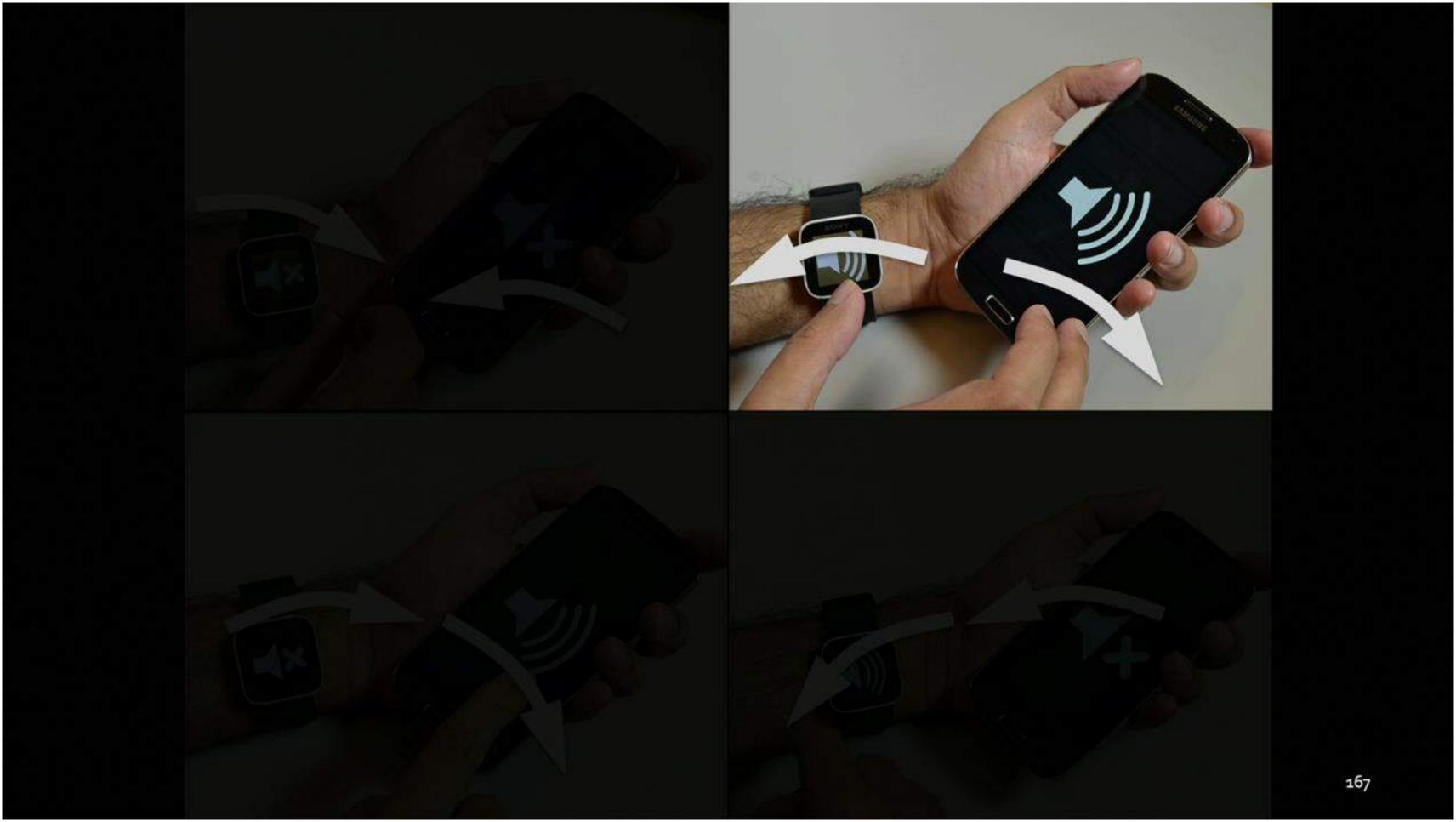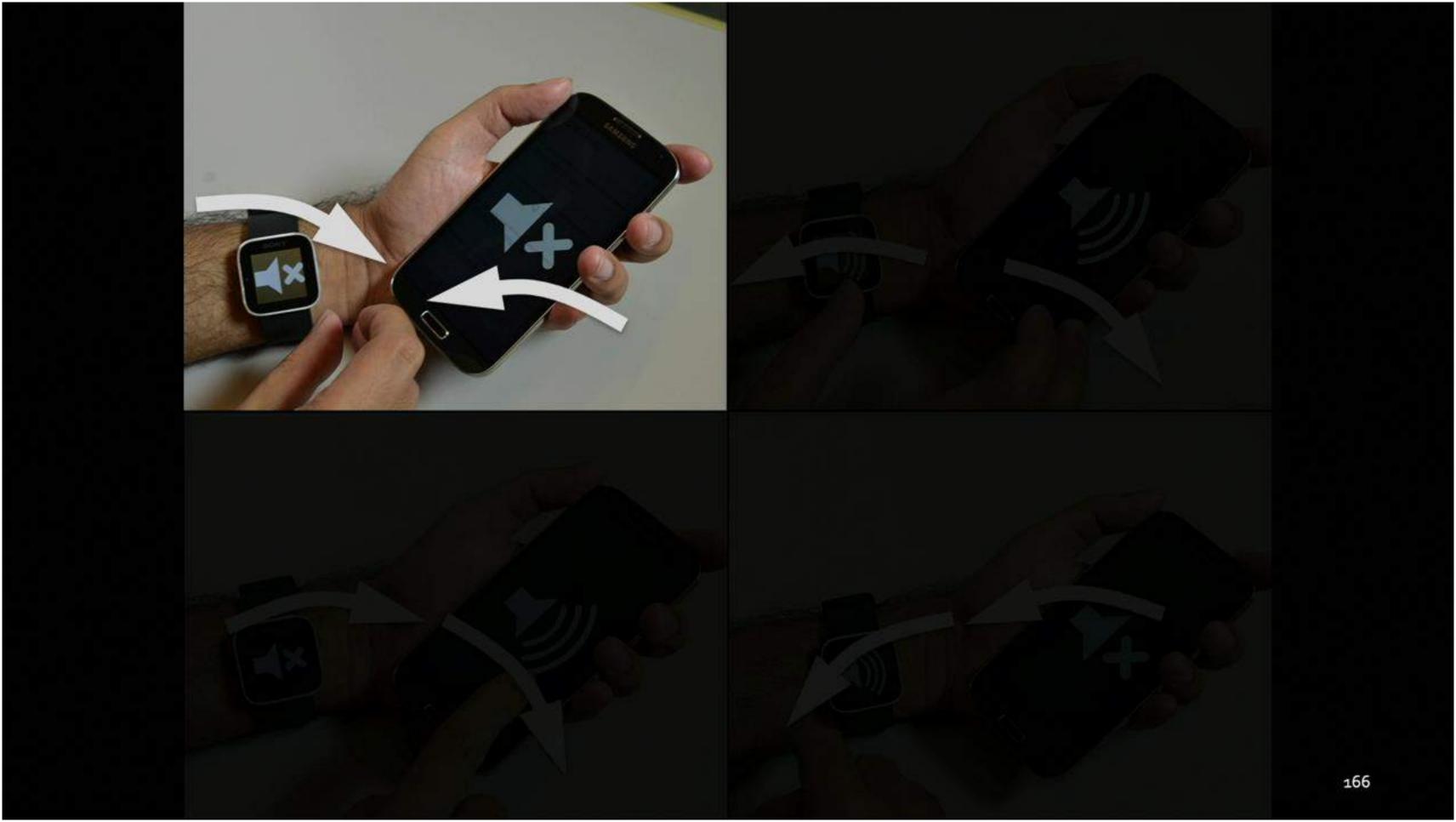
Vision

The Future
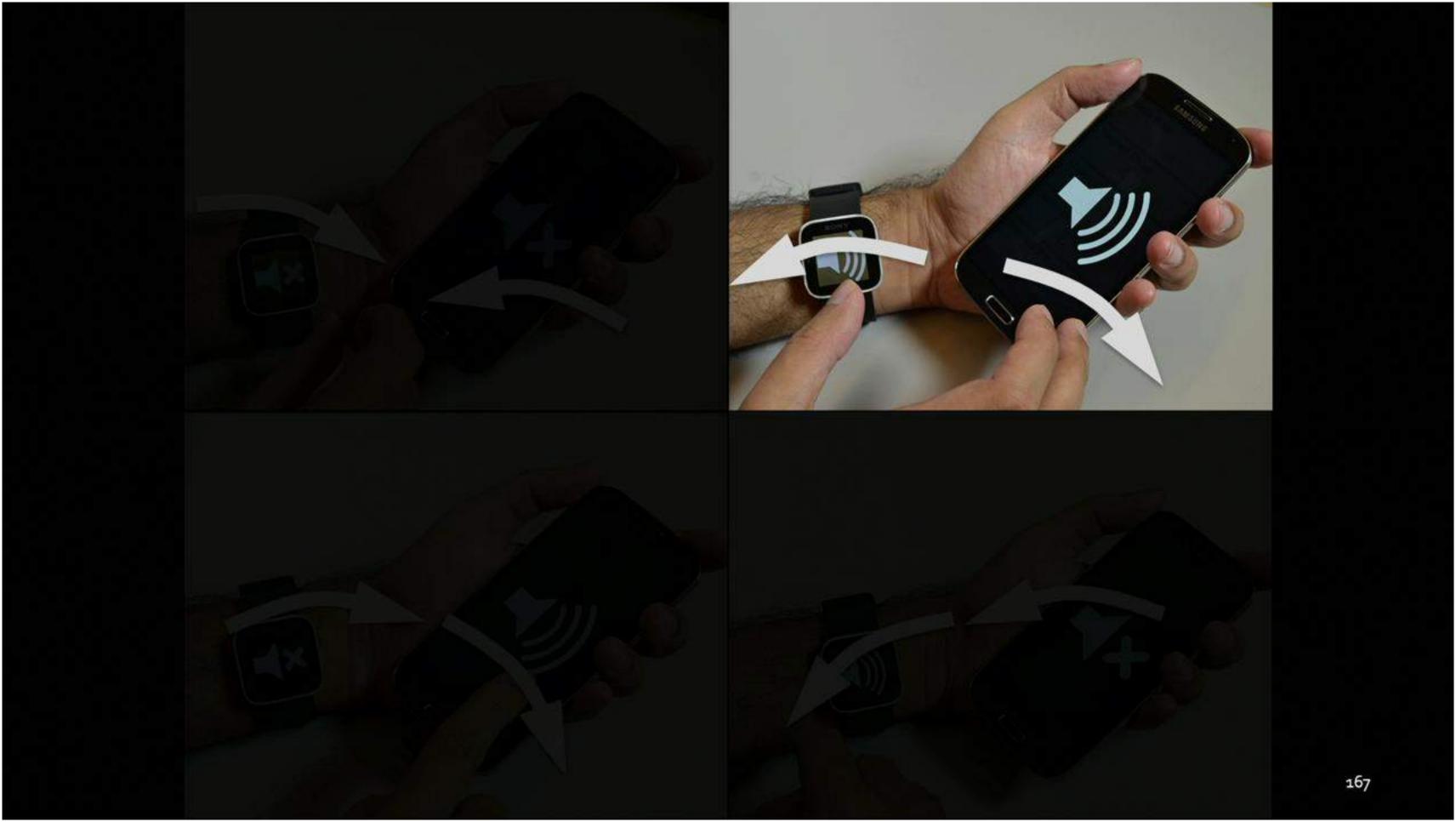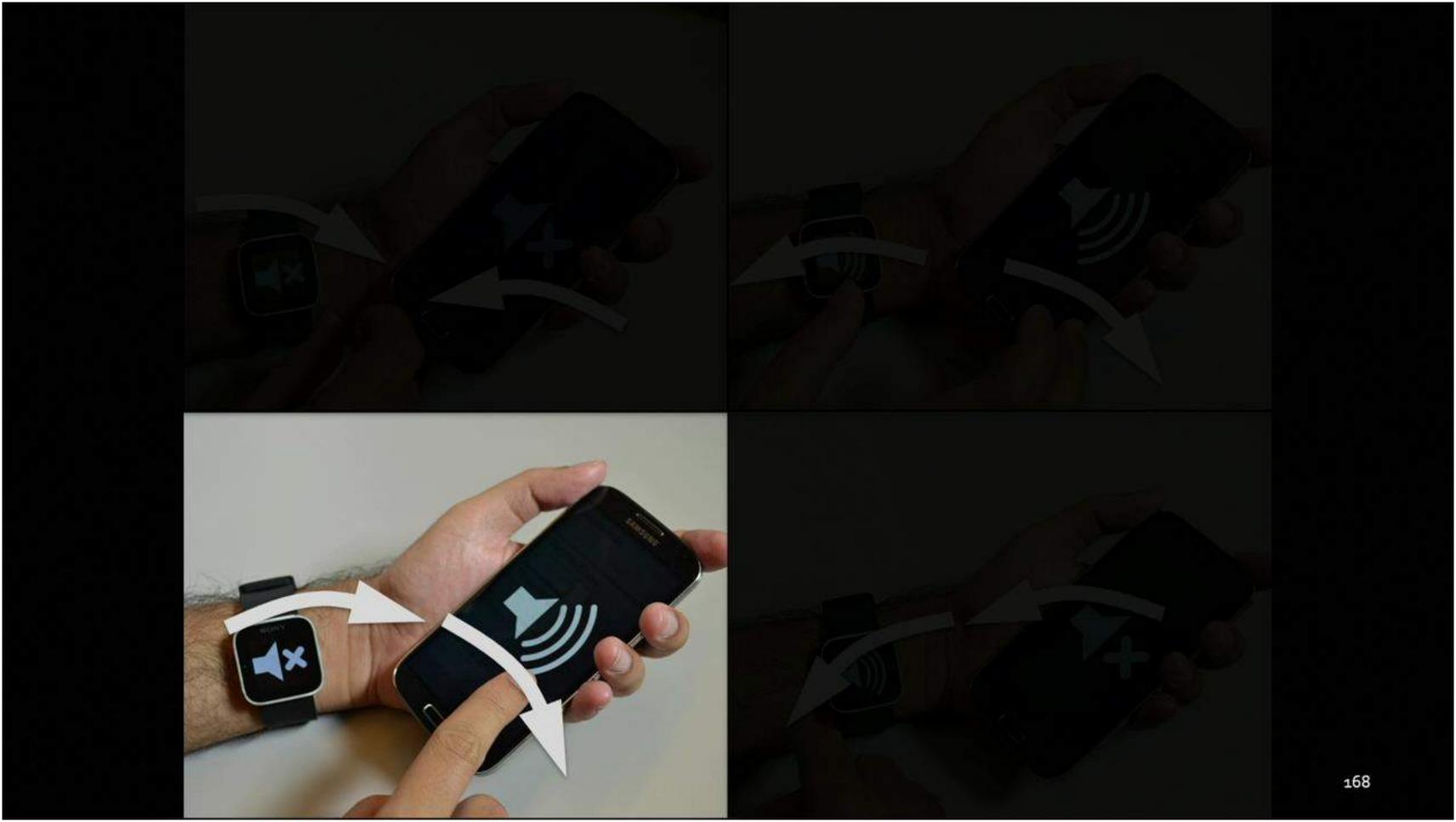
Conductor
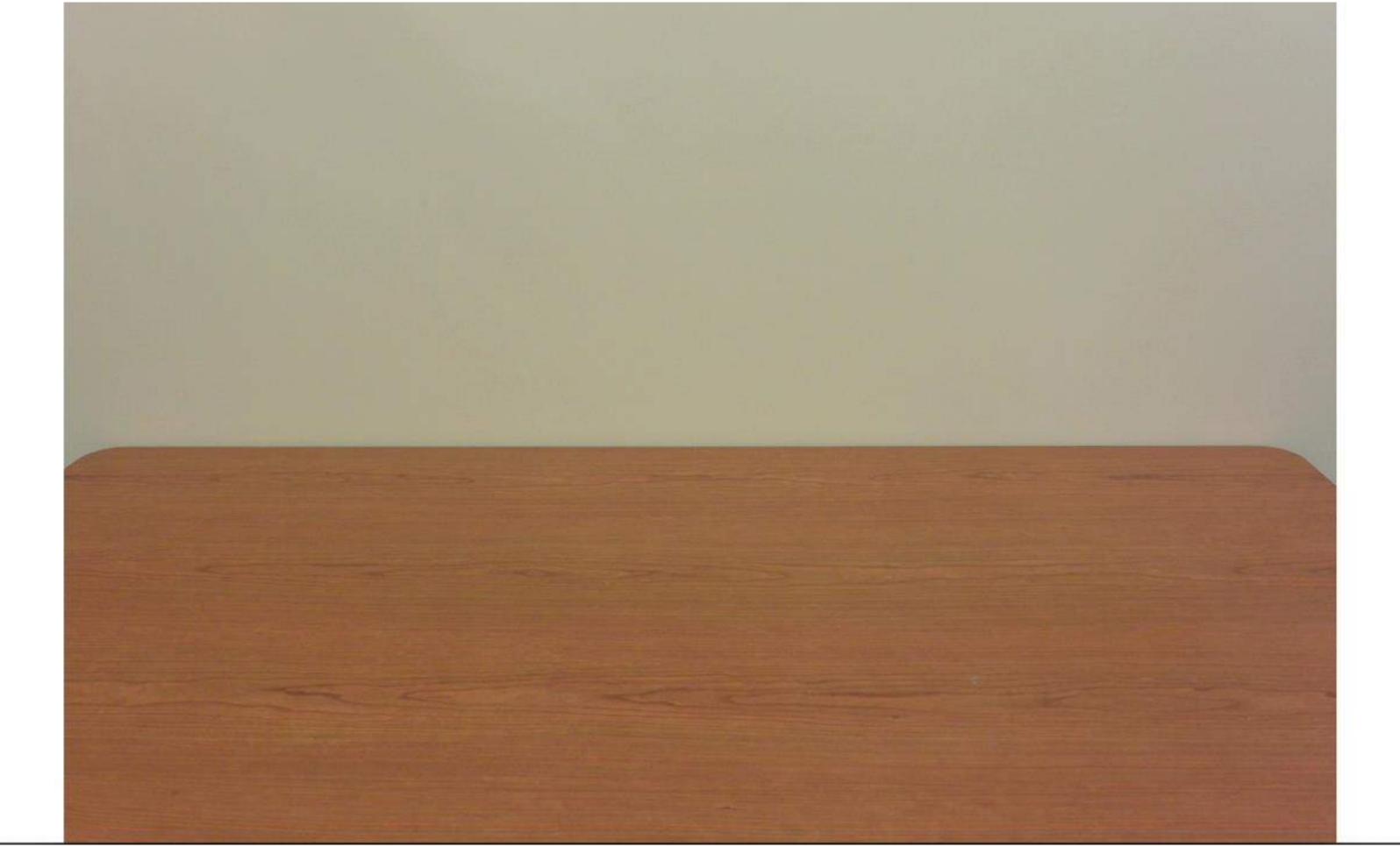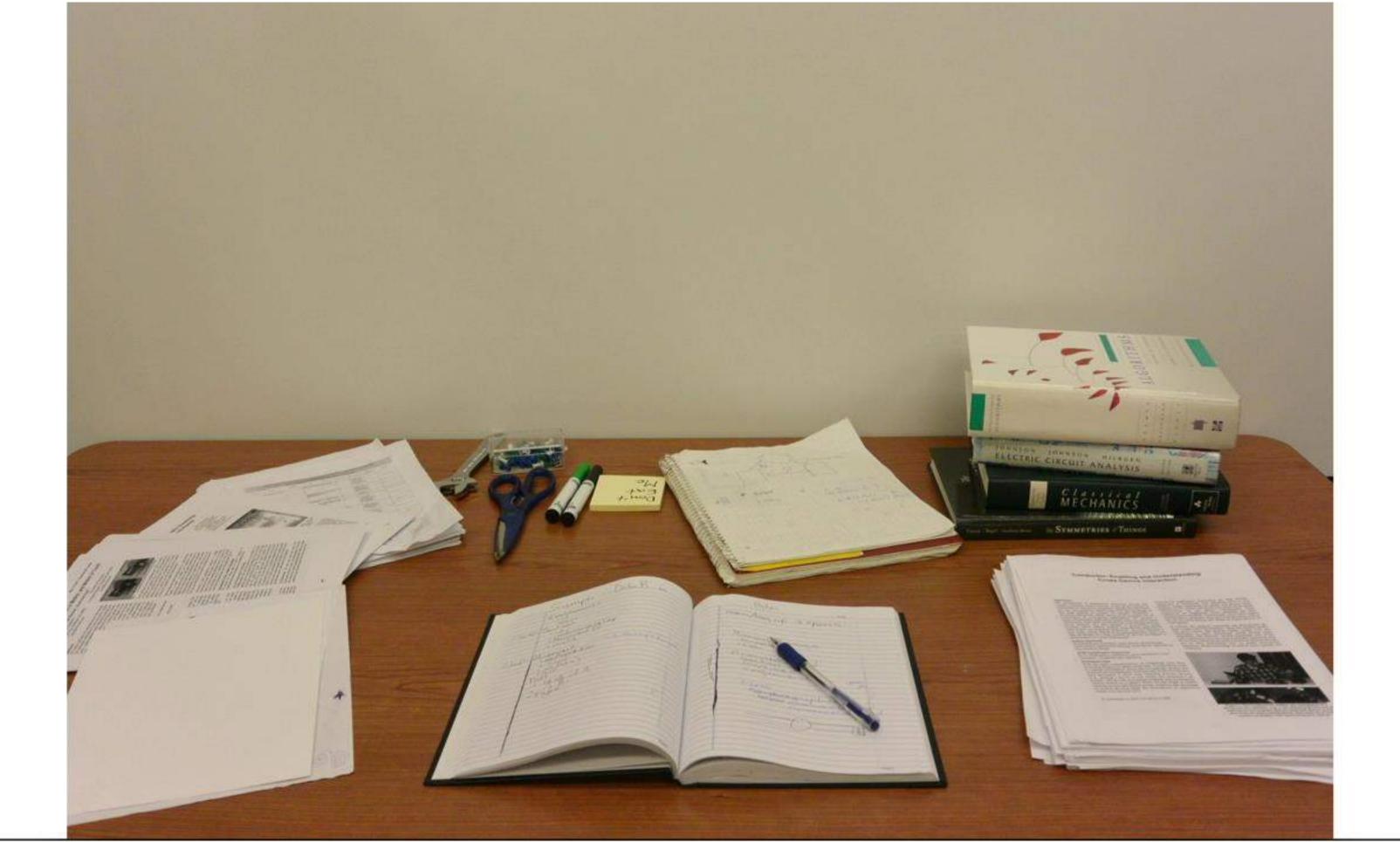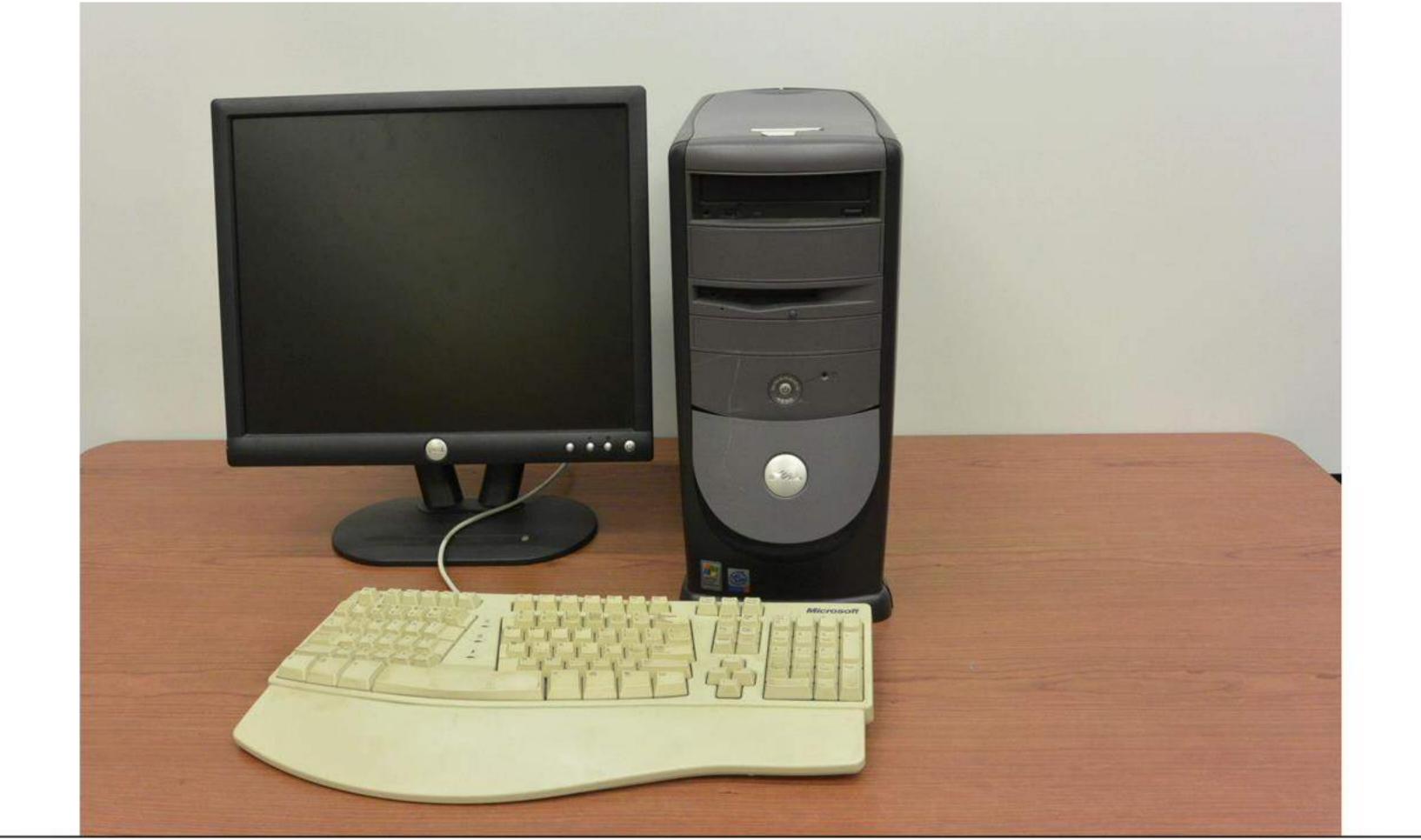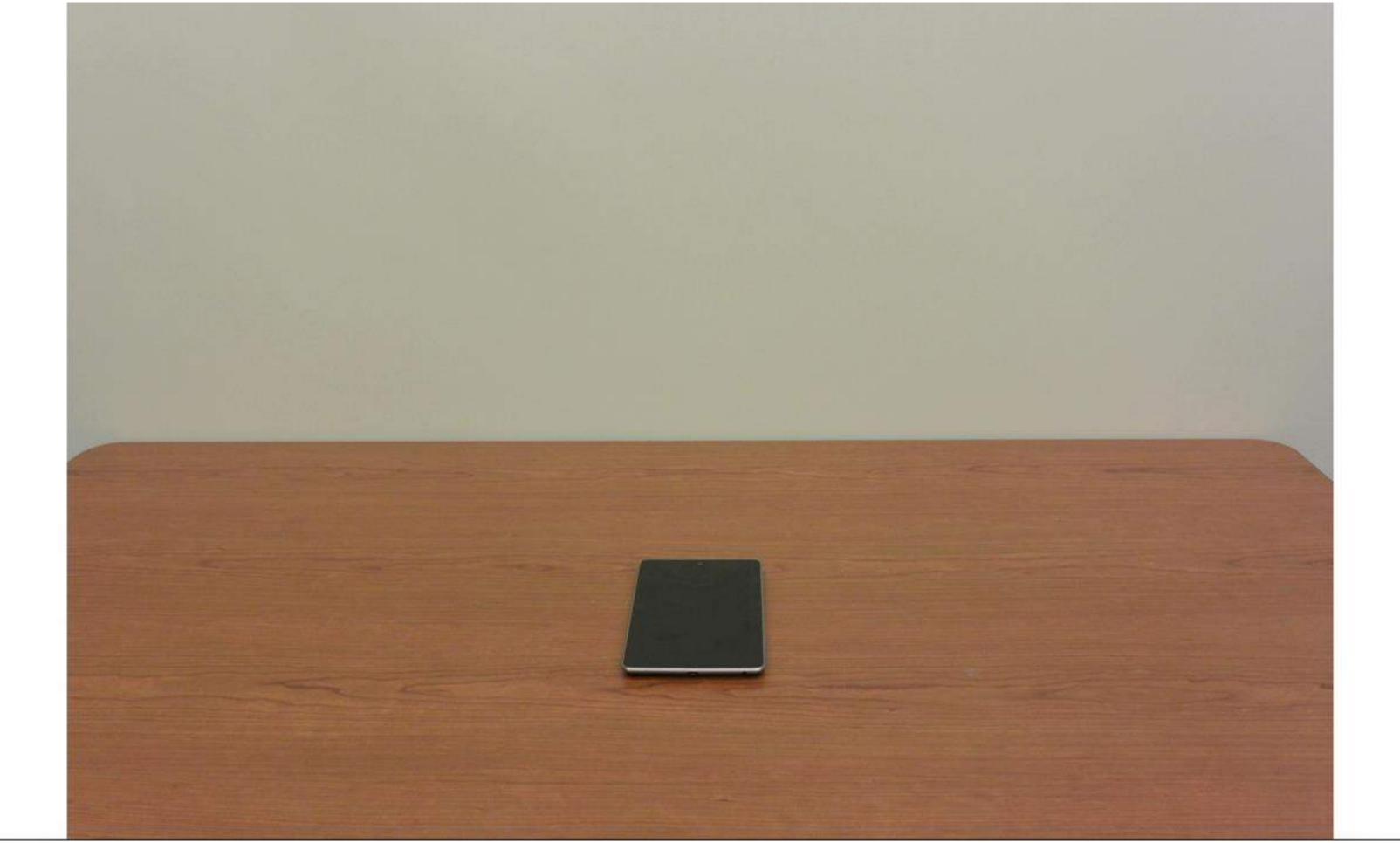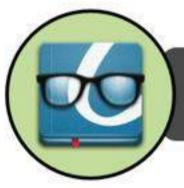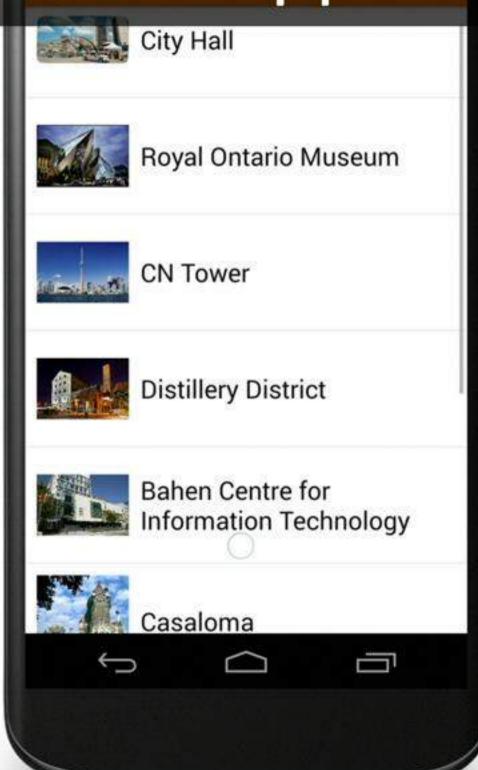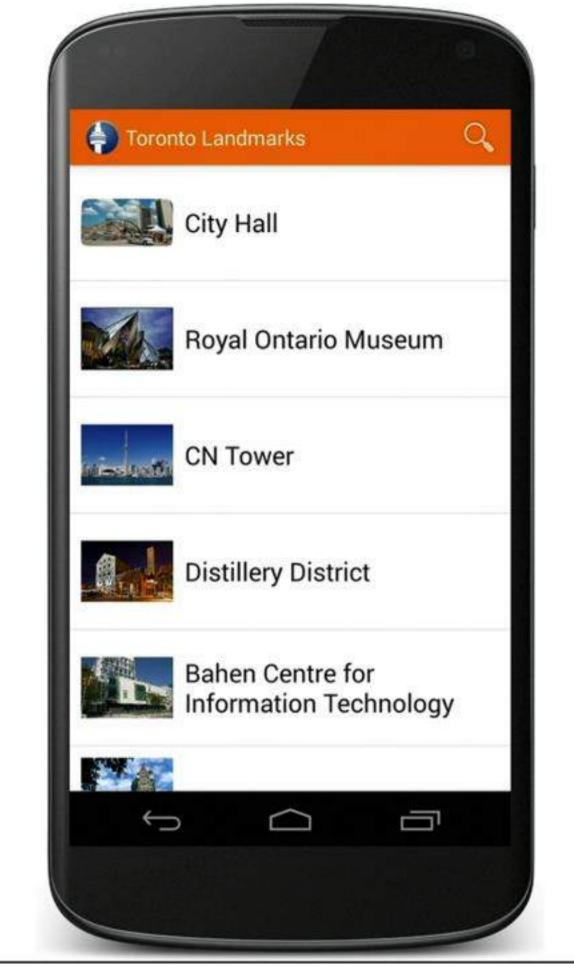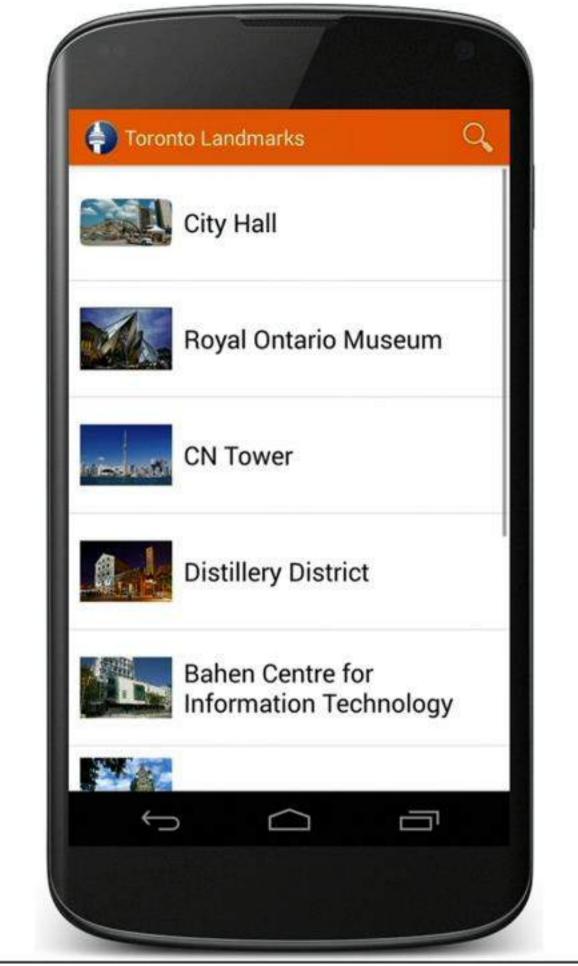
Conductor Application

Toronto Landmarks

- City Hall
- Royal Ontario Museum
- CN Tower
- Distillery District
- Bahen Centre for Information Technology
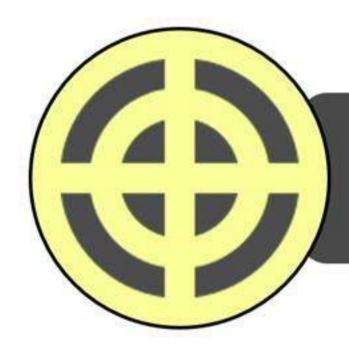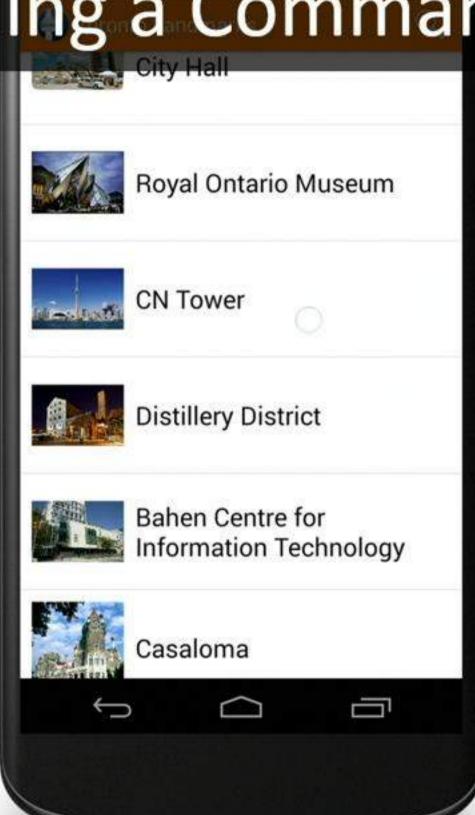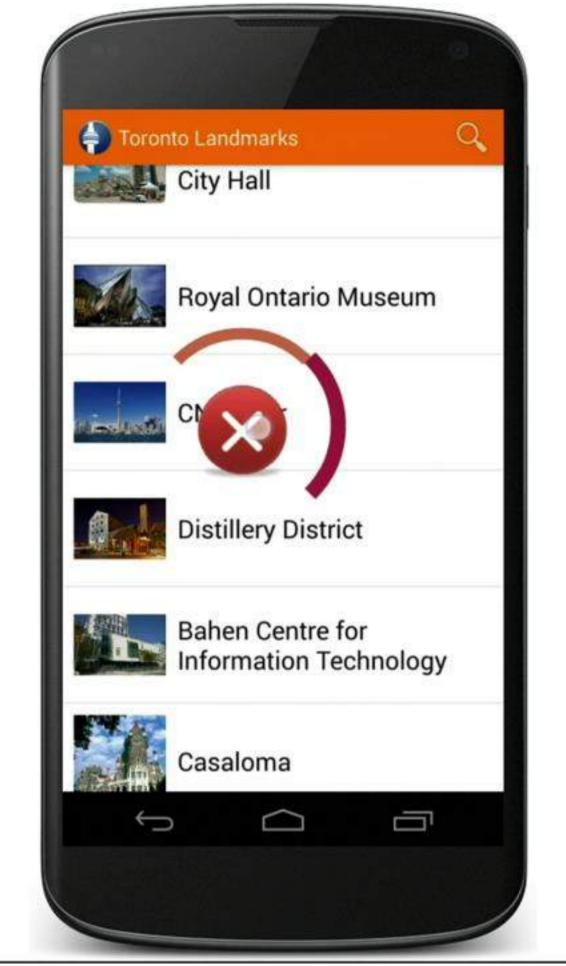
Targeted Transmissions

Sending a Command
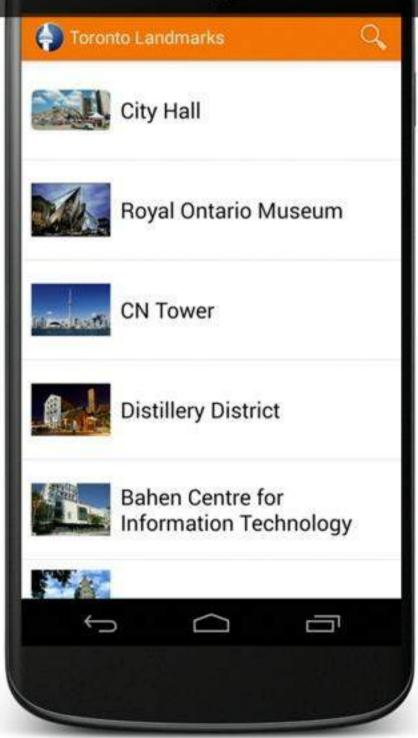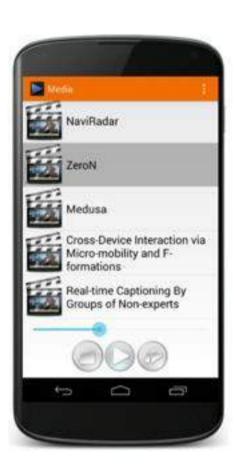
Cue Broadcasting

Broadcasting a Command
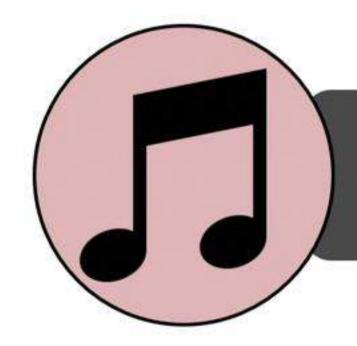
Persistent Connection

Linked
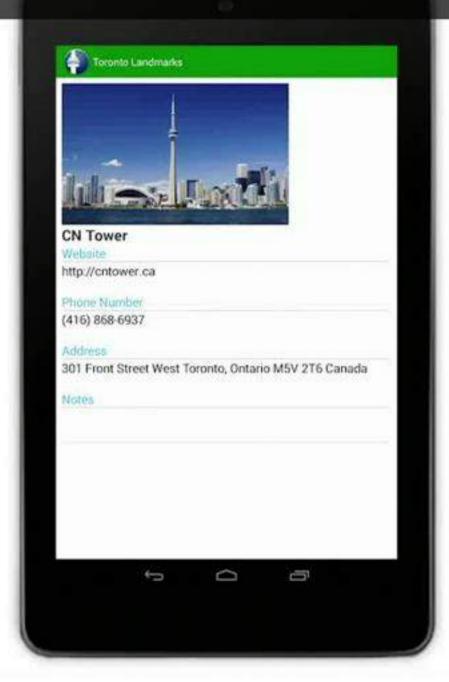
Duet Functionality Bonding

Forming Duets
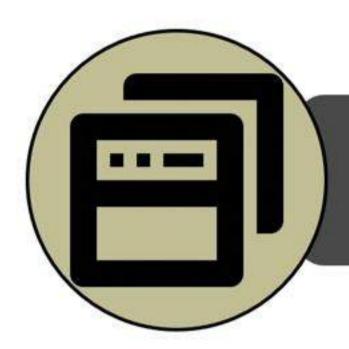
Managing Duets
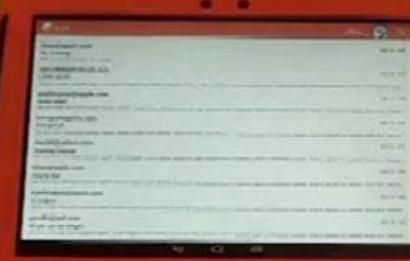
Cross-Device Task Manager

User Study

Space to Think (CHI '10)

Christopher Andrews
Alex Endert
Chris North
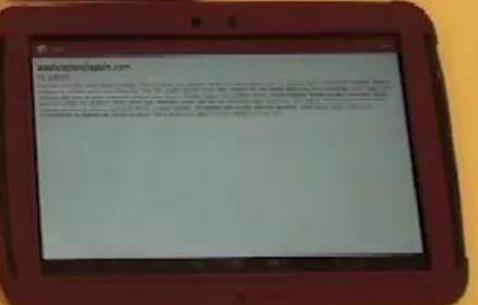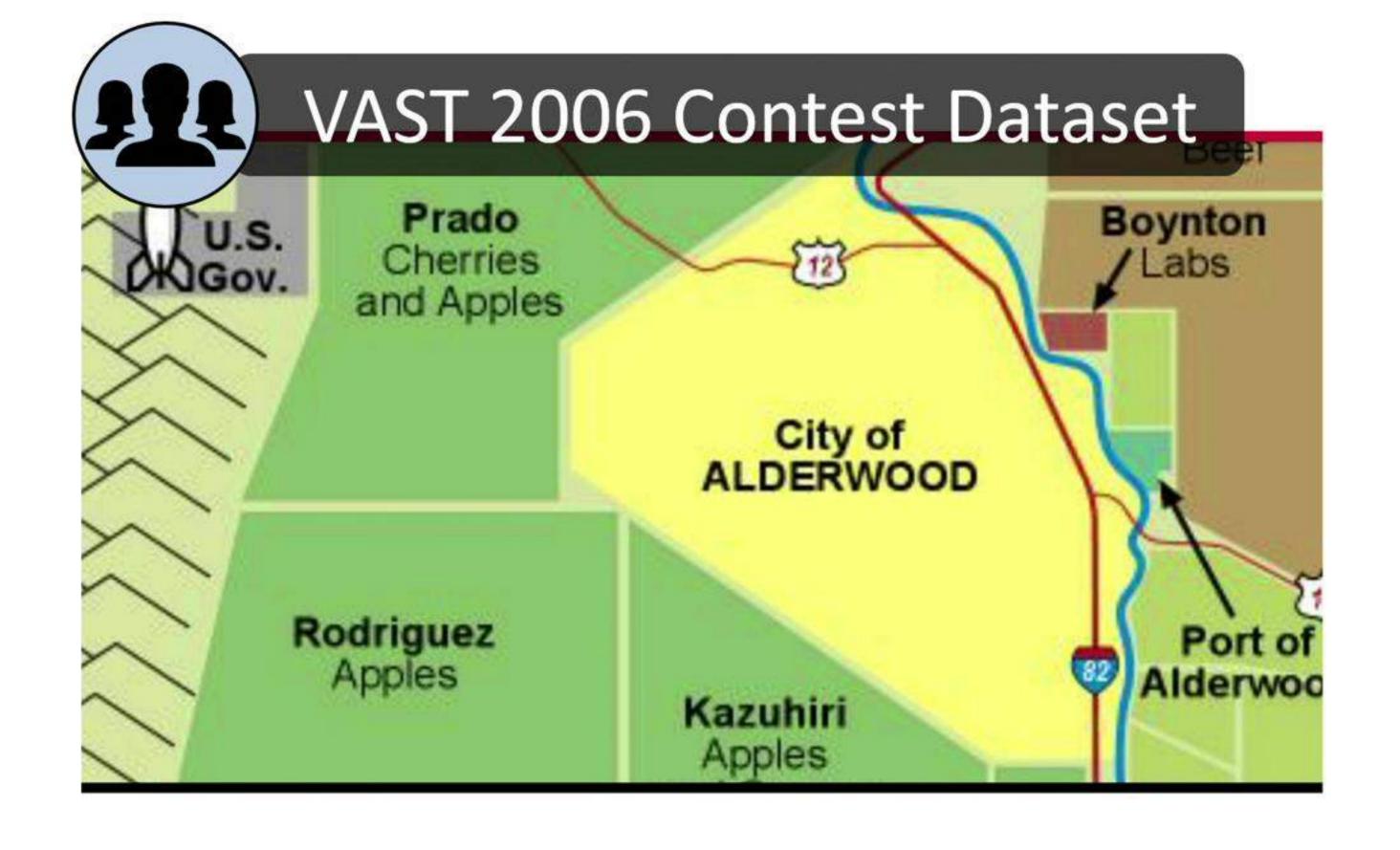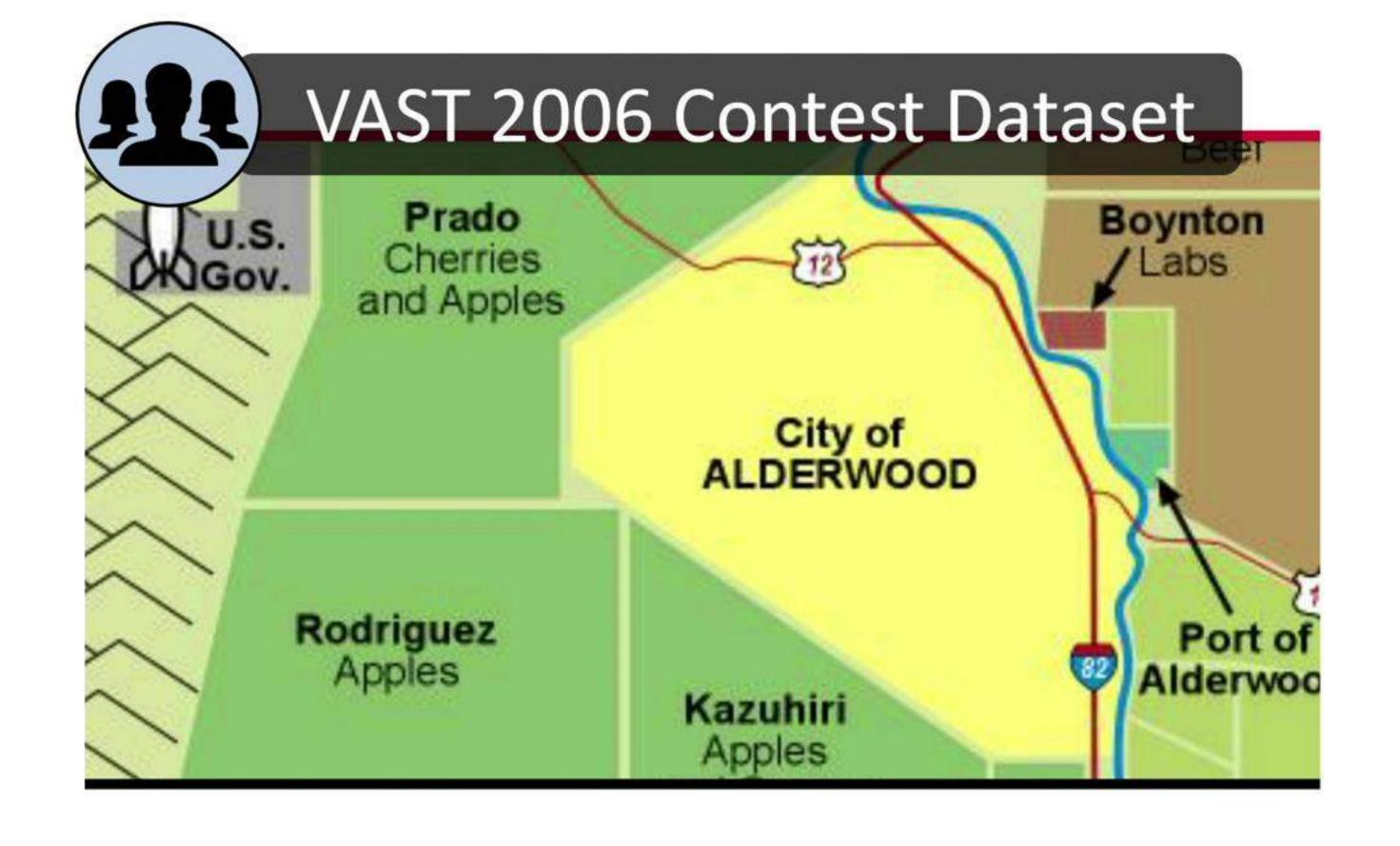
VAST 2006 Contest Dataset

Project Components

Ethnographic research

Interaction design

Development tools

Duet: Exploring joint interactions on a smart phone and a smart watch

Xiang 'Anthony' Chen, Tovi Grossman, Daniel Wigdor, and George Fitzmaurice. 2014. Duet: exploring joint interactions on a smart phone and a smart watch. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '14). ACM, New York, NY, USA, 159-168.
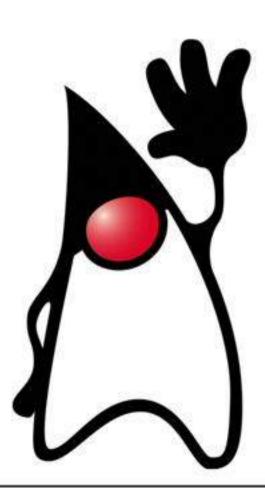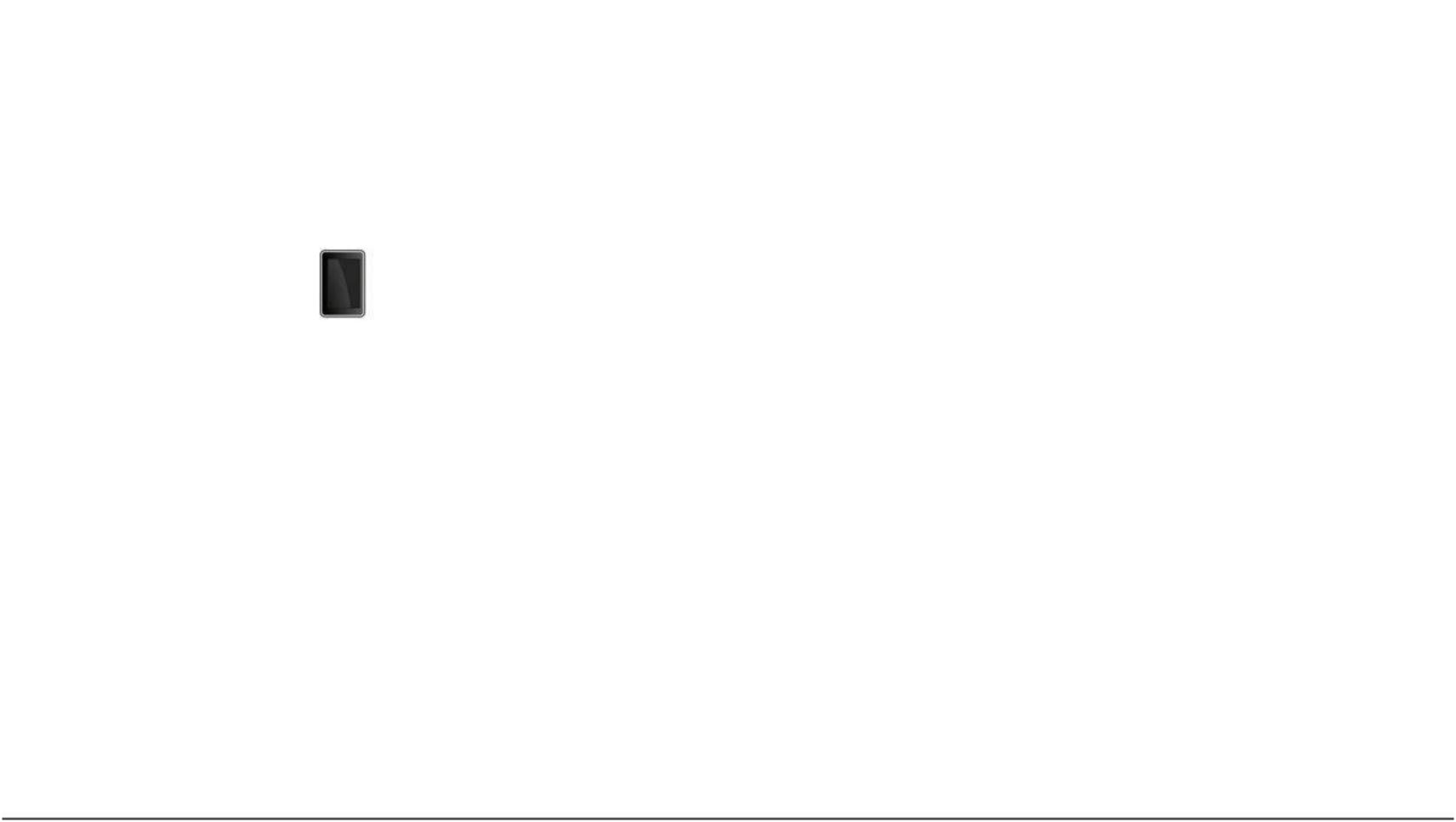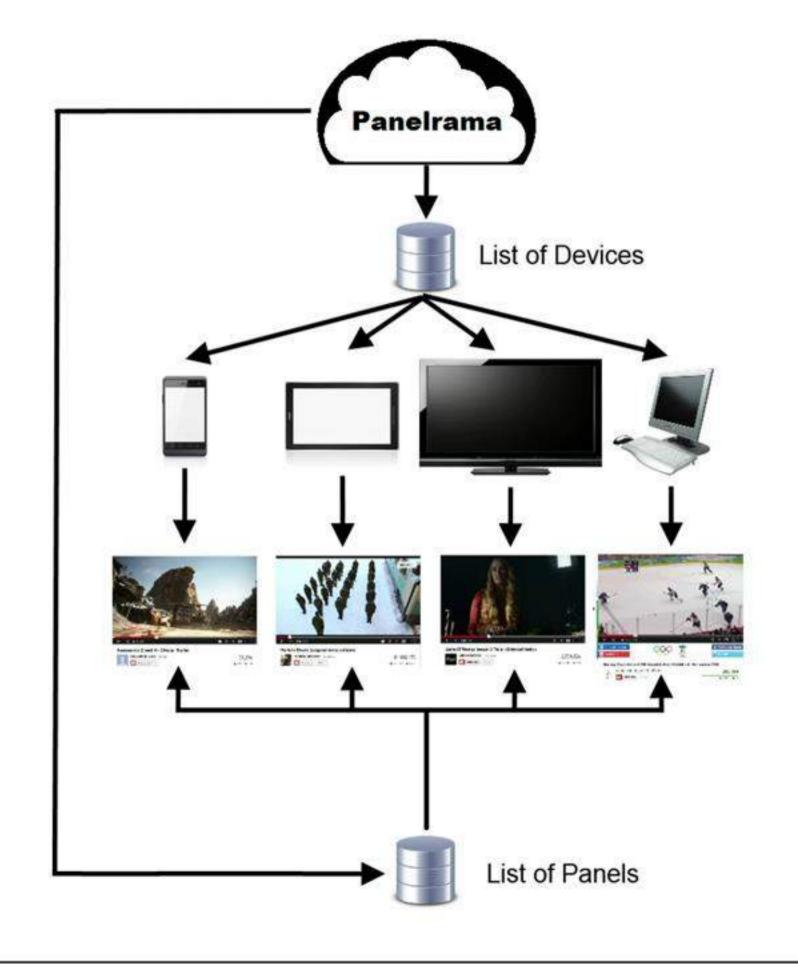
duet a unified interactive platform on a smart phone & a smart watch

	Watch Foreground	Watch Background
Phone Foreground		
Phone Background		

	Watch Foreground	Watch Background
Phone Foreground		
Phone Background		

	Watch Foreground	Watch Background
Phone Foreground		
Phone Background		

	Watch Foreground	Watch Background
Phone Foreground		
Phone Background		

	Watch Foreground	Watch Background
Phone Foreground	• Phone as a primary input and output platform; • Watch as an input device and extended display.	
Phone Background		

How can content producers target unknown device combinations?

Panelrama: Enabling easy specification of cross-device web applications

Jishuo Yang and Daniel Wigdor. 2014. Panelrama: enabling easy specification of cross-device web applications. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '14). ACM, New York, NY, USA, 2783-2792.

Panelrama

Panelrama

List of Devices

List of Panels

Panel Type	Physical Size	Keyboard Quality	Touch Quality	Proximity to User
Video Panel	●●●●●			
Playback Panel			●●●●●	●●●●●
Search Panel	●●●	●●●	●●●●	●●●
Related Videos	●●●		●●●●	●●●●

TUX

TORONTO
USER
EXPERIENCE

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3. Modeling Devices

Panel Type	Physical Size	Keyboard Quality	Touch Quality	Proximity to User
Video Panel	●●●●●			
Playback Panel			●●●●●	●●●●●
Search Panel	●●●	●●●	●●●●	●●●
Related Videos	●●●		●●●●	●●●●

Device Type	Physical Size	Keyboard Quality	Touch Quality	Proximity to User
LG 50" TV	●●●●●			
Dell Laptop PC	●●●	●●●●●		●●
Apple iPad	●●	●●●	●●●●●	●●●●
Nexus 4 Phone	●	●●	●●●●	●●●●●

```html
<body>

    <div>
        <canvas id="drawingCanvas">
        </canvas>
    </div>




    <div>
        <button type="button" id="red"/>
        <button type="button" id="green"/>
        <button type="button" id="blue"/>
    </div>

</body>
```
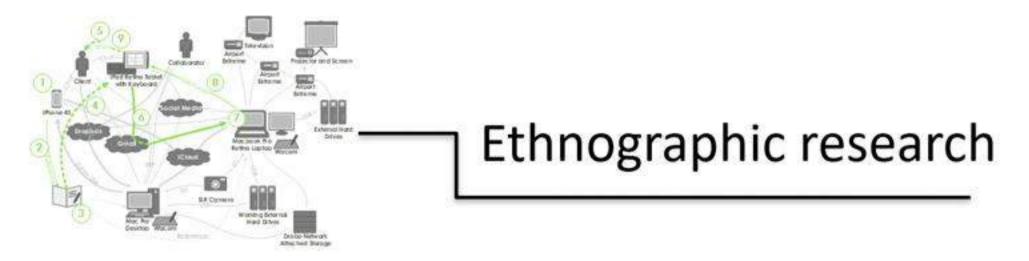
```
<body>

    <div>
        <canvas id="drawingCanvas">
        </canvas>
    </div>


    <div>
        <button type="button" id="red"/>
        <button type="button" id="green"/>
        <button type="button" id="blue"/>
    </div>

</body>
```

```html
<body>
    <panel name="CanvasPanel">
        <div class="{{panelType}}" id='{{panelId}}'>
            <canvas id="drawingCanvas">
            </canvas>
        </div>
    </panel>


    <panel name="PalettePanel">
        <div class="{{panelType}}" id='{{panelId}}'>
            <button type="button" id="red"/>
            <button type="button" id="green"/>
            <button type="button" id="blue"/>
        </div>
    </panel>
</body>
```

Project Components

Ethnographic research

Interaction design

Development tools