

# EXHIBIT E



# AppLens and LaunchTile: Two Designs for One-Handed Thumb Use on Small Devices



**Amy Karlson, Ben Bederson**  
Computer Science Department  
Human-Computer Interaction Lab (HCIL)  
University of Maryland

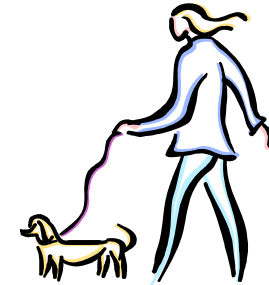


**John SanGiovanni**  
Microsoft Research  
Microsoft Corporation



# Why One-Handed Interaction?

- ❑ One hand occupied



- ❑ Unstable environment

- ❑ Attention divided among tasks



- ❑ Two handed use unnatural

# Input and Interaction on Existing Devices

## ■ Smartphones

- Input: Hardware Buttons
- Interaction: One-handed  
Keypad-mapped functions  
Directional navigation



## ■ Personal Digital Assistants (PDAs)

- Input: Touch Sensitive Display  
Hardware Buttons
- Interaction: Two-handed  
Small software targets  
Directional navigation



# Design Goal

- Scalable User Interface (ScUI)
  - Single design & interaction architecture
  - Multiple resolutions & aspect ratios
  - University of Maryland's PocketPiccolo.NET toolkit for Zoomable User Interfaces (ZUIs)



**iMate Smartphone II**

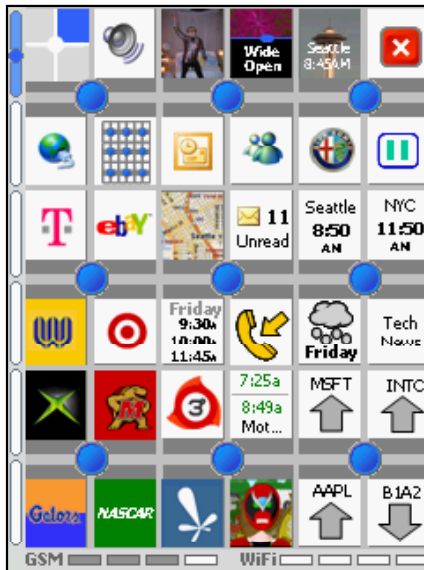
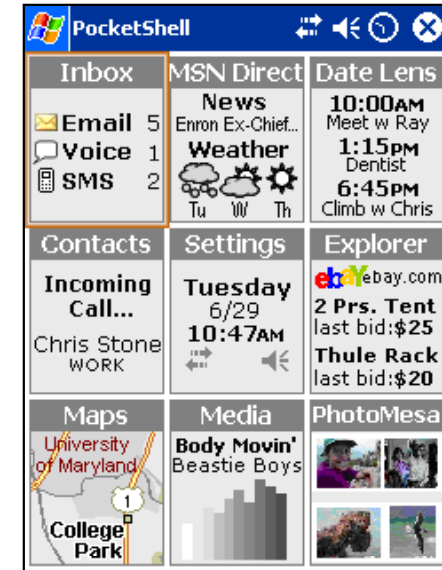


**HP iPAQ PocketPC**

# One Application, Two Designs

## AppLens: Fisheye+Pan

- 9 Application Tiles
- Fisheye Zoom
- Command-Based Gestures



## LaunchTile: Zoom+Pan

- 36 Application Tiles
- Pure Zoom
- Direct Manipulation Gestures

# Related Work

- Gestures using Position & Orientation
  - General Purpose [Reikimoto 1996] [Hinkley 2000]
  - Text Entry [Sazawal 2002] [Widgdor 2003]
- Gestures with Stylus
  - App Specific [Buyukkokten 2000] [Baudisch 2004]
  - Text Entry [Perlin 1998] [Wobbrock 2003]
- Thumb-Based Hardware



Jackito PDA



Apple iPod

# AppLens Visual Design

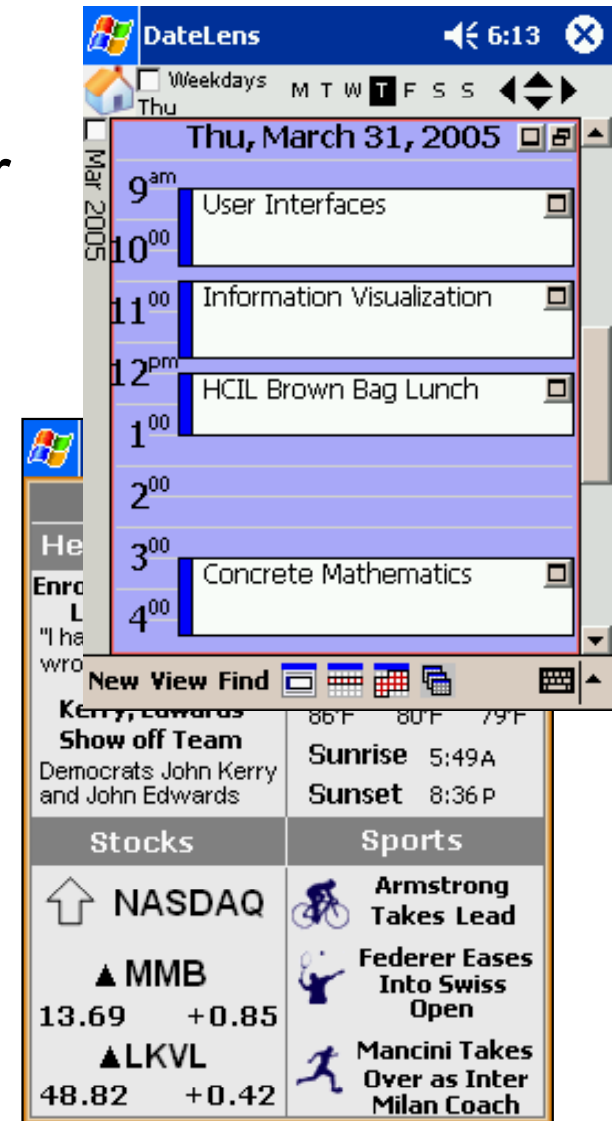
- Generalized tabular fisheye
  - Motivated by DateLens calendar
- Three (fisheye) zoom levels



Notification



Context

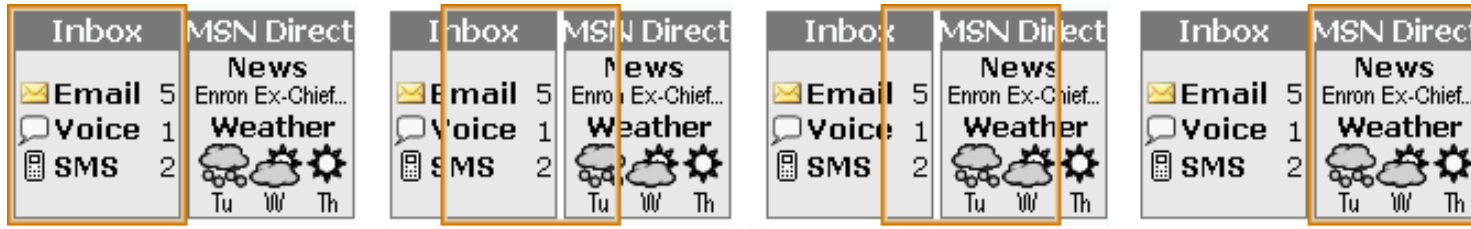


Full



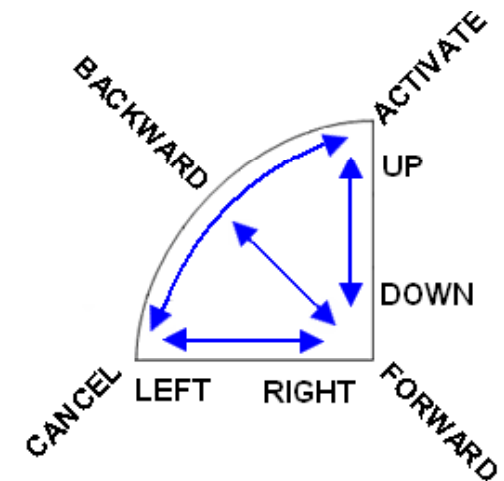
# AppLens Interaction Design

## ■ Input cursor



## ■ Command gestures

- ❑ Issued anywhere
- ❑ Access distant widgets
- ❑ Don't interfere with tap



**AppLens Video**

Interactive prototype based on images

We thank Francois Guibmretière for suggesting the arc-based design      Reference study

# LaunchTile Visual Design

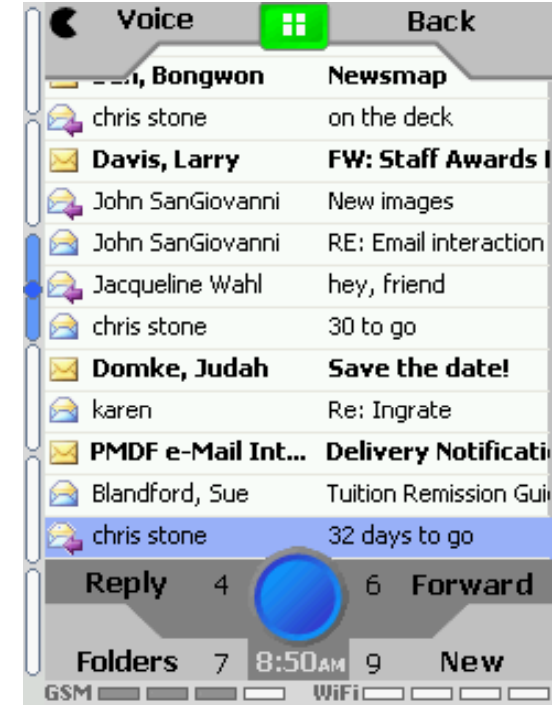
- Three (pure) zoom levels



World



Zone



Application

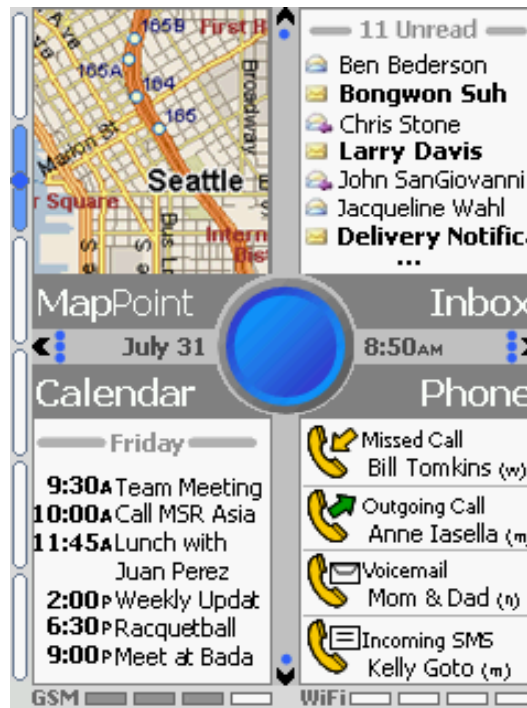
- “Blue” 
- Navigation Landmarks 

# LaunchTile Visual Design

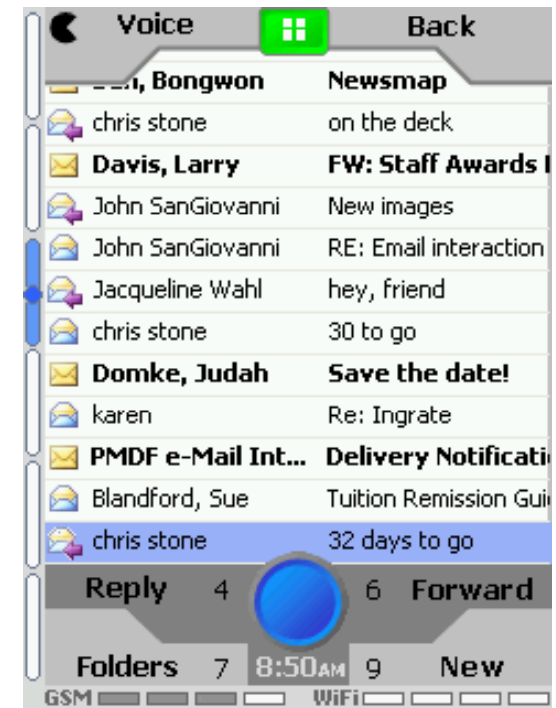
- Three (pure) zoom levels



World



Zone



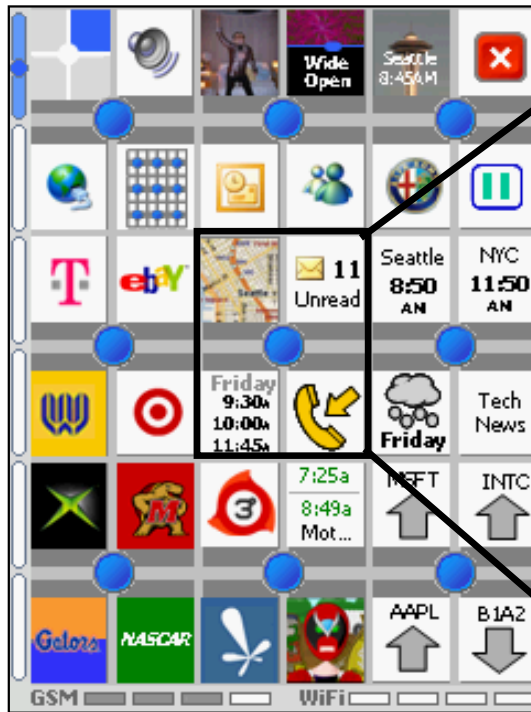
Application

- “Blue”

- Navigation Landmarks

# LaunchTile Visual Design

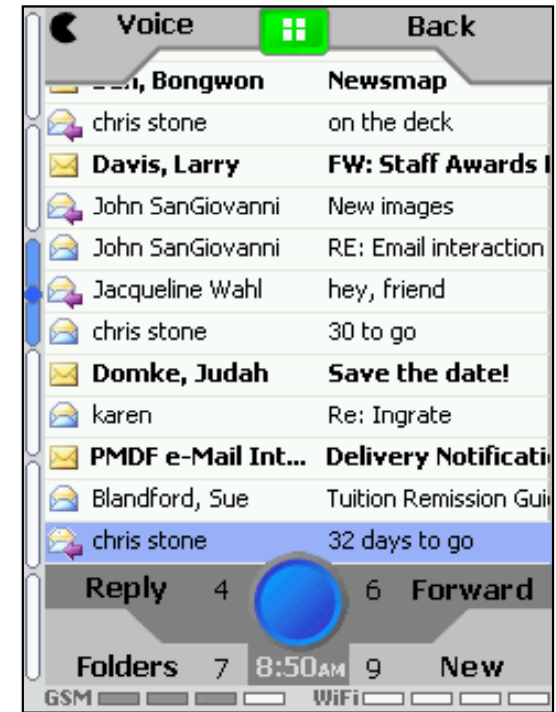
- Three (pure) zoom levels



World



Zone



Application

- “Blue”

- Navigation Landmarks

# LaunchTile Visual Design

- Three (pure) zoom levels



World

Zone

Application

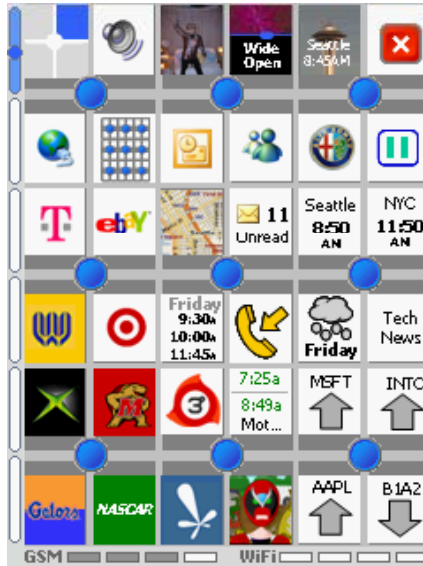
- “Blue”

- Navigation Landmarks



# LaunchTile Interaction Design

- Thumb-sized, keypad-mapped targets



World

# LaunchTile Interaction Design

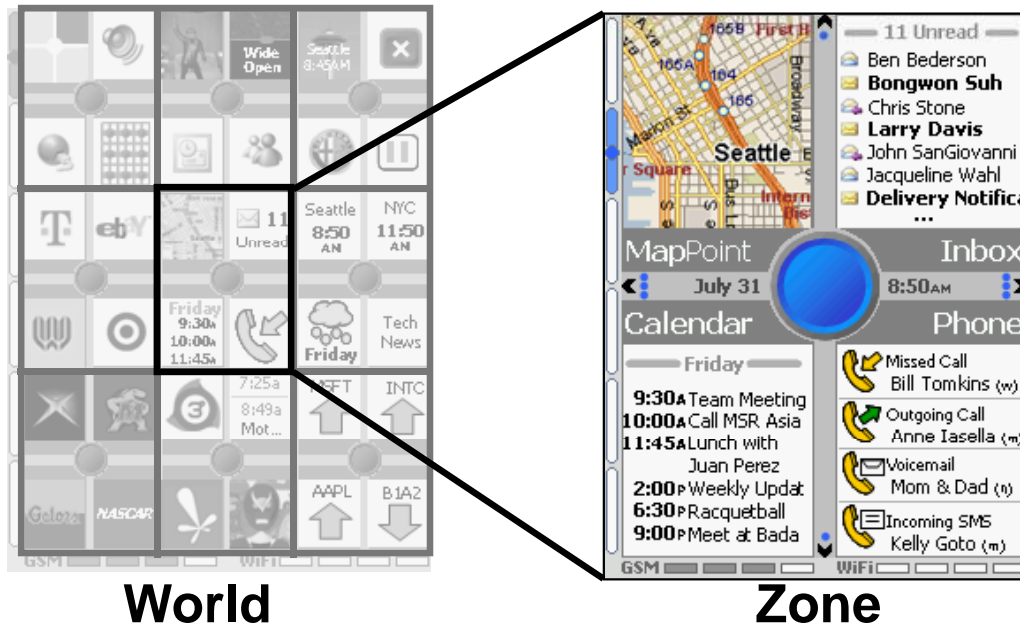
- Thumb-sized, keypad-mapped targets



**World**

# LaunchTile Interaction Design

- Thumb-sized, keypad-mapped targets





# LaunchTile Interaction Design

- Thumb-sized, keypad-mapped targets



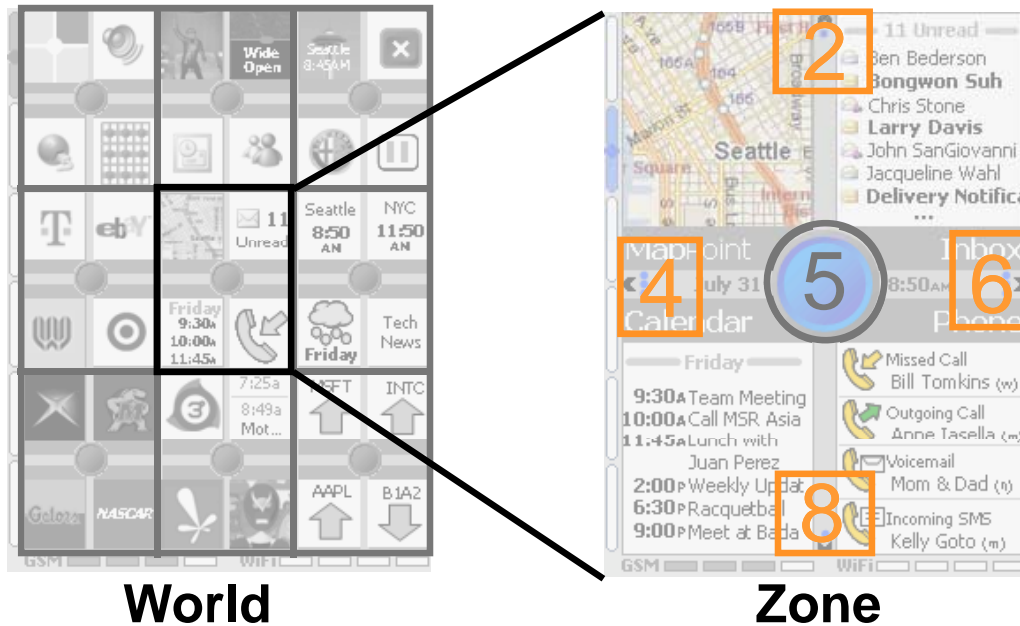
**World**



**Zone**

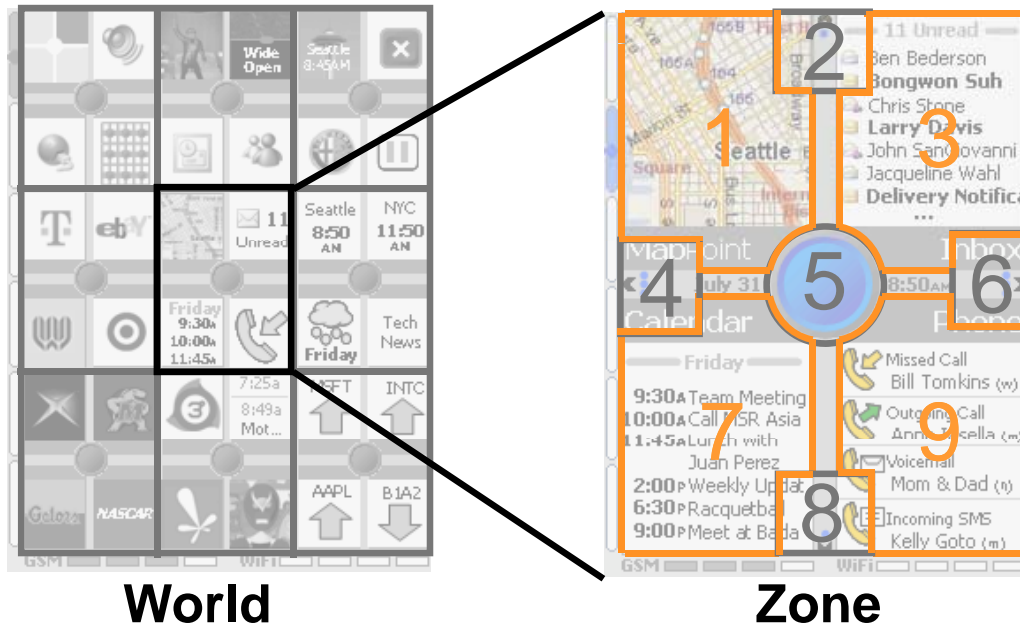
# LaunchTile Interaction Design

- Thumb-sized, keypad-mapped targets



# LaunchTile Interaction Design

- Thumb-sized, keypad-mapped targets

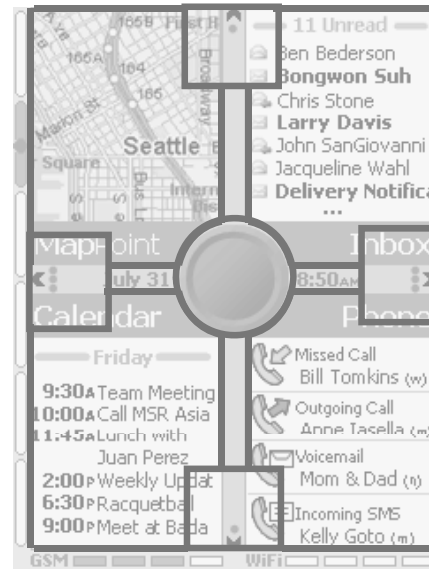


# LaunchTile Interaction Design

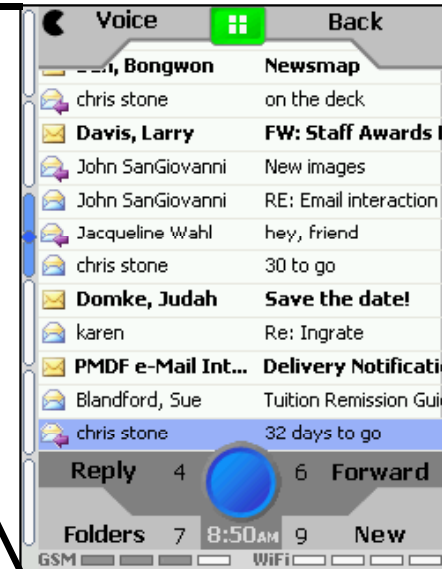
- Thumb-sized, keypad-mapped targets



**World**



**Zone**



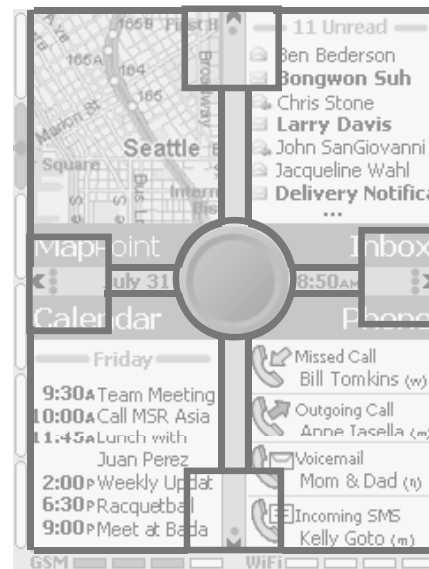
**Application**

# LaunchTile Interaction Design

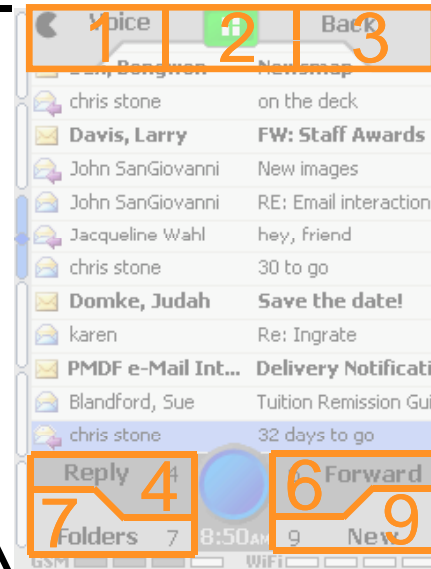
- Thumb-sized, keypad-mapped targets



**World**



**Zone**



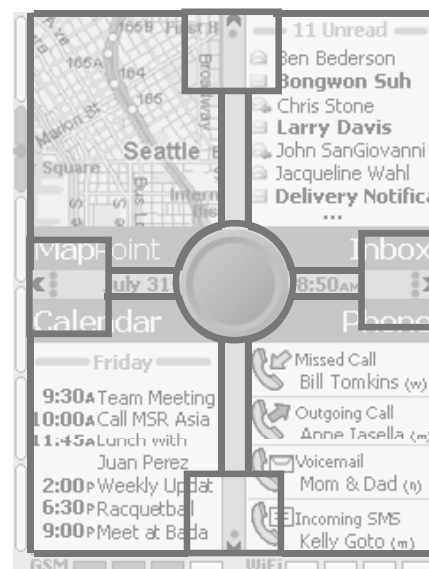
**Application**

# LaunchTile Interaction Design

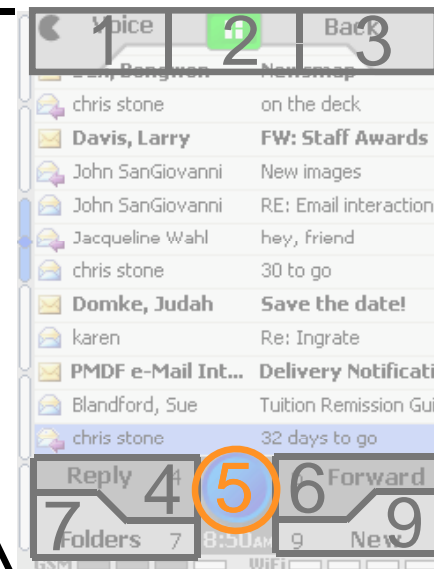
- Thumb-sized, keypad-mapped targets



**World**



**Zone**



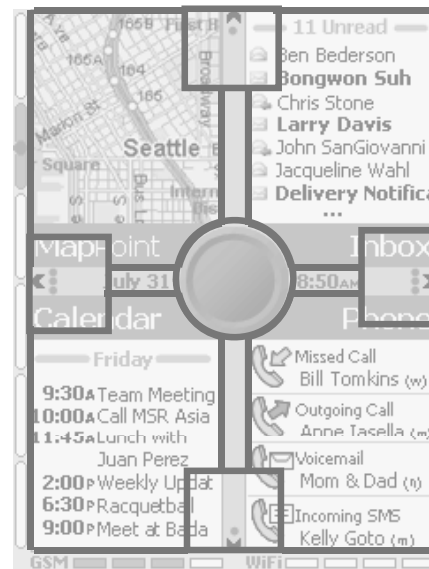
**Application**

# LaunchTile Interaction Design

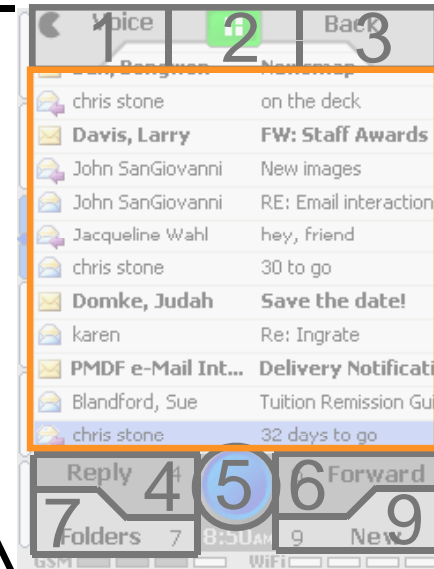
- Thumb-sized, keypad-mapped targets



**World**



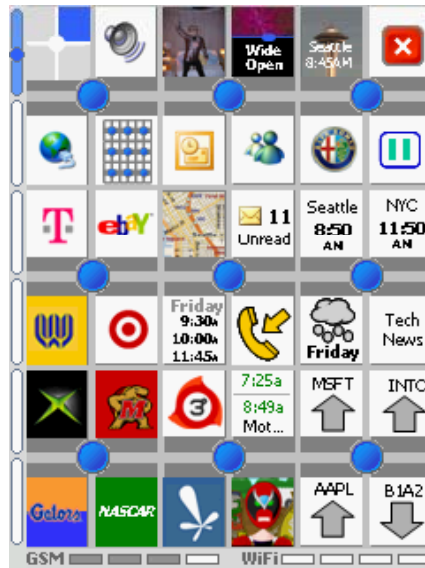
**Zone**



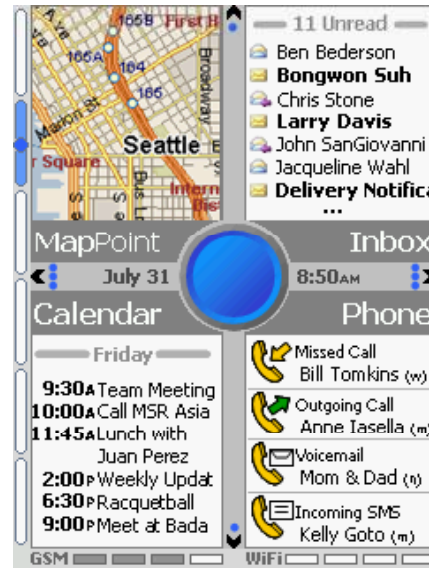
**Application**

# LaunchTile Interaction Design

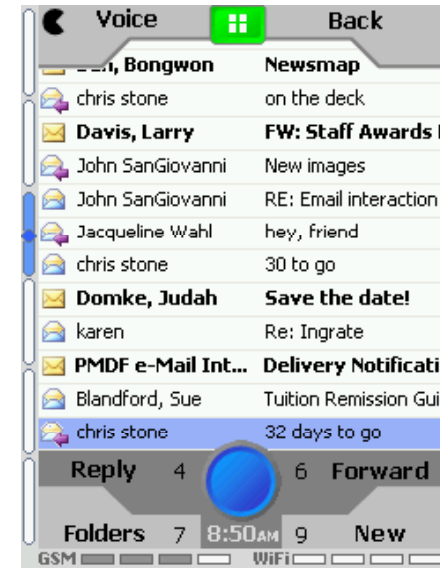
- Thumb-sized, keypad-mapped targets



World



Zone



Application

- Direct Manipulation Drag Gestures

- Zoomspace
- Application content
- Toolglass

LaunchTile Video

Interactive prototype based on images

Reference study





# AppLens Command Gesture Study

- Gestures learnable with minimal training?
- Participants
  - 20 (12 Male, 8 Female)
  - 12 advanced computer users
  - 6 regular PDA users
- Time
  - Training: 5-15 minutes
  - Tasks: 15-30 minutes

# Methods

## ■ Tasks

- Gesture
- Navigation

## ■ Measures

- Correctness and Speed
- Correctness and Efficiency

## ■ Environment

- Hierarchical
- Tabular
- Zoomable

Navigation Phase 10:33		
Navigate to 6.5.4		
1	2	3
4	5	6
7	8	9

Navigation Phase 10:34		
Navigate to 6.5.4		
6.5.1	6.5.2	6.5.3
6.5.4	6.5.5	6.5.6
6.5.7	6.5.8	6.5.9

Navigation Phase 10:36		
Activate the 5 in 6.5.4		
6.5.1	6.5.2	6.5.3
6.5.4	6.5.5	6.5.6
6.5.7	6.5.8	6.5.9

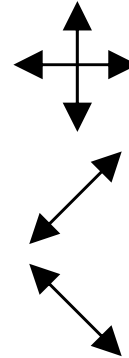
Video

Gesture Study

# Results

## ■ Gesture Tasks

- Directional
- Activate / Cancel
- Backward / Forward



% Correct	Speed (sec)
<b>93%</b>	<b>1.2</b>
<b>87%</b>	<b>2.7</b>
<b>67%</b>	<b>3.6</b>

## ■ Navigation Tasks

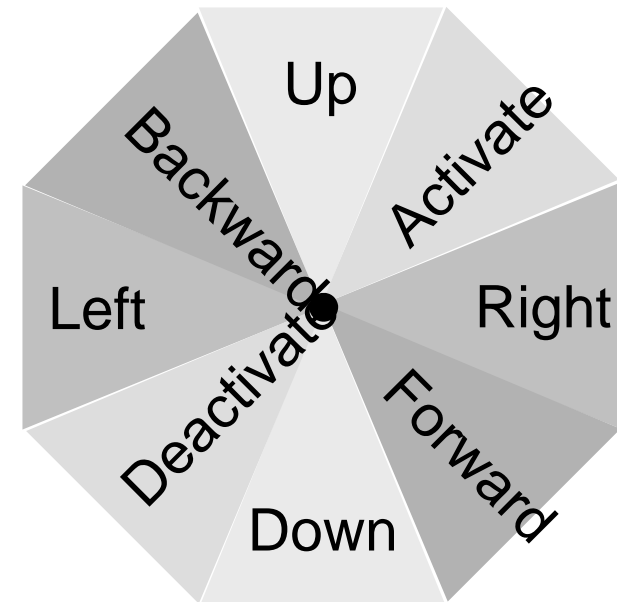
- 95% correct
- +2.4 gestures per task
- Most of the problems from one third of users

## ■ Subjective Reactions on 9-Point Scale

- All between 5.9 - 6.75 (9 was best)

# Discussion

- Errors from recall or execution?
  - Logs indicate both
- Navigation better than Action Gestures
  - Spatial mapping helps learnability
  - Abstract mappings require more effort
  - Similar mappings can be confusing





# Formative Study Comparing Designs

## ■ Goals:

- Usability issues
- Comparative preferences

## ■ Participants:

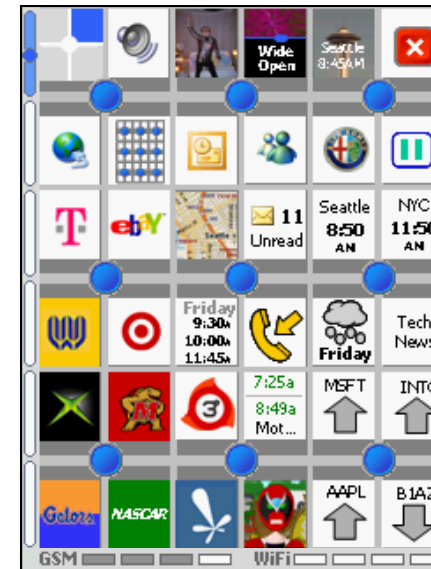
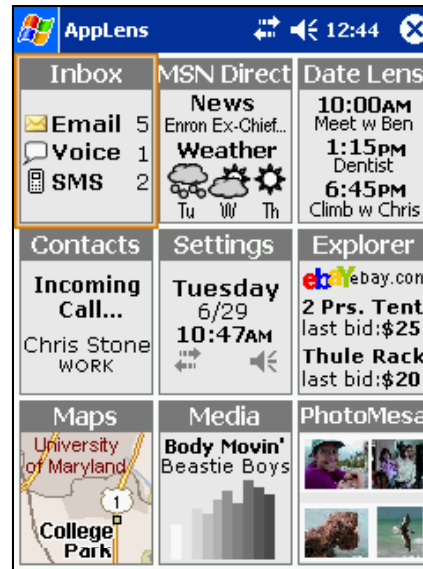
- 10 (8 Male, 2 Female)
- All advanced computer users
- 4 regular PDA users

## ■ Time:

- 45 minutes: 15 per interface, 15 discussion

# Method

## ■ Software:



## ■ Tasks:

- Exercised navigation & interaction features

## ■ Measures:

- Subjective reactions
- Comparative preferences

# Results: AppLens

- Likes
  - Easy to learn
  - Effective to navigate
  - Comfortable
  - Fisheye valuable
  - Simultaneous access to apps
  
- Usability Issues
  - Gestures were hardest part



# Results: LaunchTile

## ■ Likes

- Effective to navigate
- Comfortable
- “Blue”
- Access to many apps

## ■ Dislikes

- Too many apps

## ■ Usability Issues

- Multi-modal “Blue”



- Disorienting

- Panning in Zone view





# Results: AppLens vs. LaunchTile

- With minimal training, AppLens preferred
  - Easier to use
  - Faster application access
  - Better at-a-glance value
  - For own PDA use



# Discussion

- AppLens beats LaunchTile?
  - Not necessarily
  - AppLens was simpler, shallower, fewer apps
    - Easier to learn and manage under time constraints
    - Performance unaffected by device limitations
  
- General Observations
  - Tapping used more than gestures
  - Utility of notification tiles



# Conclusion

- Promising Interfaces:
    - One-handed
    - Notification-based
    - Tappable
  
  - Unknown:
    - Scalable interfaces
  
  - Potential Challenge:
    - Gesture-based interfaces
-