Predicting Task Execution Time on Handheld Devices Using the Keystroke Level Model

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Motivation and goals

- Keystroke Level Model (KLM)
  - *A priori* prediction of expert user task time
  - Intensively used on desktop computers
  - Not yet been adapted to handheld devices
    - Limited display size
    - Input device: stylus, touch-screen, hardware buttons
    - Interaction methods: tap, Graffiti, etc.
- Investigate KLM on handheld UIs
  - Applicability of model to novel interface modalities
  - Accuracy of model predictions

KLM in brief

- Describe a task by placing operators in a sequence
  - K – keystroke (tap)
  - P – point with mouse (with stylus)
  - H – homing (move hand from mouse to keyboard) (N/A)
  - D (takes parameters) – drawing
  - R (takes parameters) – system response time
  - M – mental preparation
  - G – Graffiti stroke (580 ms – Fleetwood, et al 2002)

- Five heuristic rules to insert candidate Ms into the sequence
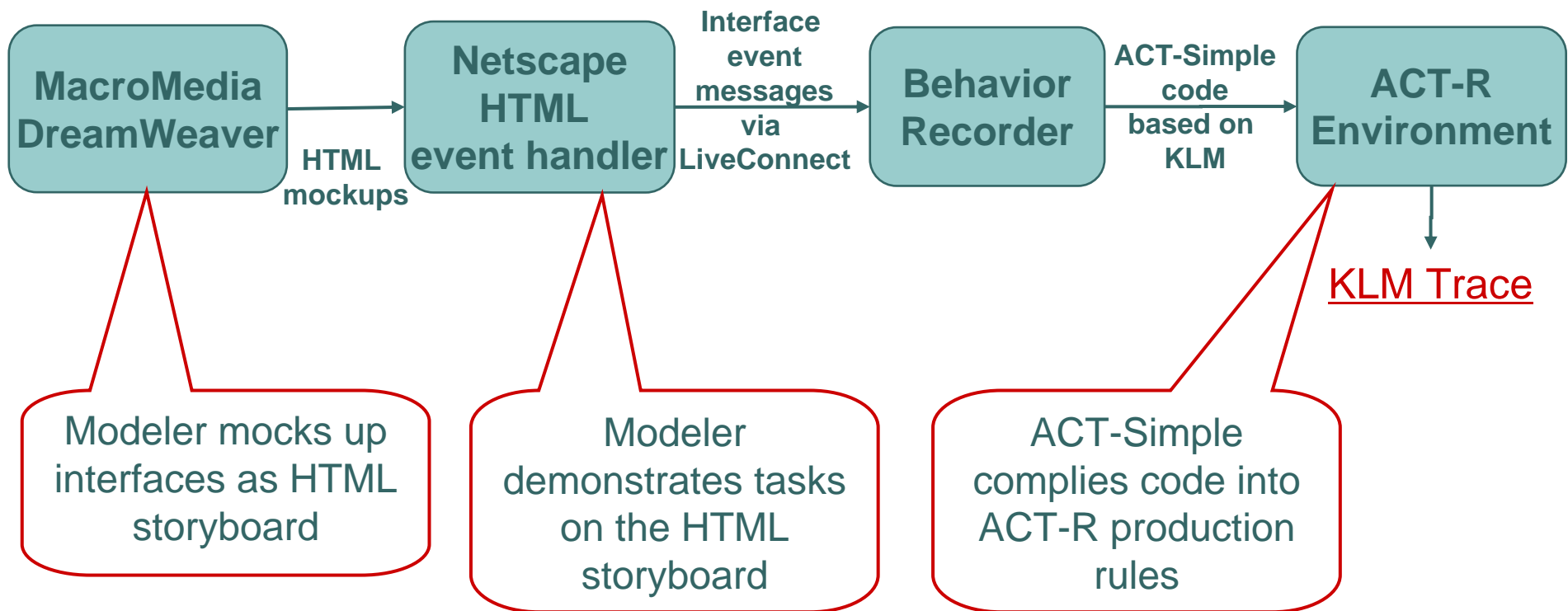- Task execution time =   all operators involved

Handheld task:
Find information about the MET

Start

City map

Region map

Street map

Query result

Museums list

Scroll list

Soft keyboard

Graffiti

Create KLMs

- One KLM for each of the four methods
- Used CogTool (John, et al 2004)

MacroMedia DreamWeaver → **HTML mockups** → Netscape HTML event handler → **Interface event messages via LiveConnect** → Behavior Recorder → **ACT-Simple code based on KLM** → ACT-R Environment → KLM Trace

Modeler mocks up interfaces as HTML storyboard

Modeler demonstrates tasks on the HTML storyboard

ACT-Simple complies code into ACT-R production rules

Behavior Recorder

File   Edit   Display   Prod. System   Windows   Help

○ **Demonstrate Mode**   ○ Pseudo-Tutor Mode   ○ Prod. System Mode

RecordNo...

ACD FotoS...
3.1

AC...

Result - Mozilla Firefox

File   Edit   View   Go   Bookmarks   Tools

Customize Links   »

Applet BehaviorRecorderApplet loaded

Mozilla Firefox

PalmVx

NYC   (Note) (Map)(More)
Metropolitan Museum of Art
1000 5th Ave & 82nd St.
Subway:4,5,6(86 St)
Bus:M4   Tel:212-535-7710
Open: Sun, Tue, Wed, Thu
         9:30-5:30pm; Fri, Sat

At 82 St

Internet www.metmuseum.org

Behavior Recorder

top

Movies

call

NU

ChoiceWay Guide New York

-1,Maps

state1

-1,Upper

state2

-1,MET

state3

-1,MET_S

state4

-1,MET_b

state5
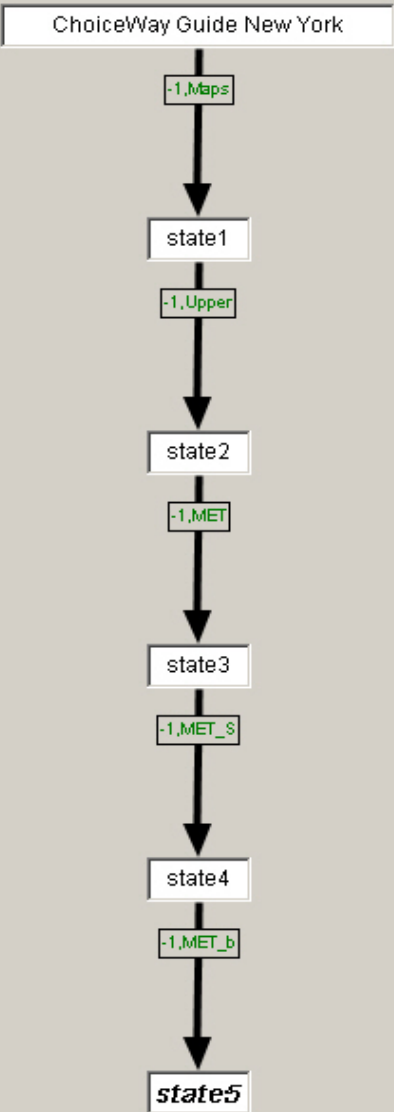
Executing Model map_srt_0330.asb

Restart   Total time: 8.811001

ACT-R

Time 8.456: Klm-Look-At-15 Selected
Time 6.506: Klm-Look-At-15 Fired
Time 6.506: Module :VISION running command MOVE-ATTENTION
Time 7.506: Klm-Move-Mouse-16 Selected
Time 6.556: Klm-Move-Mouse-16 Fired
Time 6.556: Module :MOTOR running command MOVE-CURSOR
Time 6.591: Module :VISION running command ENCODING-COMPLETE
Time 6.591: Vision sees WIDGET40
Time 6.656: Module :MOTOR running command PREPARATION-COMPLETE
Time 6.706: Module :MOTOR running command INITIATION-COMPLETE

Time 7.051: Device running command MOVE-CURSOR-ABSOLUTE
Time 7.101: Module :MOTOR running command FINISH-MOVEMENT
Time 7.101: Klm-Think-17 Selected
Time 8.301: Klm-Think-17 Fired
Time 8.301: Klm-Find-18 Selected
Time 8.351: Klm-Find-18 Fired
Time 8.351: Module :VISION running command FIND-LOCATION
Time 8.351: Vision found LOC46
Time 8.351: Klm-Look-At-19 Selected
Time 8.401: Klm-Look-At-19 Fired
Time 8.401: Module :VISION running command MOVE-ATTENTION
Time 9.401: Klm-Move-Mouse-20 Selected
Time 8.451: Klm-Move-Mouse-20 Fired
Time 8.451: Module :MOTOR running command MOVE-CURSOR
Time 8.486: Module :VISION running command ENCODING-COMPLETE
Time 8.486: Vision sees WIDGET45
Time 8.501: Module :MOTOR running command PREPARATION-COMPLETE
Time 8.551: Module :MOTOR running command INITIATION-COMPLETE

Time 8.761: Device running command MOVE-CURSOR-ABSOLUTE1510
Time 8.811: Module :MOTOR running command FINISH-MOVEMENT
Time 8.811: Checking for silent events.
Time 8.811: * Nothing to run: No productions, no events.

User study

- 10 expert PDA users (Female:Male = 3:7)
- At least one year experience using:
  - Palm series, pocket PC, or smart cell phone

- Instructed to perform the task on a PalmVx
  - Using four different methods (within subject design)
- Training session before real session
  - Repeating each method for 10 times

- Data collection
  - EventLogger: records system events to a log file
  - Videotaped modeler's behavior for verification

New results since paper published

- Better estimation of system response time
- Latest version of CogTool
- Detailed analysis of model and user traces (140/400 removed)
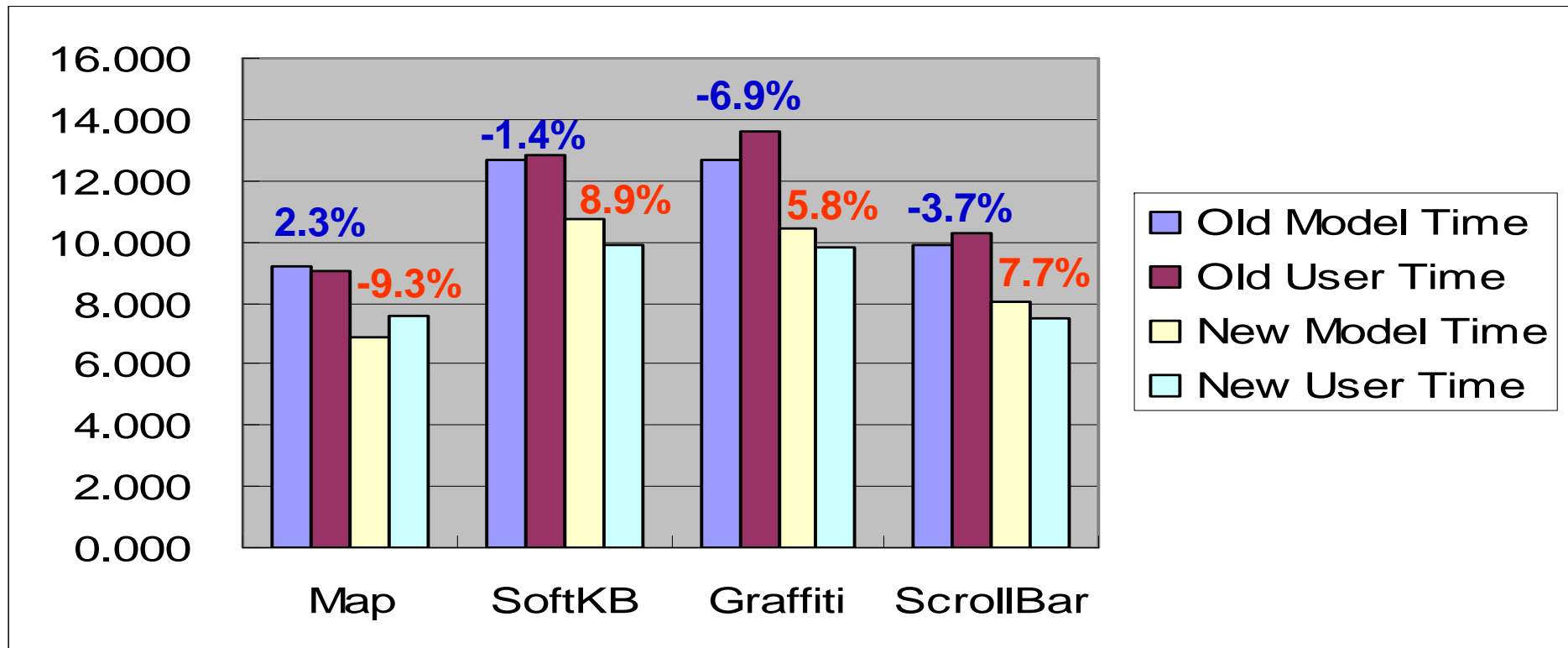
Conclusion & Future work

- KLMs produced with CogTool are effective for handheld user interfaces:
  - Produces accurate execution time prediction
  - Supports new input modalities: Graffiti

- Future work:
  - Detailed analysis of the user pauses (mental time)
  - Use predictions of pauses to assist energy management

Thank you!

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- The CogTool project:
  - http://www.cs.cmu.edu/~bej/cogtool/