Community-Driven Adaptation: Automatic Content Adaptation in Pervasive Environments

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One Size Does Not Fit All!

Useful Customizations

- Plethora of techniques for transforming content
  - Modality
  - Fidelity
  - Layout
  - Summarization
- Distinct content types usually benefit from different transformations
- Most transformations have configuration parameters that can be varied

How do we choose?

Content Adaptation

- Manual Adaptation
  - High human cost, not scalable, difficult to maintain consistency and coherence
- Automatic Adaptation
  - Rule-based and Constraint-based techniques are the state-of-the-art

Limitations of Rules and Constraints

- Specifying per-object, per-device, per-task rules is too much work
  - No different than manual adaptation
- In practice, a small set of global rules are utilized
- Global rules are insufficient because they are content and task agnostic

Fidelity sufficient to distinguish which object is a cell phone but not determine manufacturer visually

Core Issues

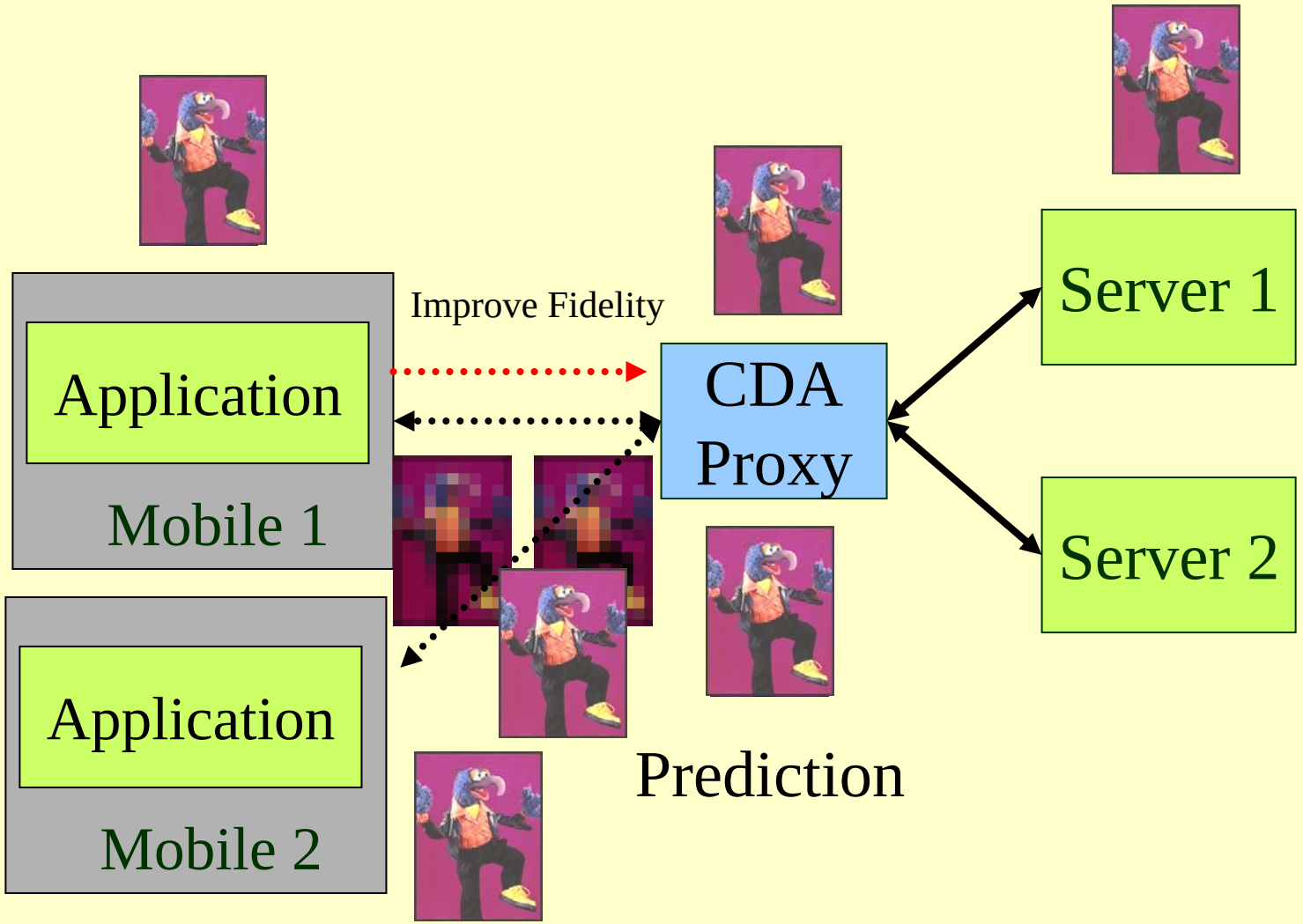
- Need rule for every object, device, task
  - Computer alone can't do it
  - Human Designer can, but it is costly and does not scale

- Idea:
  - Let user make corrections
  - Apply decision to like-minded users

Community-Driven Adaptation (CDA)

- Group users into communities based on adaptation requirements
- System makes initial prediction as to how to adapt content (use rules and constraints)
- Let user fix adaptation decisions
  - Feedback mechanism
- System learns from user feedback
- Improve adaptation prediction for future accesses by member of community

How it Works


Improve Fidelity
Application
Mobile 1
Application
Mobile 2
CDA
Proxy
Server 1
Server 2
Prediction

Advantages

- User Empowerment: Can fix bad adaptation decisions
- Minimal Inconvenience: Burden of feedback is spread over entire community and is very low for each member
  - User does not have to provide feedback in every interaction

Research Issues

- How good are CDA predictions?
- How do we classify users into communities?
  - How large of a community do we need?
- What interfaces would encourage users to provide feedback?
- Types of adaptations supported by this technique?

Experimental Evaluation

- How do we quantify performance?
  - Extent to which predictions meet users' adaptation requirements?

- Approach:
  - Step 1: User study
    - Collect traces capturing the adaptation desired by actual users for realistic tasks and content
  - Step 2: Simulation
    - Compare predictions to values in trace

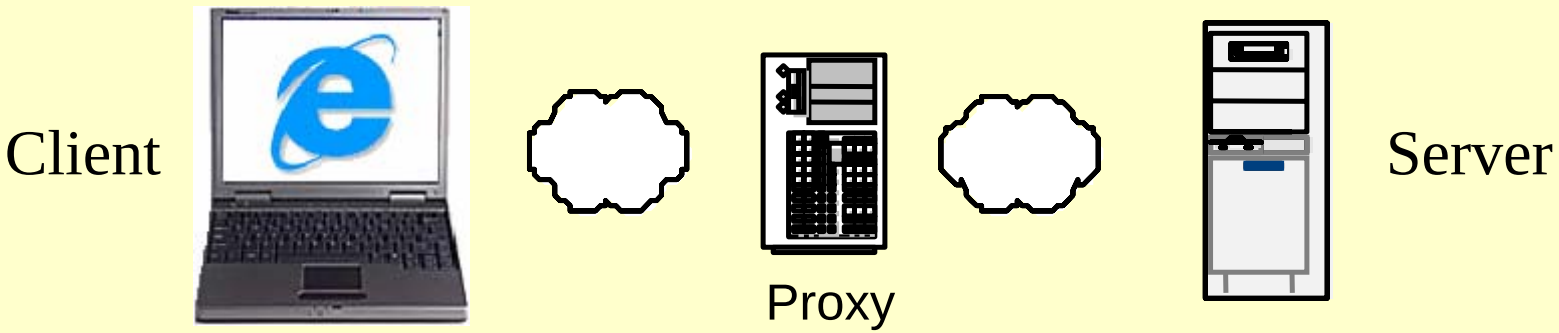
Experimental Setup

- 1 application
- 1 kind of adaptation
- 1 data type
- 1 adaptation method
  - Web browsing
  - Fidelity
  - Images
  - Progressive JPEG compression

- 1 community
  - Same device
    - Laptop at 56Kbps
  - Same content
  - Same tasks

Trace Gathering System

- Goal: Capture the desired fidelity level of a user for every image in a task



- Transcode images into progressive JPEG
- Provide only 10% on initial page load
- IE plug-in enables users to click on an image to request fidelity refinements
  - Each click increases fidelity by 10%
  - Add request to trace

Web Sites and Tasks

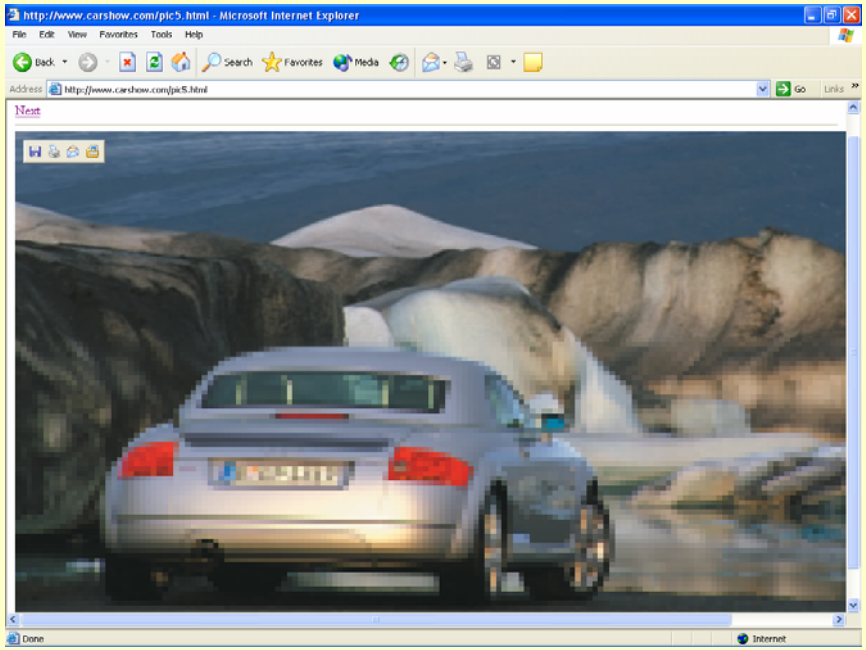
Sites	Tasks
Car show	Find cars with license plates
E-Store	Buy a PDA, Camera and Aibo based on visual features
UofT Map	Determine name of all buildings between main library and subway

Goal: finish task as fast as possible (minimize clicks)

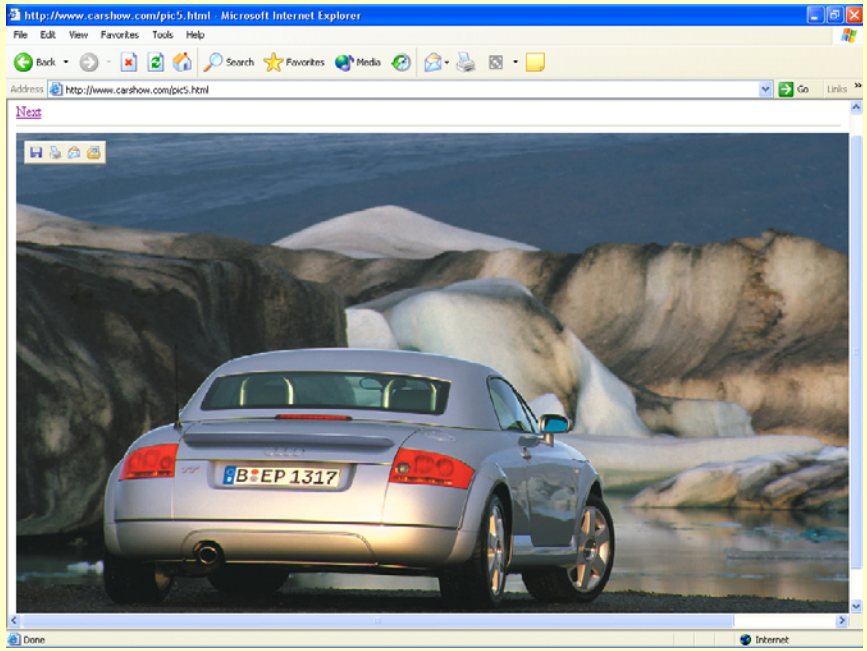
Traces capture minimum fidelity level that users' consider sufficient for the task at hand.

Sample Web Site and Task Screenshot

Car show application



Lowest fidelity



Improved fidelity

Trace Characteristics

- 28 users
- 77 different full-sized images
- All tasks can be performed with images available at Fidelity 4 (3 clicks)
- Average data loaded by users for all 3 tasks
  - 790 KB
- 32 images are never clicked by any user

Evaluation Metrics

	Fidelity Level Selected By User	Fidelity Level Predicted by Policy	
Image 1	3	3	Correct!
Image 2	2	3	Overshoot Extra Data
Image 3	4	2	Undershoot Extra Clicks

Examples of Policies

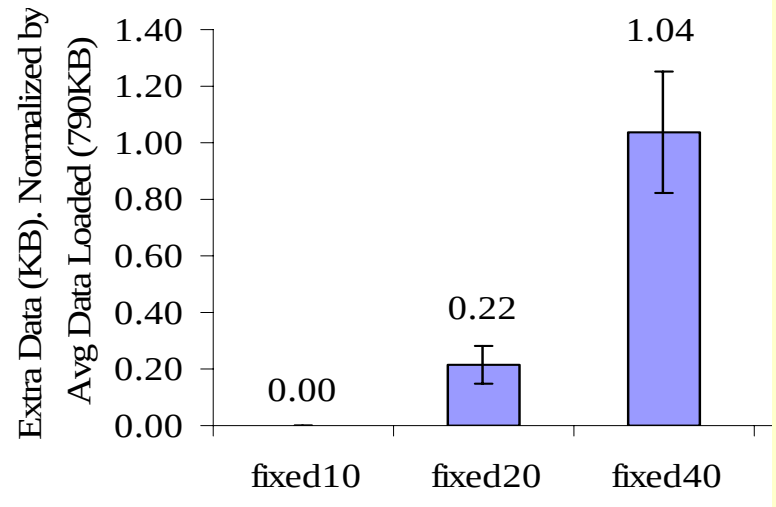
- Rule-based
  - Fixed1, Fixed2, Fixed4
  - Level based on file size
- CDA
  - MAX, AVG, MEDIAN, MODE
  - AVG3, MAX3
    - Limited window
  - UPPER60
    - Fidelity that covers 60% of requests

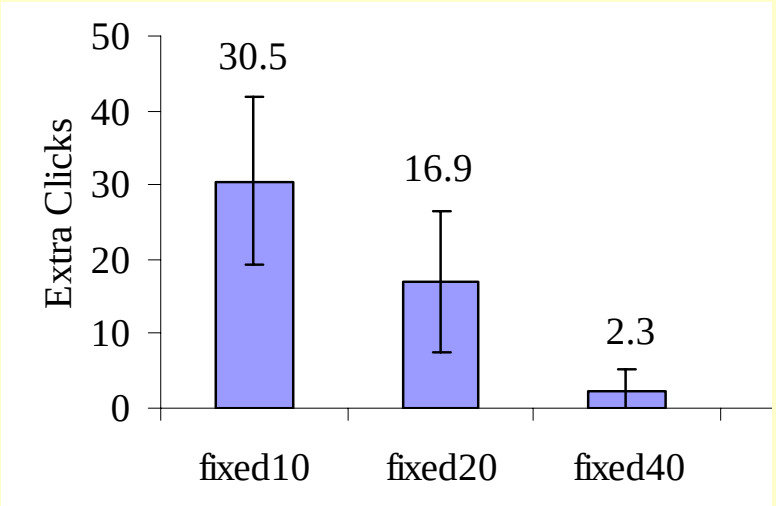
CDA User Ordering

- In practice, almost all users will access proxy after some history has been accumulated

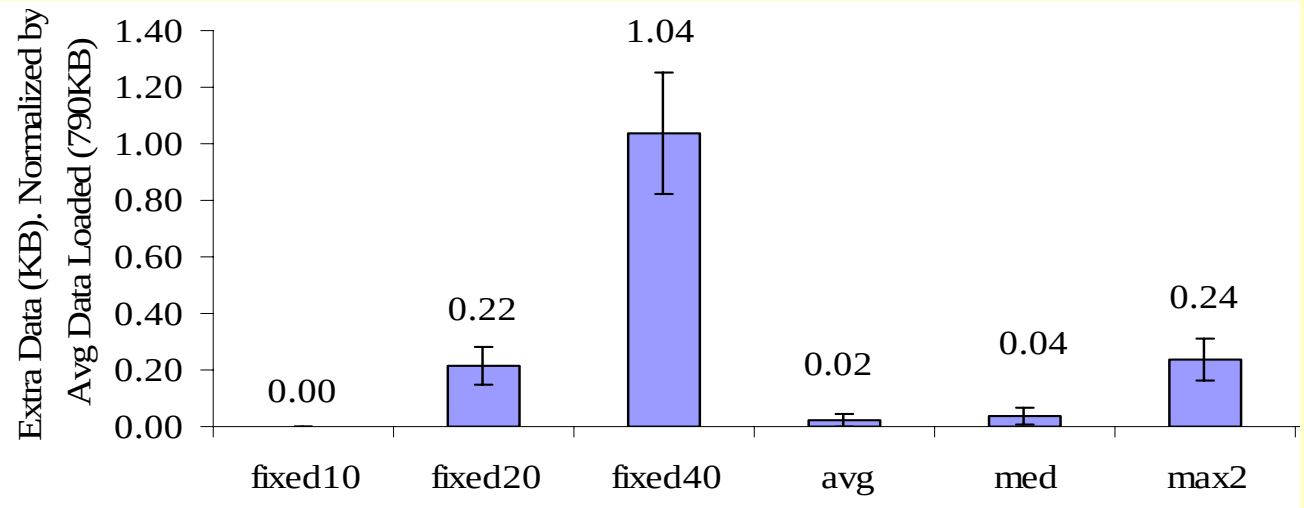
- Fix each user to be the last one
- Randomize ordering of previous users
- Average performance among all user-ordering combinations

Results


Extra Data (KB). Normalized by Avg Data Loaded (790KB)
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.00
0.22
1.04
fixed10
fixed20
fixed40


Extra Clicks
50
40
30
20
10
0
30.5
16.9
2.3
fixed10
fixed20
fixed40

Results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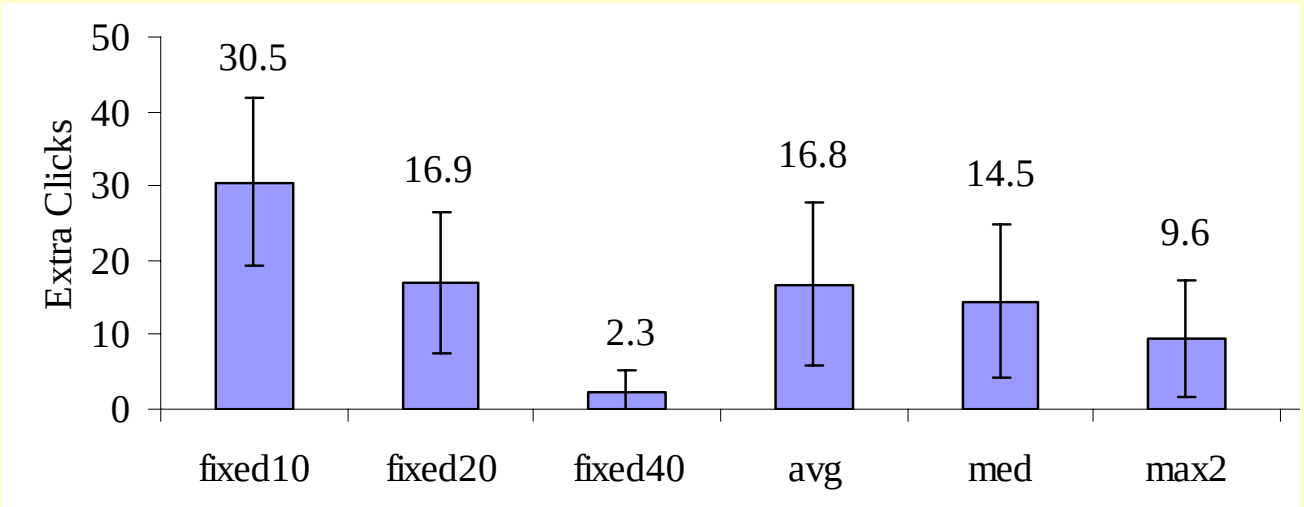
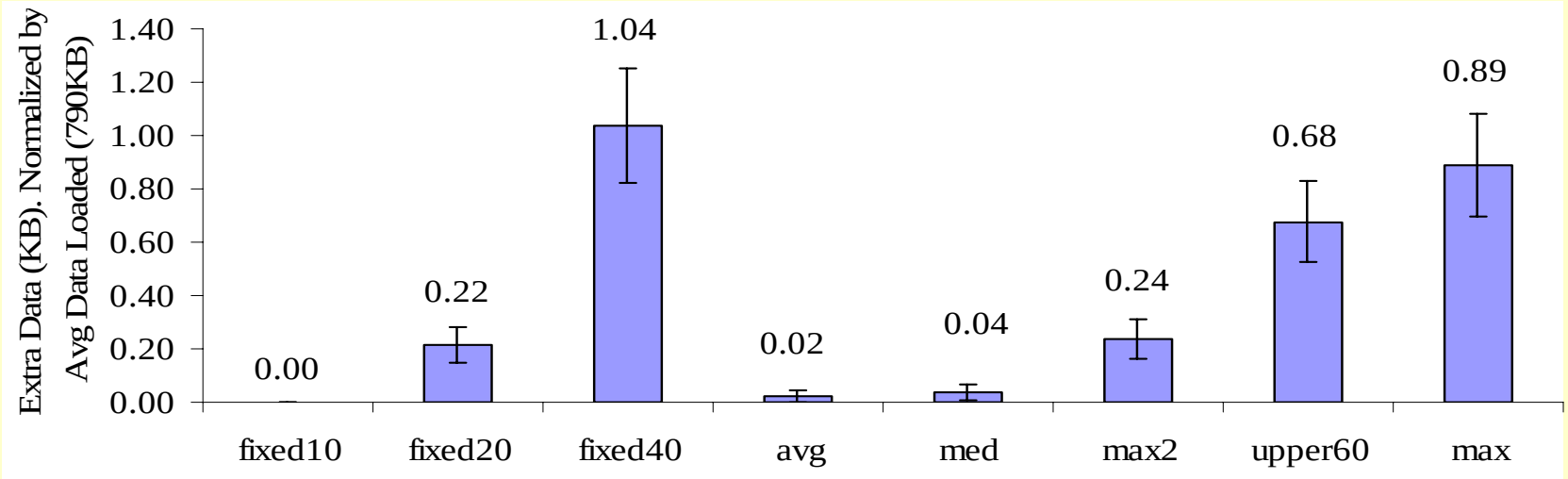
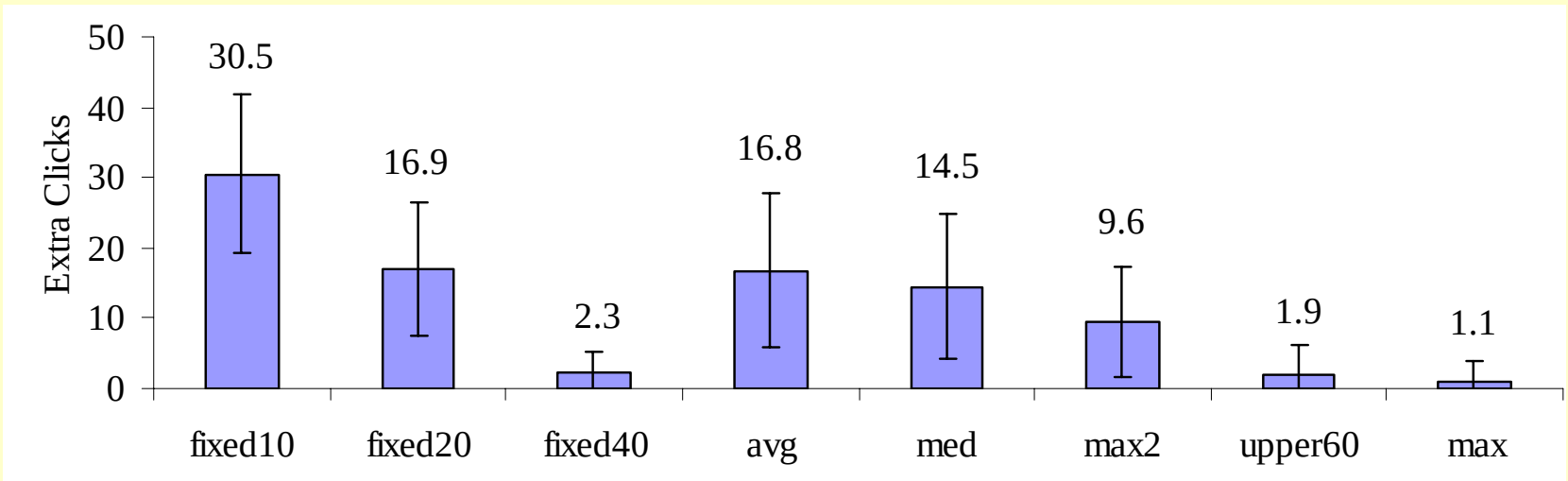
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.00
0.22
1.04
0.02
0.04
0.24
fixed10
fixed20
fixed40
avg
med
max2

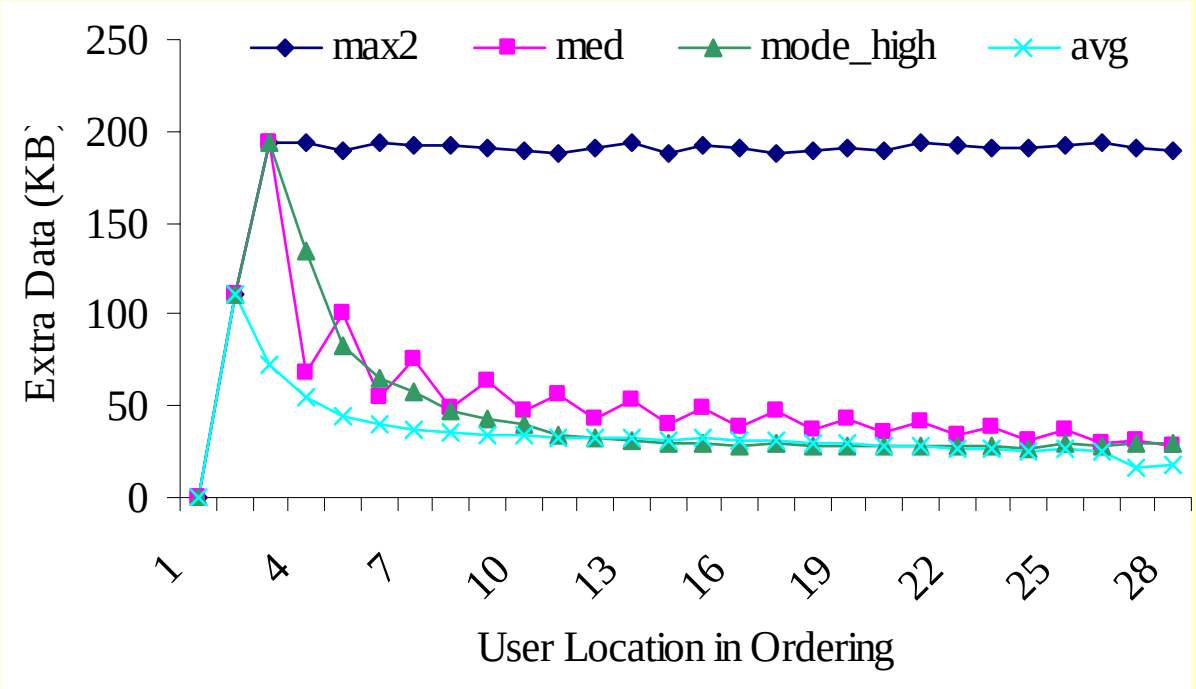

Extra Clicks
50
40
30
20
10
0
30.5
16.9
2.3
16.8
14.5
9.6
fixed10
fixed20
fixed40
avg
med
max2

Results


Extra Data (KB). Normalized by Avg Data Loaded (790KB)
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.00
0.22
1.04
0.02
0.04
0.24
0.68
0.89
fixed10
fixed20
fixed40
avg
med
max2
upper60
max


Extra Clicks
50
40
30
20
10
0
30.5
16.9
2.3
16.8
14.5
9.6
1.9
1.1
fixed10
fixed20
fixed40
avg
med
max2
upper60
max

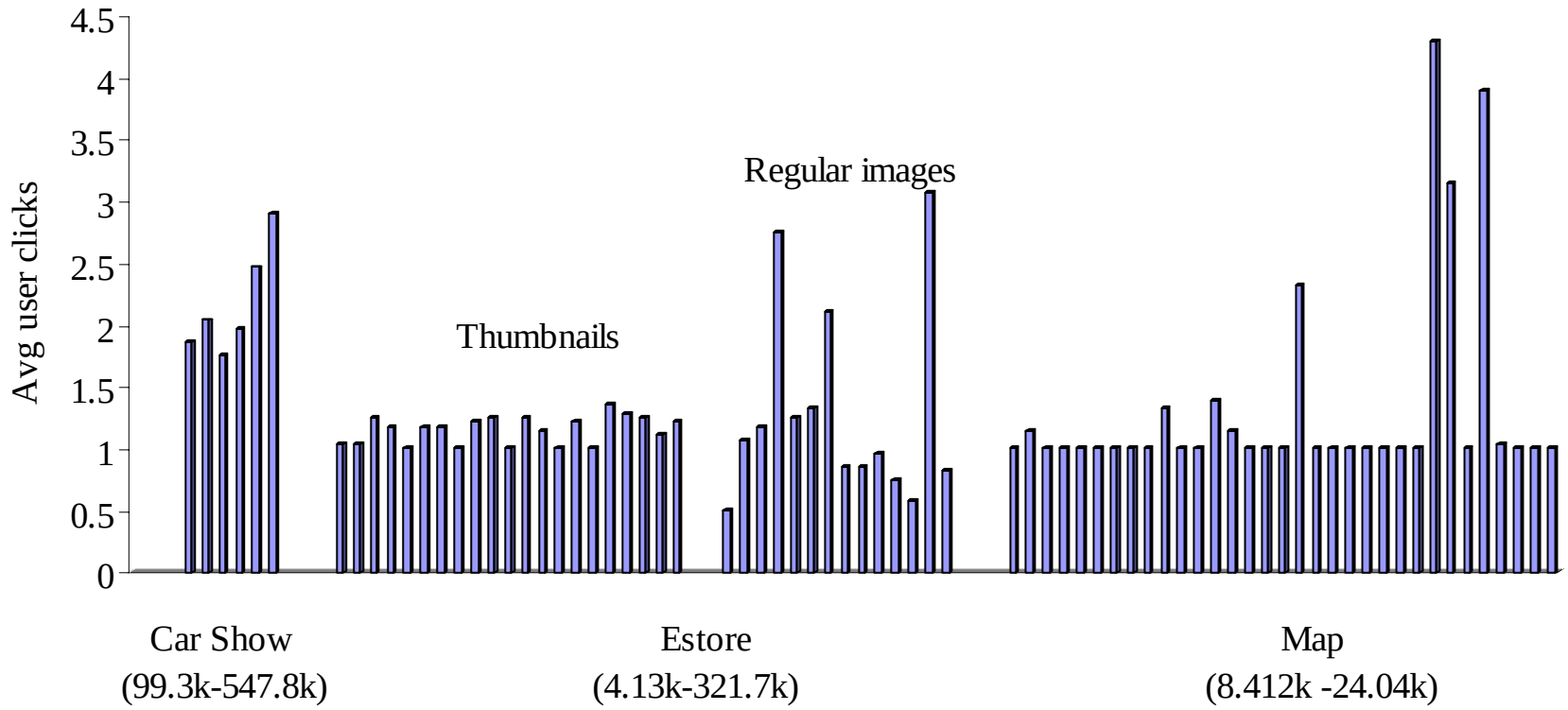
CDA Policy Convergence



Policies converge quickly

- Communities can be small

Size vs. Fidelity



No correlation between image size and optimal fidelity

- Size-based general rules will not work

Summary

- CDA
  - Groups users into communities
  - Improves adaptation based on user feedback

- CDA outperforms rule-based adaptation
  - ✓90% less bandwidth wastage
  - ✓40% less extra clicks

Questions and Comments

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