

CS 528:

Mobile and Ubiquitous Computing

Cost-Aware Mobile Web Browsing

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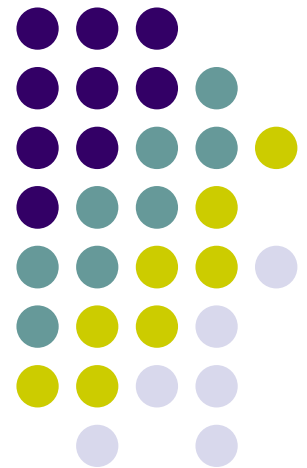
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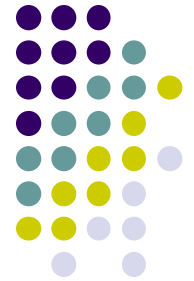
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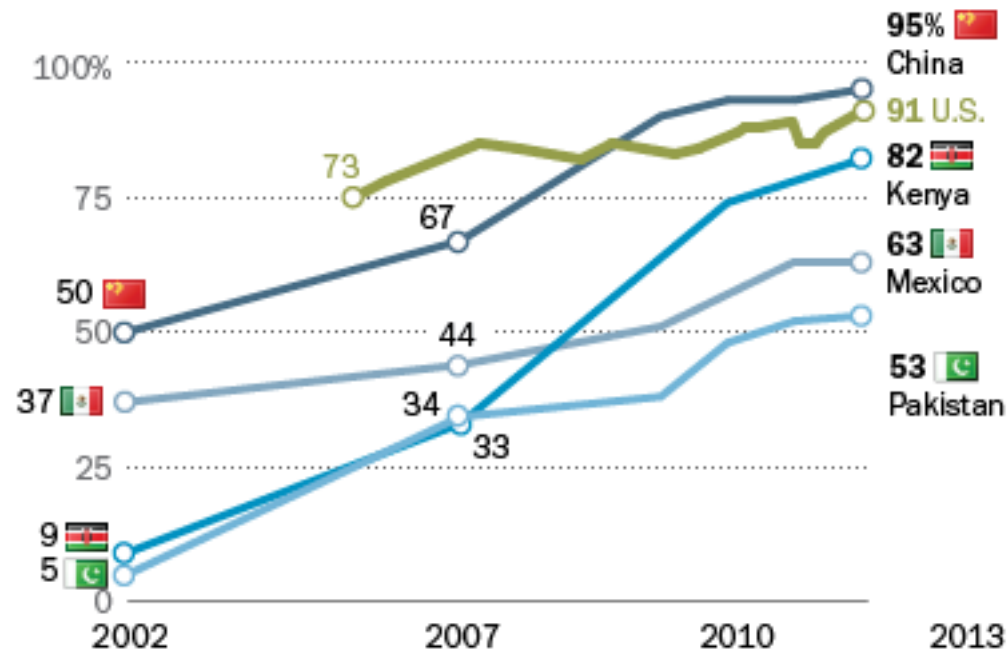


MOTIVATION



Sharp Rise of Cell Phone Ownership in Select Countries

Percent of adults who own a cell phone



PEW RESEARCH CENTER

<http://www.pewresearch.org/> ^[1]



MOTIVATION

- Usage based pricing – developing countries
 - 2MB download costs \$1
 - 22x growth in webpage size since 1999
 - 30x – 50x increase in #objects per page
 - Manual adaptation to mobile is impractical
-
- Get user's pricing plan
 - Automatically adapt web pages



VISION



- Adapt web pages to maximize utilization of pricing plan
- Support for multimedia-centric websites
- Robust to dynamic pricing model – based on
 - Congestion
 - Time of the day
 - Adapted pages



RELATED WORK

- RSS feed and Opera Mini ^[2]
 - Proxy based
 - Pre-renders pages
 - ✗ Not cost-based
- Content transformation
 - Suit small display – Layout change ^[3]
 - Split page to blocks and filter unnecessary ones ^[4]
 - User feedback ^{[5][6][7]}
 - ✗ None based on pricing plan

SYSTEM DESIGN



- 3-step approach
 1. Get the cost quota
 2. Adapt based on content adaptation ladder
 3. User feedback

SYSTEM DESIGN

COST QUOTA



- Two types of pricing plans
 - Constant rate model
 - charged α per MB $\Rightarrow Q = B/\alpha$ where B = budget
 - Bundle rate model
 - Charged C for Q MB. Beyond that, charged α per MB
 - Beyond Q , user specifies budget B and constant rate model is applied

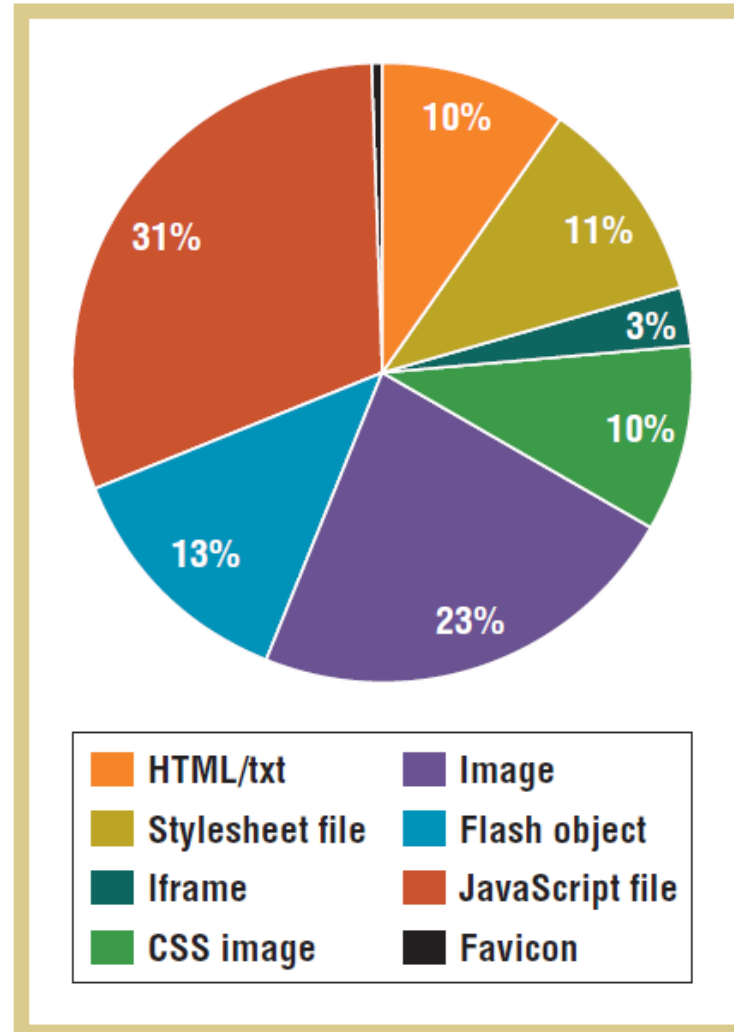
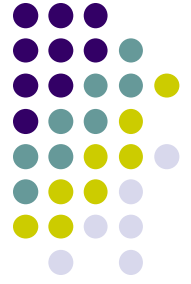
- Quota for a web request

$$\frac{(Q - q(t)) \times t}{n(t) \times (T - t)}$$

T – billing cycle days
t – time elapsed during current billing cycle
q(t) – quota consumed till t
n(t) - #requests made till t

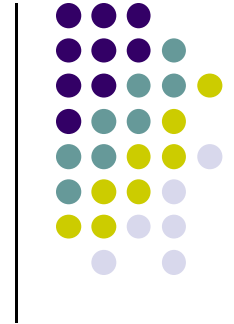
SYSTEM DESIGN

CONTENT ADAPTATION LADDER



SYSTEM DESIGN

CONTENT ADAPTATION LADDER



- 6 Levels - 2 categories

- Text-only Ladder

- Snippet
- Text-only
- Page Summarization (Level 0)

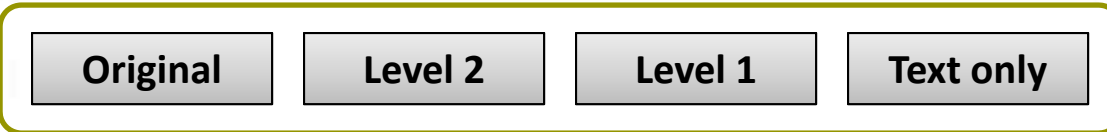
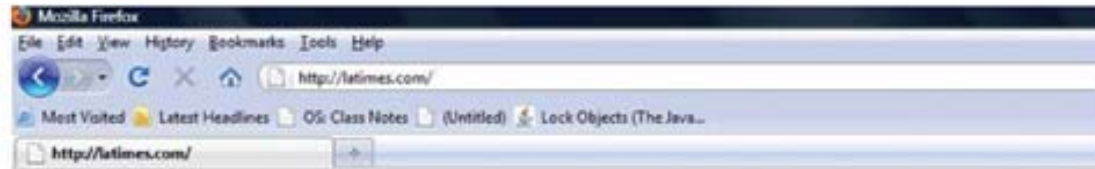
$$\hat{n}_i = \frac{\sum_{k=-p}^p n_{i-k} e^{-\frac{2k^2}{p^2}}}{\sum_{k=-p}^p e^{-\frac{2k^2}{p^2}}}$$

- Advanced Ladder

- Level 1 – HTML, CSS, Iframe, JS and heading images
- Level 2 – Level 1 + compressed images
- Level 3 – Level 2 + embedded objects

SYSTEM DESIGN

USER FEEDBACK



User
Feedback

[Plane crash guts leadership, opens wounds for Poland](#)

[4 missing miners found dead](#)

[The surprisingly liberal legacy of Justice Stevens](#)

[Woods birdies at hole 13, now tied for third at Masters](#)

[Spotlights from the Los Angeles Times](#)

[Health](#)

[Are eggs truly bad for the heart?](#)

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[Catalina Island: 15 free activities and half off new zipline](#)

[Home](#)

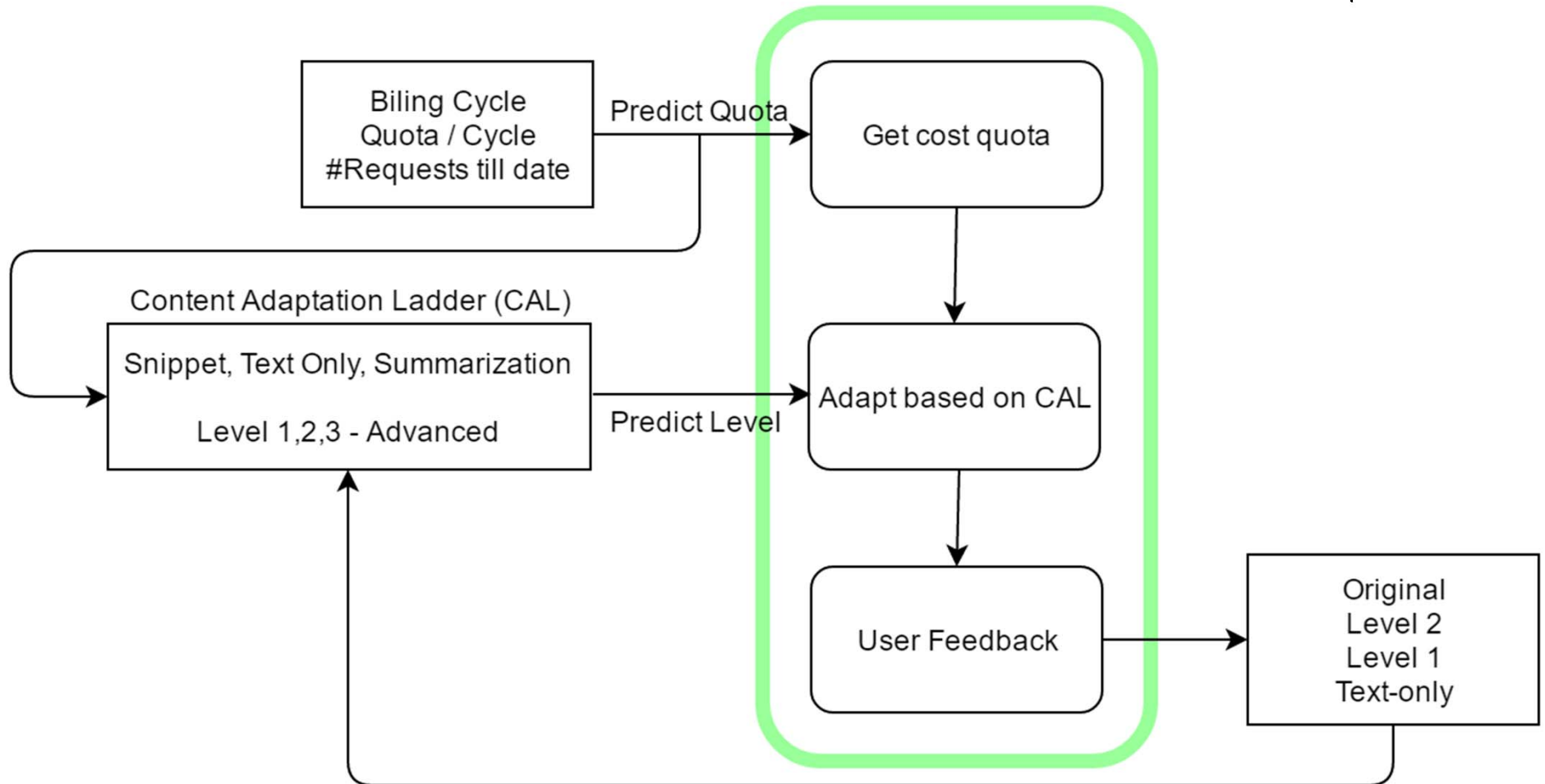
[Affordable housing goes green too](#)

[Image](#)

Done



SYSTEM DESIGN - SUMMARY



Flow Chart drawn using <https://www.draw.io/>

IMPLEMENTATION



- System Architecture - 2000 lines Java code - 2 Modules
 - Proxy – Service Page Requests
 - Listen on port 7500, spawn new thread, read cost parameters from disk and store user state in memory
 - Receives web-page, compute quota
 - Adapt according to CAL, send page to user, update cost info
 - Local Storage
 - Lightweight DB – XML files
 - Stores registered user id, data plan and cost quota
 - Performance – user record update after service



EVALUATION

- Alexa's list of most popular web pages^[8]
- Three key results :-
 1. Adaptation Ladder
 - Study system behavior – Levels 0, 1 and 2
 - Manually tested for wide range of sites
 2. Size Reduction
 - Cumulative distribution of reduction factor for page size
 3. Cost Savings
 - Tested for two quotas - 10 MB/day and 5 MB/day

RESULTS – ADAPTION LADDER: LEVEL 2



Original images

Masterful Mickelson Wins Third Jacket

Phil Mickelson's five-under classic round is just enough to hold off challengers at Augusta.

Complete 2010 Masters leaderboard

Where did Tiger Woods finish?

Slideshow: See action from Sunday's final round

1 of 5

MUST-SEE NEWS TRAVEL DO THIS!

Obama faces global nuclear realities

Video: What brought down Polish president's jet?

Commander: Apollo 13 was 'successful failure'

Video: Space shuttle era nears the end

Blast rattles U.K. spy HQ in N. Ireland

Senator will fight airline carry-on bag fee

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POPULAR SEARCHES

'A successful failure'

Forty years ago, Apollo 13 took one wild ride. Houston, we've had a problem here.

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Kissinger & homicide case | Boy terrified adoptive kin?

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Images down sampled

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MUST-SEE

NEWS

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TRAVEL

DO THIS!

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Kissinger & homicide case | Boy terrified adoptive kin?

Elephant kills circus worker | Virus & 40 child deaths

Wife Nelson's band & charges? | New Spiderman?

Planes hijack ship | Farmer congressman dies

Hal Holbrook mourns | Glenn Beck & \$32M paycheck

HOTMAIL

Sign in

Windows Live

Facebook

Advertisement removed

2x smaller



RESULTS – ADAPTION LADDER: LEVEL 1



Image removed

Original image

(a)

(b)



3x smaller

RESULTS – ADAPTION LADDER: LEVEL 0



(a)

(b)

Plane crash guts leadership, opens wounds for Poland

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Affordable housing goes green too

Image

Done

(b)

All formatting removed



50x smaller

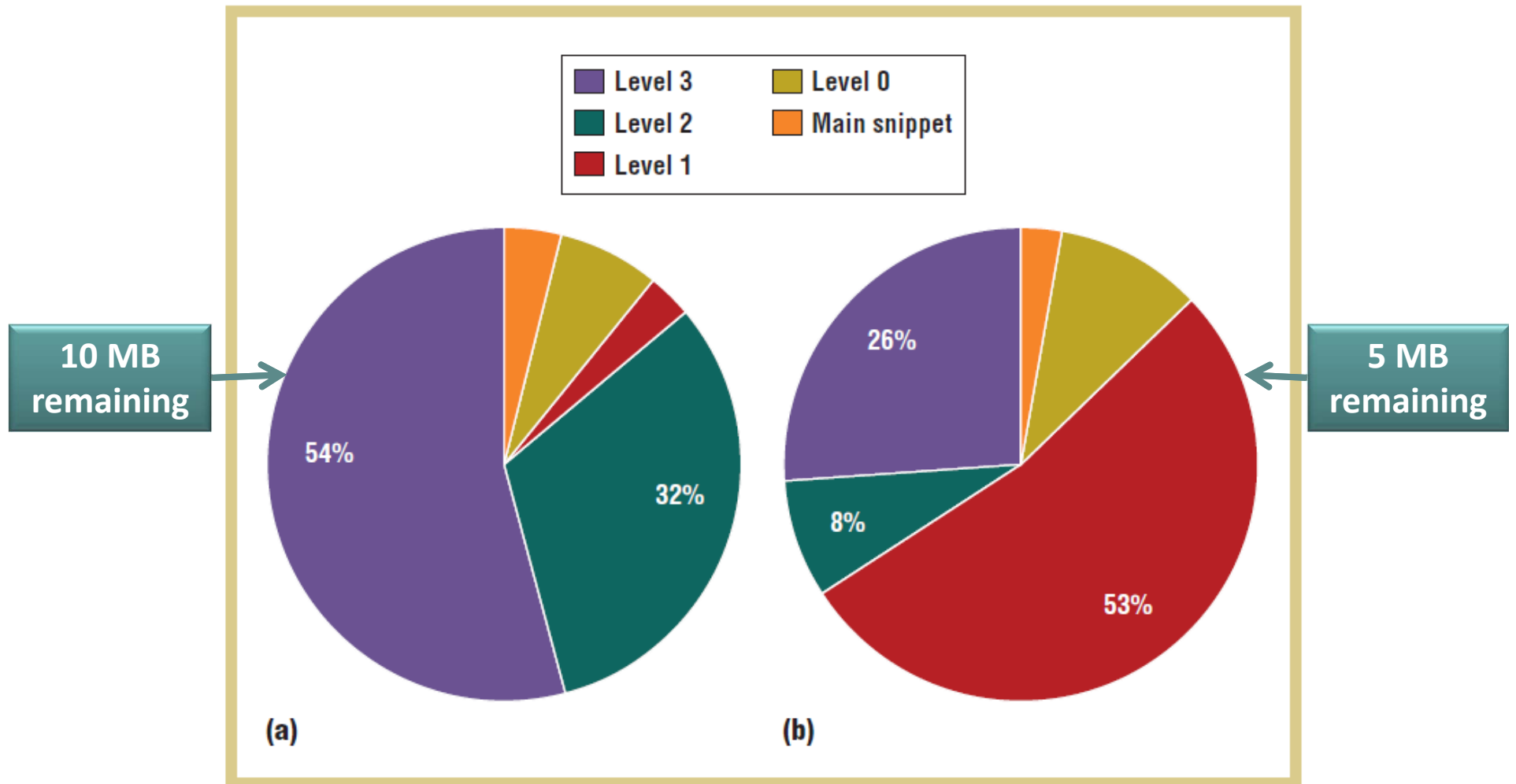
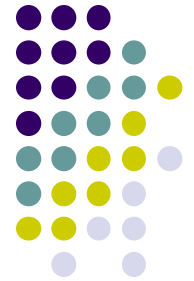


RESULTS – SIZE REDUCTION

Type	50%	75%	90%	95%
Snippet	110	200	300	350
Level 1	3	7	15	20
Level 2	2	5	10	16

Cumulative distribution of size reduction factor from original page

RESULTS - COST SAVINGS





SURVEY RESULTS

- Small scale user study - 7 US Grad Students

User	Overall satisfaction (0-5)	Use the proxy
1	4	Yes
2	4	Yes
3	4	Yes
4	3.5	Yes
5	3.5	Maybe
6	3	Maybe
7	3	No

CHALLENGES & CONCLUSION



- Network operators may switch to dynamic pricing
- Extension of framework for media-centric websites
- Increasing web page complexity may hamper adaptation ladder technique
- Difficulty in extracting relevant info

- Websites usage based content adaptation model
- This framework provides the foundation to build on

REFERENCES



1. <http://www.pewresearch.org/fact-tank/2014/02/13/emerging-nations-catching-up-to-u-s-on-technology-adoption-especially-mobile-and-social-media-use/>
2. A. Blekas, J. Garofalakis, and V. Stefanis, **“Use of RSS Feeds for Content Adaptation in Mobile Web Browsing”**
3. T. Laakko and T. Hiltunen, **“Adapting Web Content to Mobile User Agents”**
4. E. Lee et al., **“Topic-Specific Web Content Adaptation to Mobile Devices”**
5. P. Baudisch et al., **“Collapse-to-Zoom: Viewing Web Pages on Small Screen Devices by Interactively Removing Irrelevant Content”**
6. P.K. Mishra et al., **“User Interactive Web Content Adaptation for Mobile Devices”**
7. I. Mohomed et al., **“Context-Aware Interactive Content Adaptation”**
8. <http://www.alexa.com/topsites>



Thank you for your time



Questions?