Why the developing world needs a load of ¢a$hes {£¥€}

Or, A ~~The Design Philosophy of the DARPA Internet Protocols~~ for GAIA

Nishanth Sastry
King's College London

Two kinds of GAIA networks

Connectivity sharing overlays

* Incumbent provider is not doing a good enough job

* To enable new services over provider's network

Local loops

* Market is not big enough for provider to offer service

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Maine and Aberdeen are not South Sudan
This is not *just* a developing world problem!

Outline

- "Why": Purpose of connectivity sharing and local loops

- Design considerations

- The role of caches

Connectivity sharing nets

- Why: Under-utilised home internet connections can be shared

- Why: Expanding connectivity at home to guest access outside

- How: Mesh network - Meraki (roofnet)

- How: ISP connection share - Fon

- How: Less than Best Effort - PAWS

MIT
Roof net

FON

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Need exists.
Technical feasibility shown.
Business case developed.

MIT
Roof net

FON

WiFi EVERYW
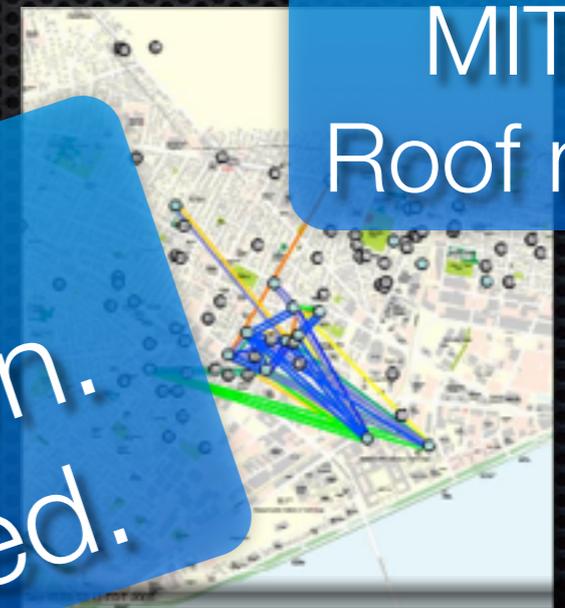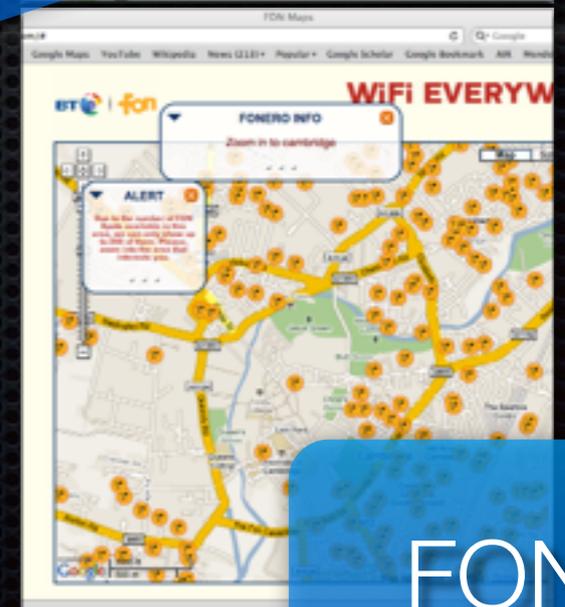
"Local-loop" networks

Digital Gangetic Plains

Berkeley/Intel TIER project
at
Aravind Eye Hospital

- Why: Wi-Fi cheaper than other solutions (cellular)
- New MAC protocols for long distance links
- Tuned for predictable performance
- (weather/line-of-sight requirement etc.)

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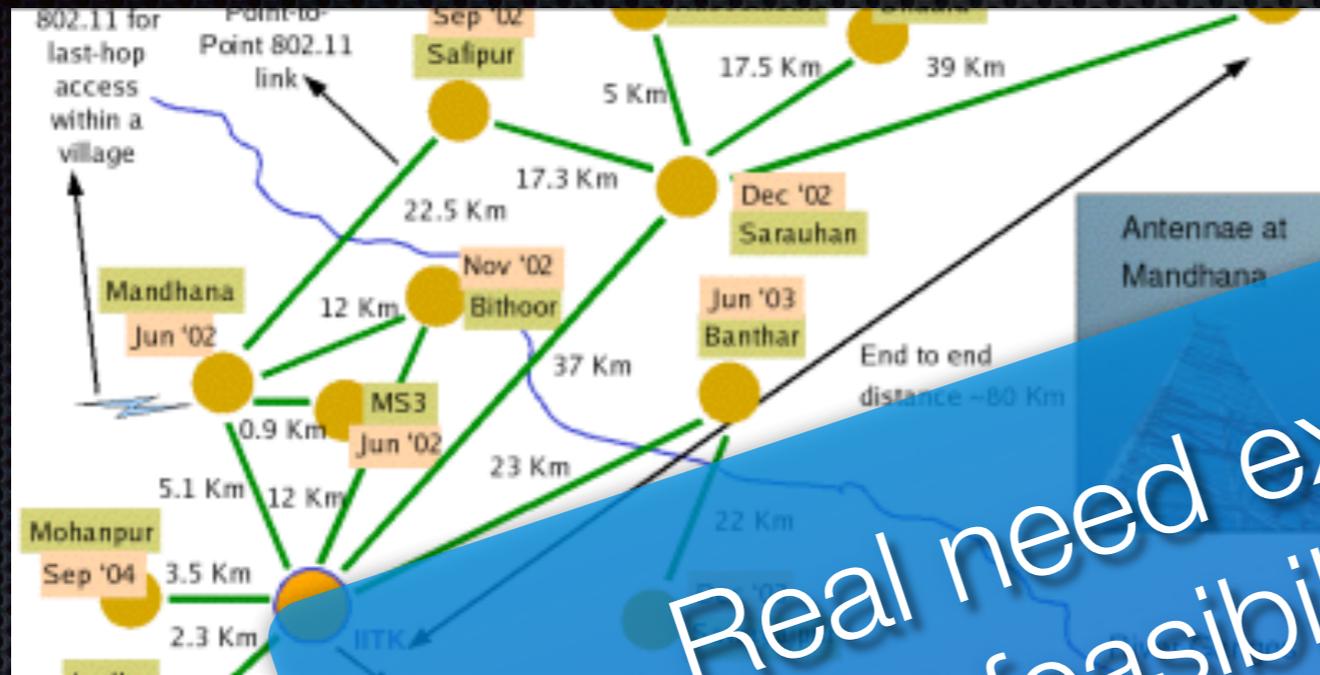
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So, what's next?

Are we on the right path?
What should GAIA's design considerations be?

Networks need killer apps
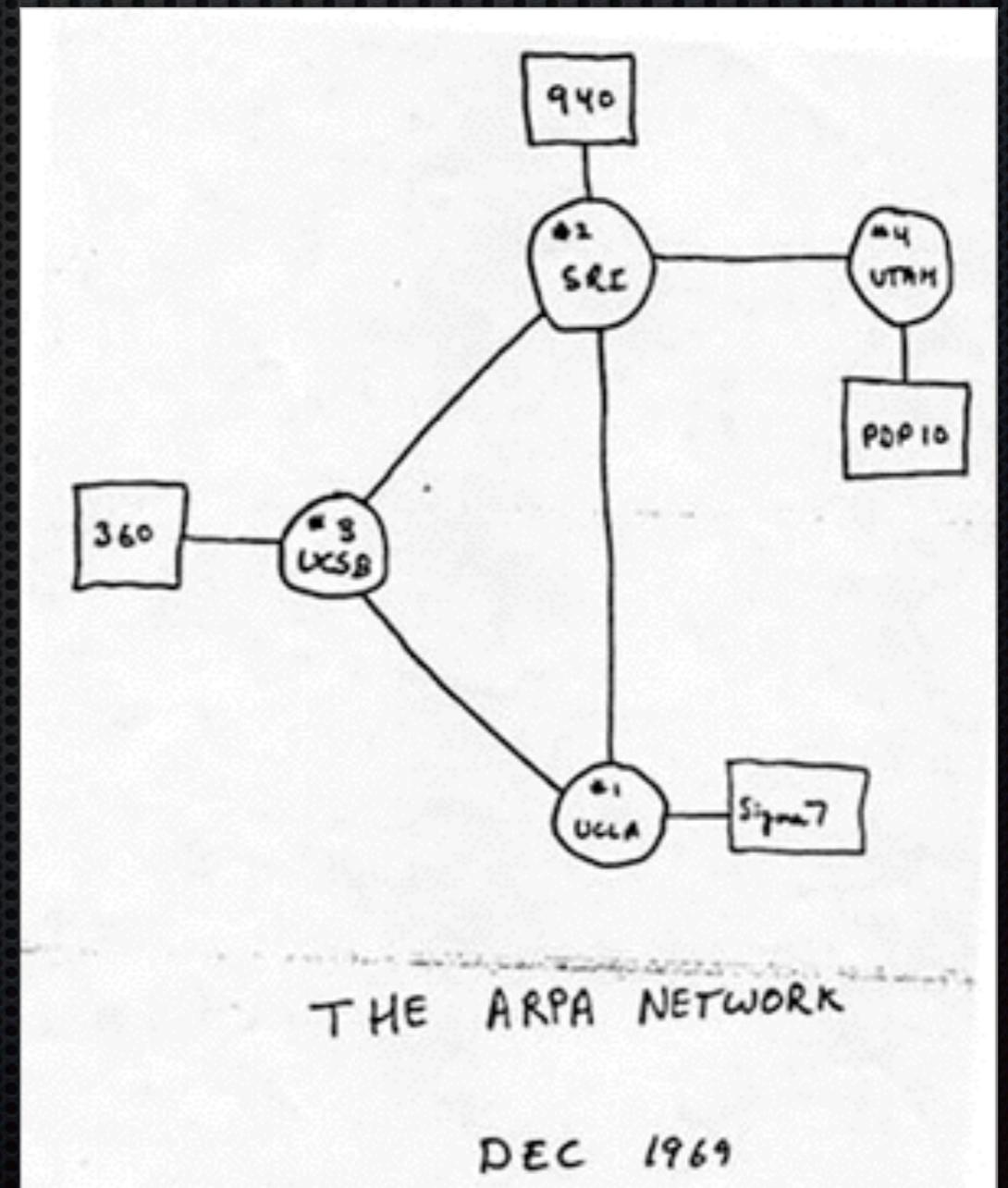
Networks need killer apps

The Internet only became World-Wide after the Web was invented
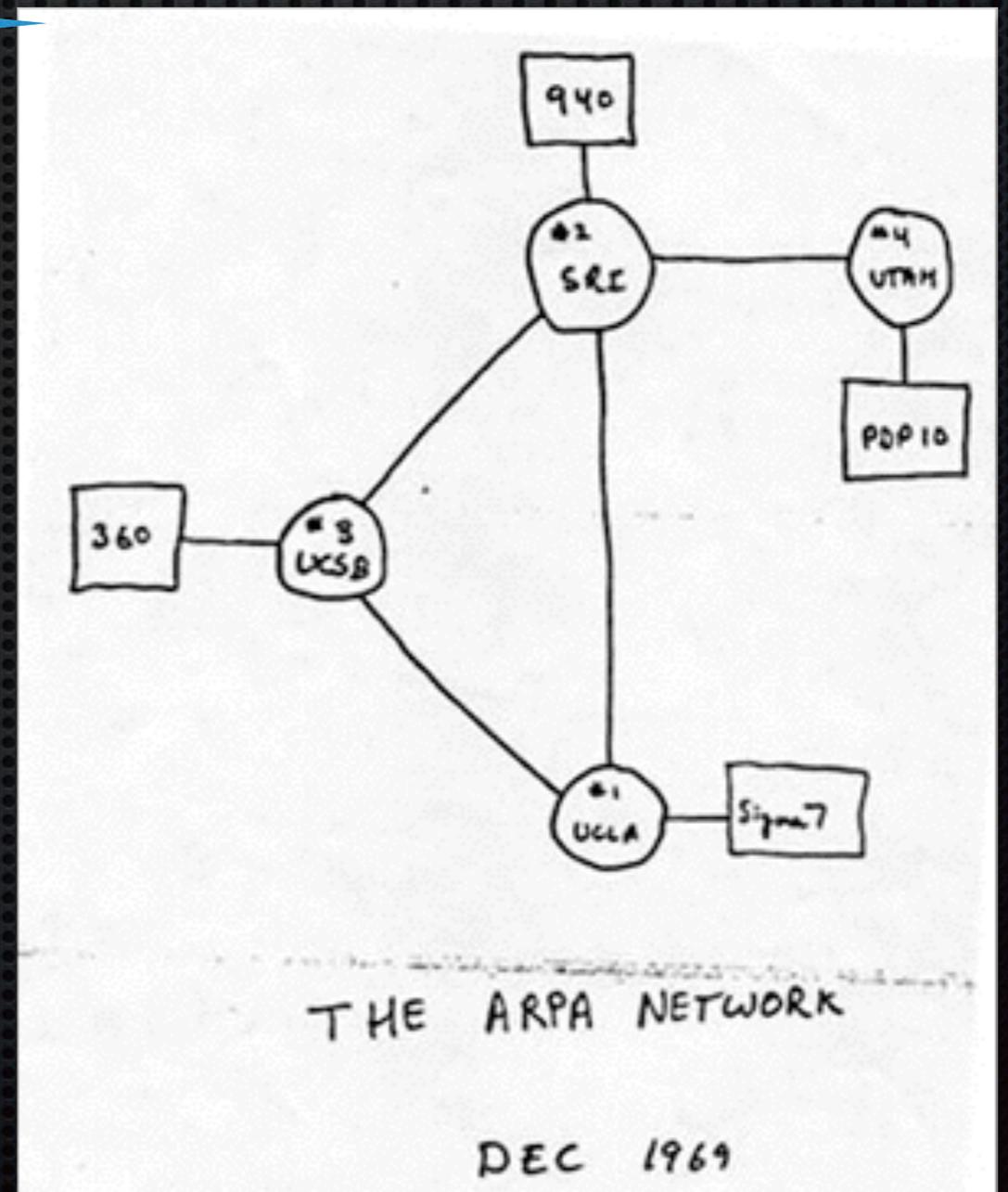
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'If you "hang out" at a village communications store for few hours, you will witness many young folks come and ask for a phone that has Facebook on it' - Chintan Vaishnav on the GAIA mailing list
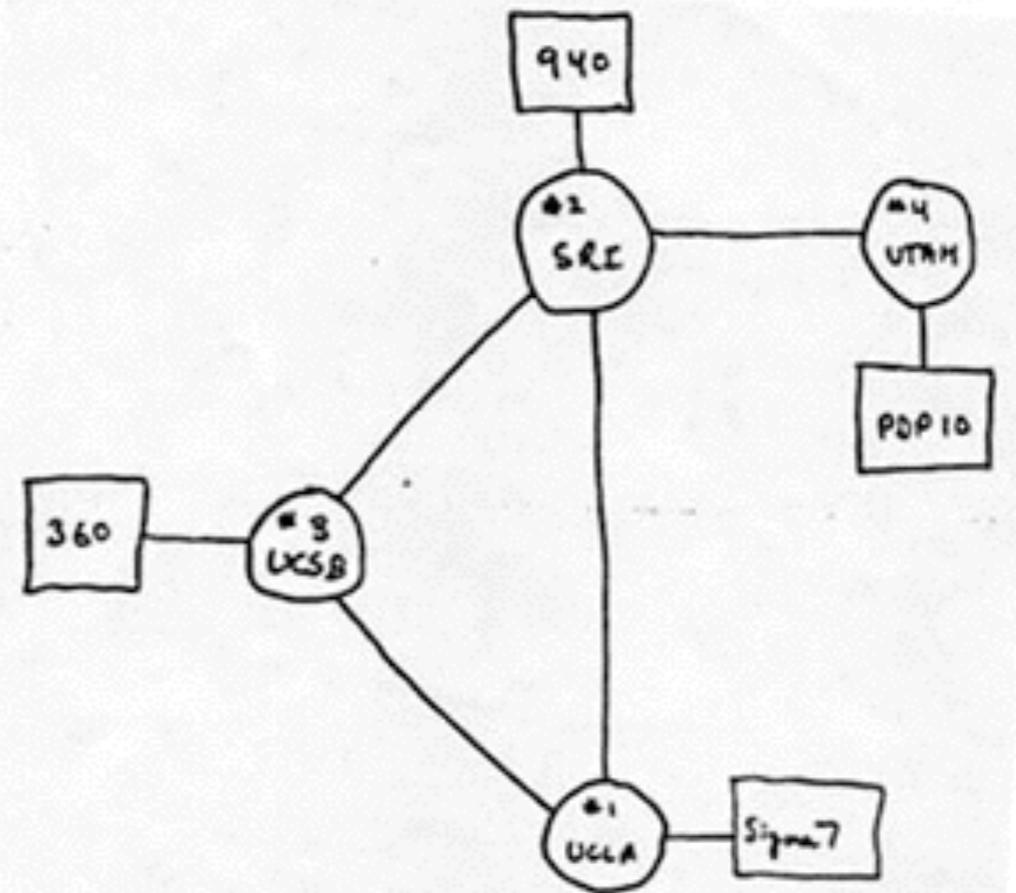
Is Facebook zero-rating the solution?

No! The Internet was built with a secret sauce that allowed the Web to become World Wide!
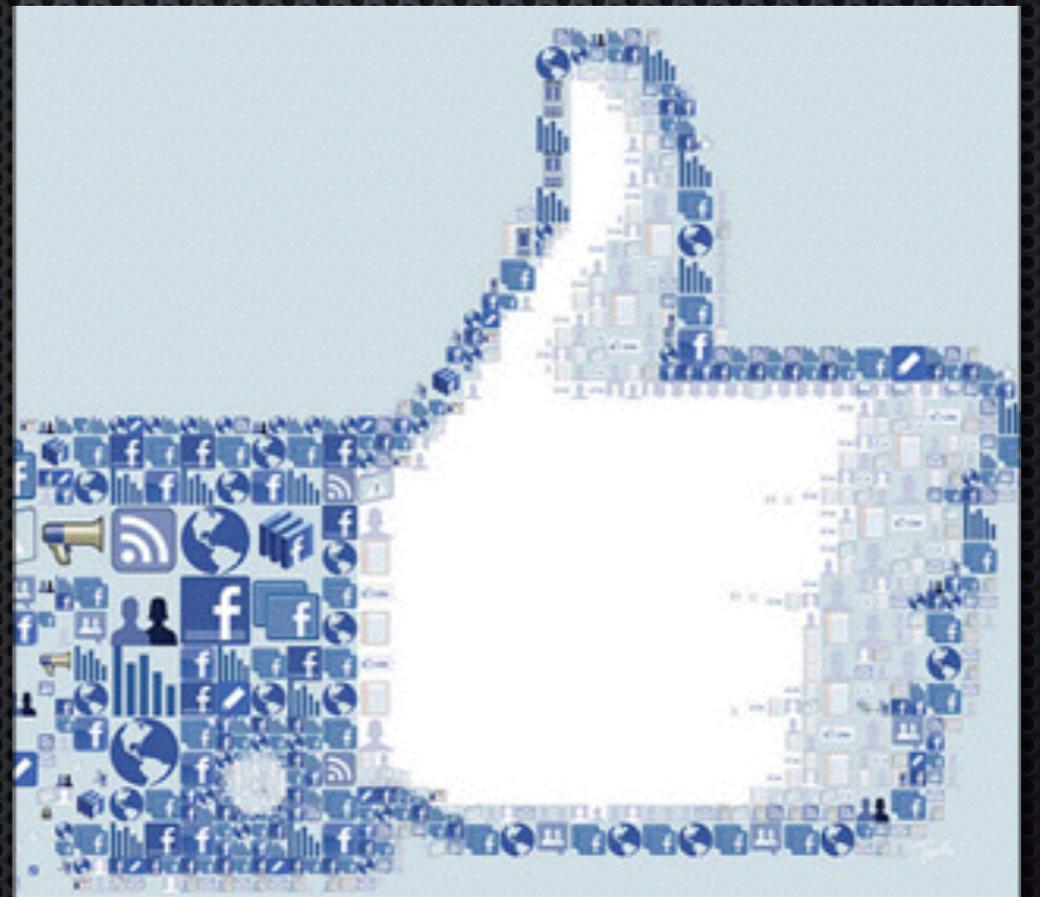
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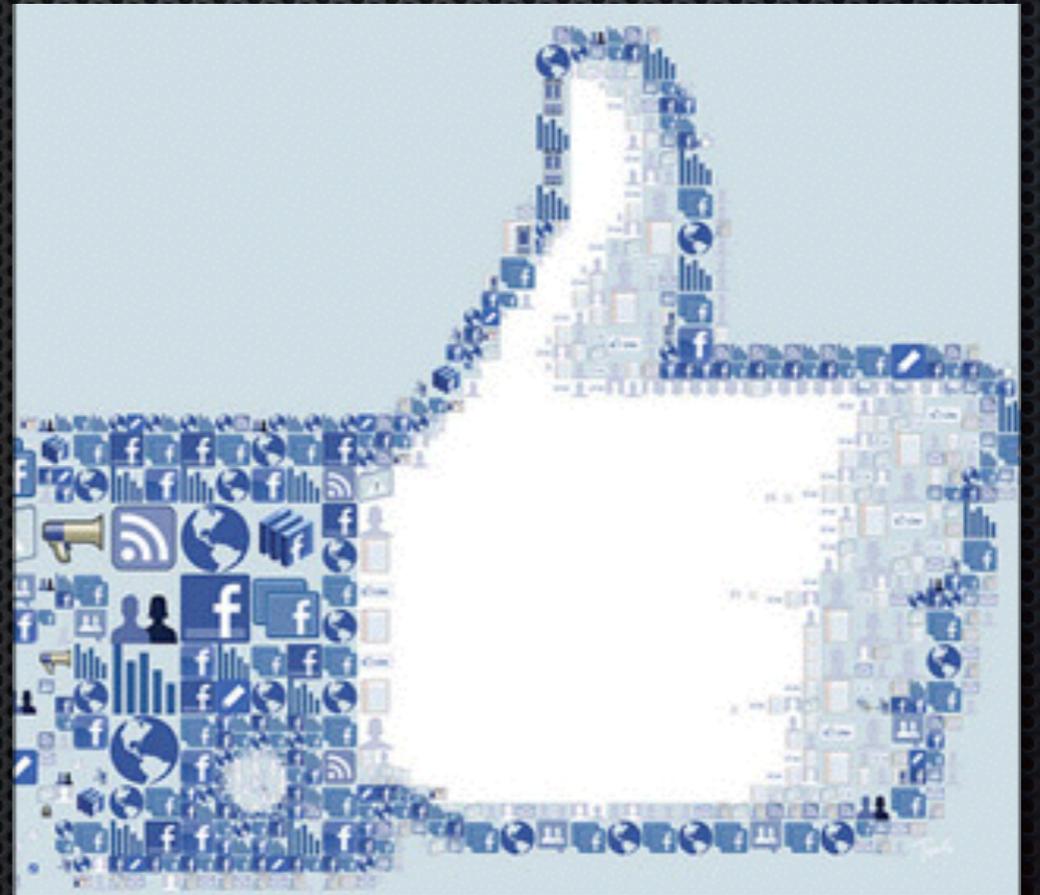
(Killer apps need killer infrastructure)

The Design Philosophy of the DARPA Internet Protocols

Secret Sauce

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Massachusetts Institute of Technology
Laboratory for Computer Science
Cambridge, MA. 02139

(Originally published in Proc. SIGCOMM '88, Computer Communication Review Vol. 18, No. 4,
August 1988, pp. 106–114)

Internet designed for heterogeneous connectivity

Enabled expansion to WWW scale when needed!

What should GAIA be designed for?

Case 1: local-loop nets

Surana et al (NSDI 2008)

Micro-operators and users are not technically savvy

- Circuit breakers can trip

- Flash card containing OS corrupted after power surge

- Routing misconfiguration is common

- Wall erected in front of antenna!

- loose cables

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Need to design for arbitrary link failures

Case 2: connectivity-sharing

Link availability is not guaranteed

- Link relinquished if primary user needs it (Fon/PAWS)

- Radio channel quality can vary (Meraki/RoofNet)

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Not that different from arbitrary link failure!

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   * Implementing functionality at the "correct" layer

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3. Expect topology to change

   - Yes, like ad-hoc nets, but don't jump to heal topology…

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- "I don't have Content X. Will Y be OK?" 😊

ICN: *-proof networks

- Tolerance to network partitions

- Tolerance to change in link quality (e.g., radio channels)

- Generally handles client mobility well (Tyson et al, CACM'13)

- Well suited for broadcast/radio access

  - REACH: Rural broadband intErnet Access using Co-operative mesh networking in wHite space spectrum

- Will hit ratios be high enough to make storage pay off?

- Amount of network state: at content item level rather than host address level

'Nudge' users to ⬆ hit ratio

- Current mindset: User is king

- Operators/providers attempt to satisfy all user accesses

- Idea: 'Nudge' user to behaviours better suited to network!
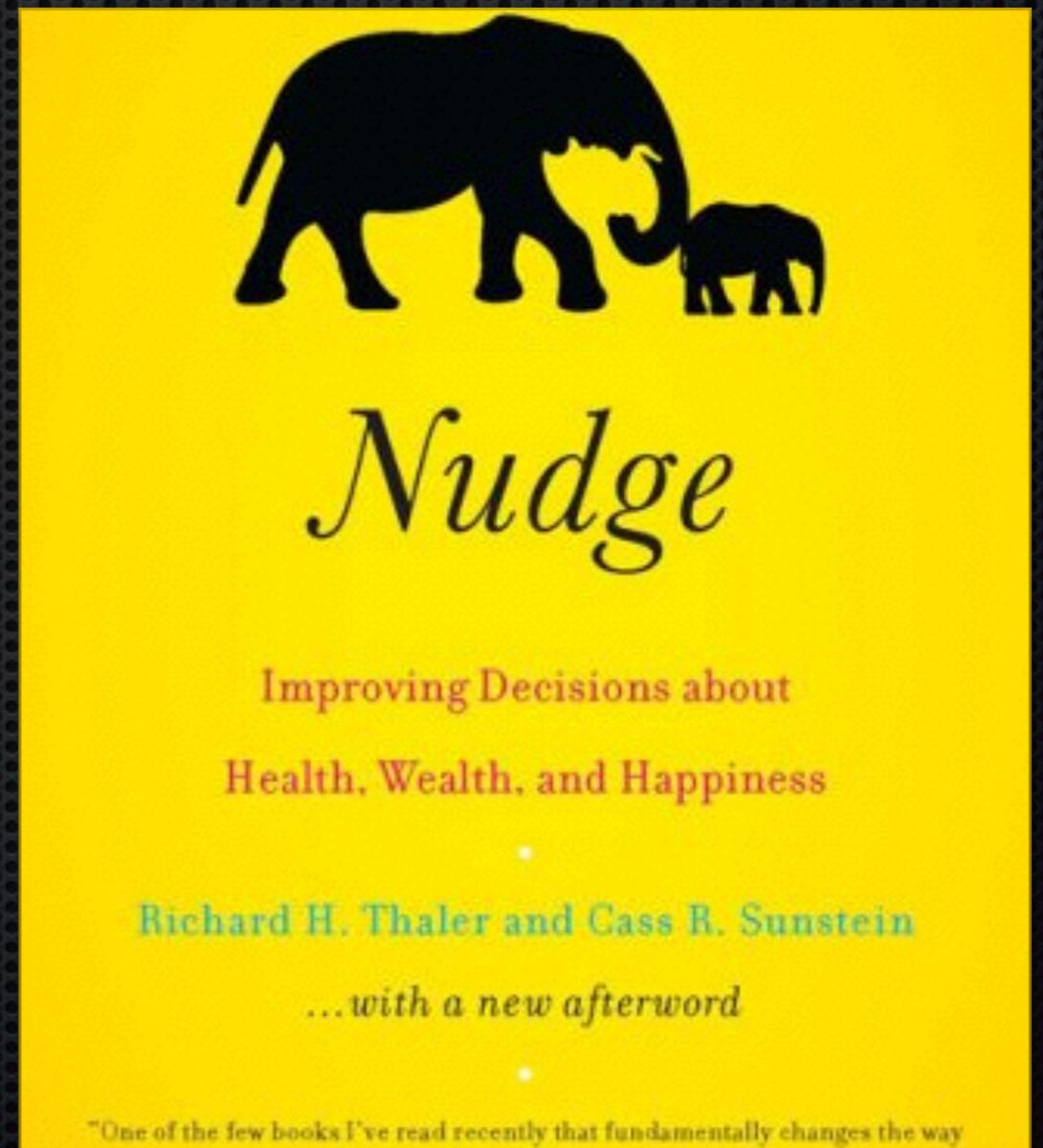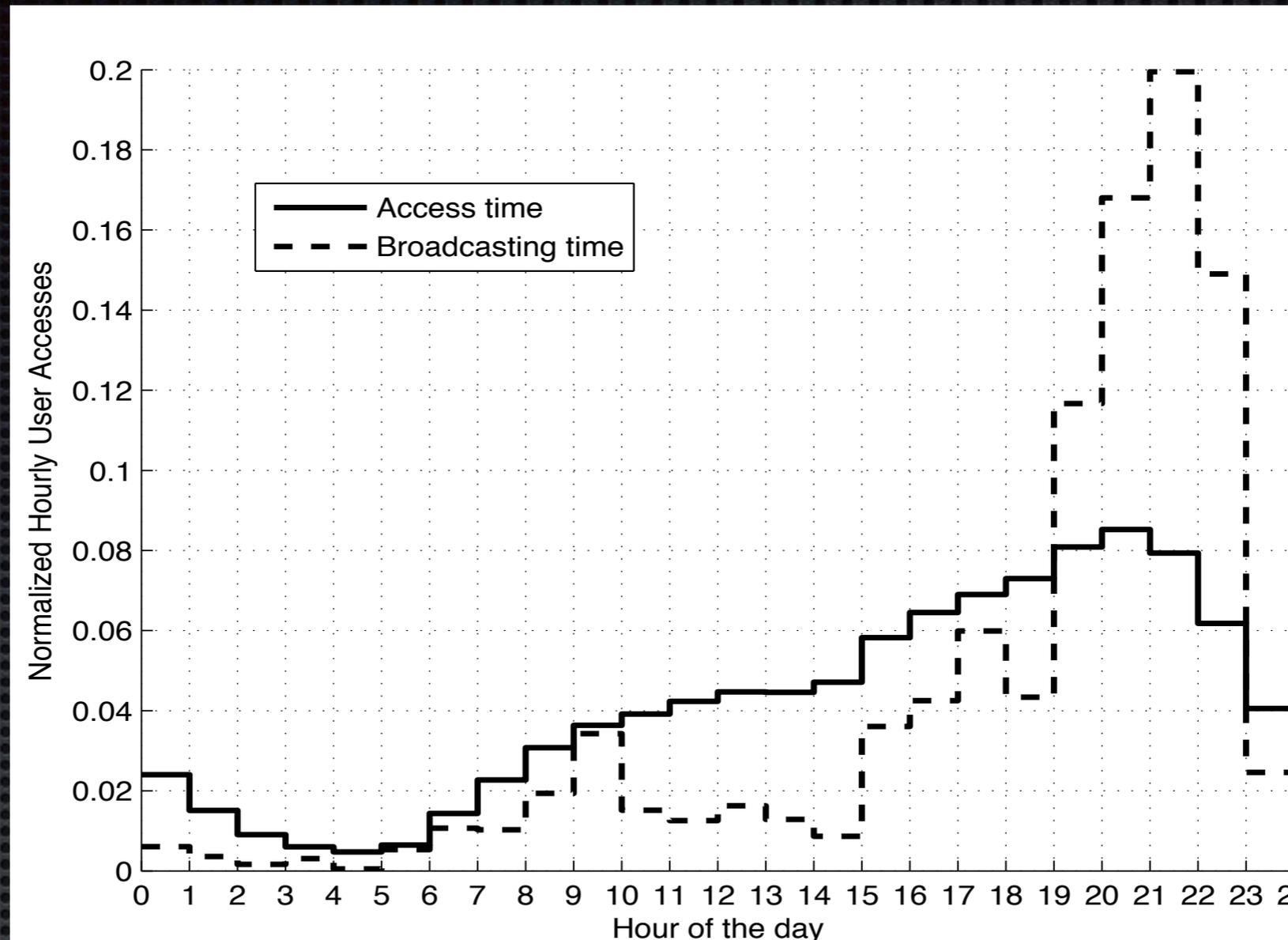
Nudge

Improving Decisions about
Health, Wealth, and Happiness

Richard H. Thaler and Cass R. Sunstein

...with a new afterword

"One of the few books I've read recently that fundamentally changes the way

Passive Nudging

Make it easy to choose best option for network

E.g.: Give users flexibility to choose time of access
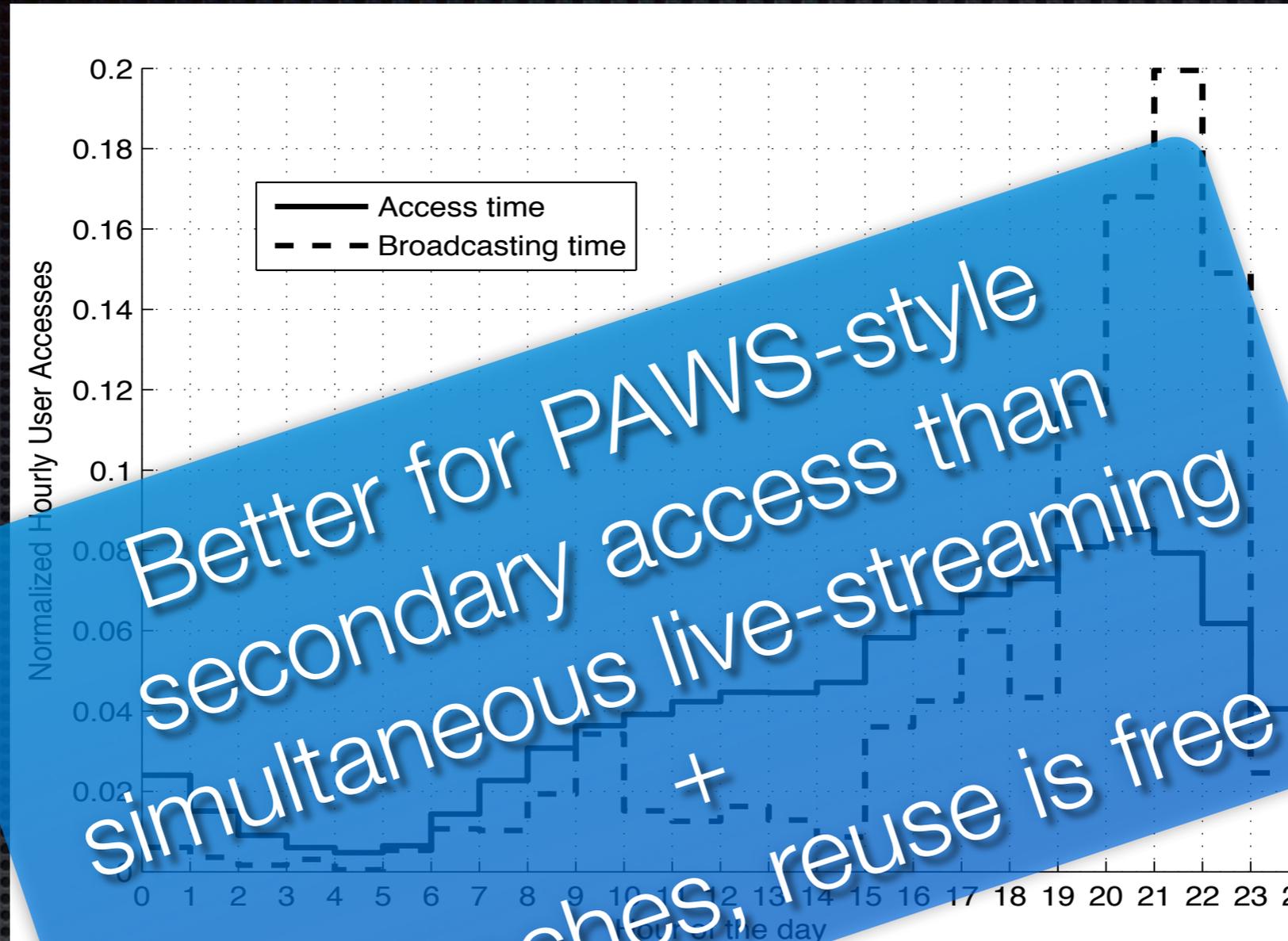
Better for PAWS-style secondary access than simultaneous live-streaming

+

With caches, reuse is free

Passive Nudging

Make it easy to choose best option for network

E.g.: Give users flexibility to choose time of access

Automatic nudging

Choose the best option for the network by profiling user access patterns

Digital Video Recorder

DTT Interface

Hard Disk

Internet

IP Network Interface

Television Set

Optimiser

π_i

Speculative pre-fetching has benefits when network costs are heterogeneous
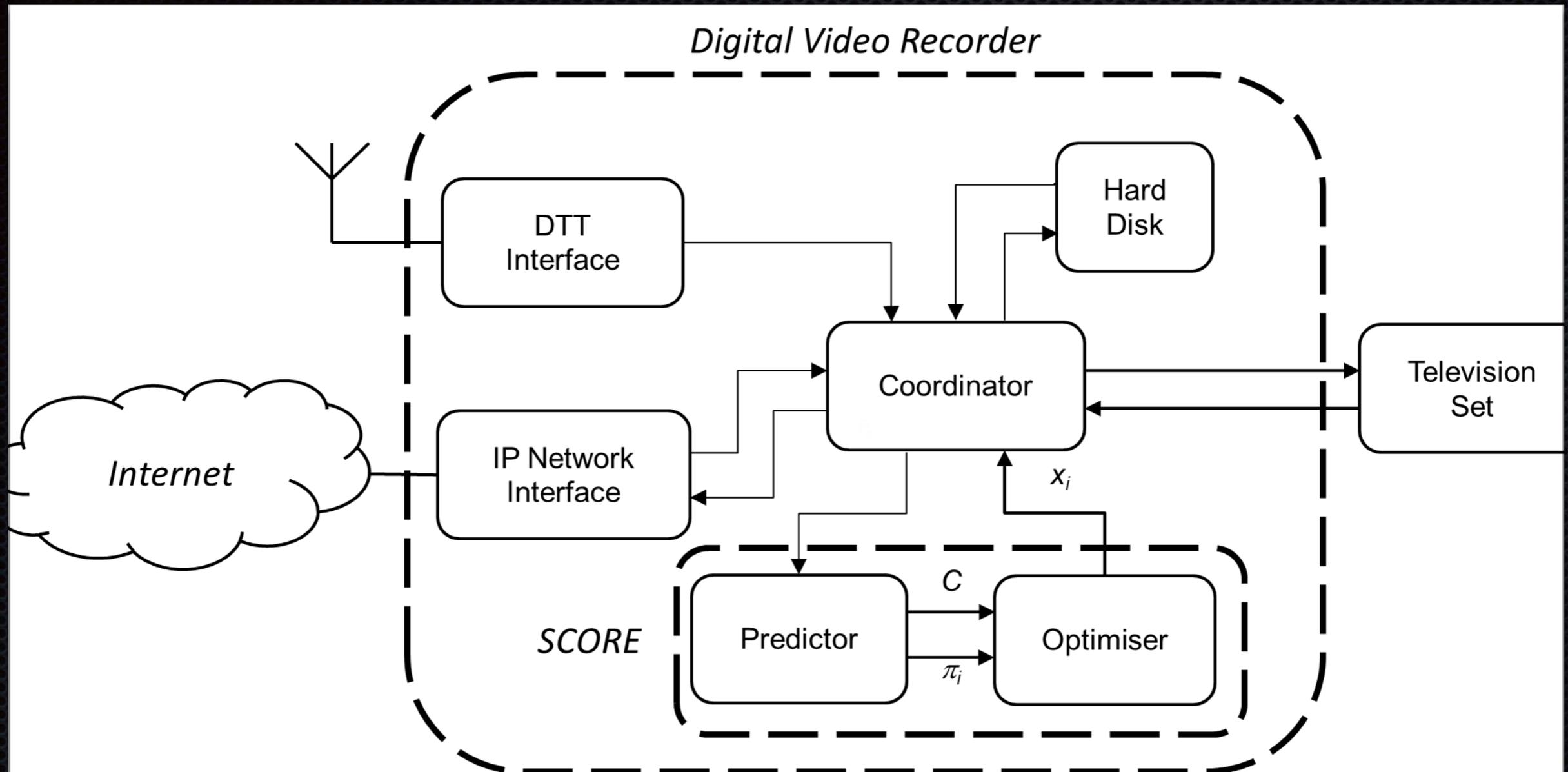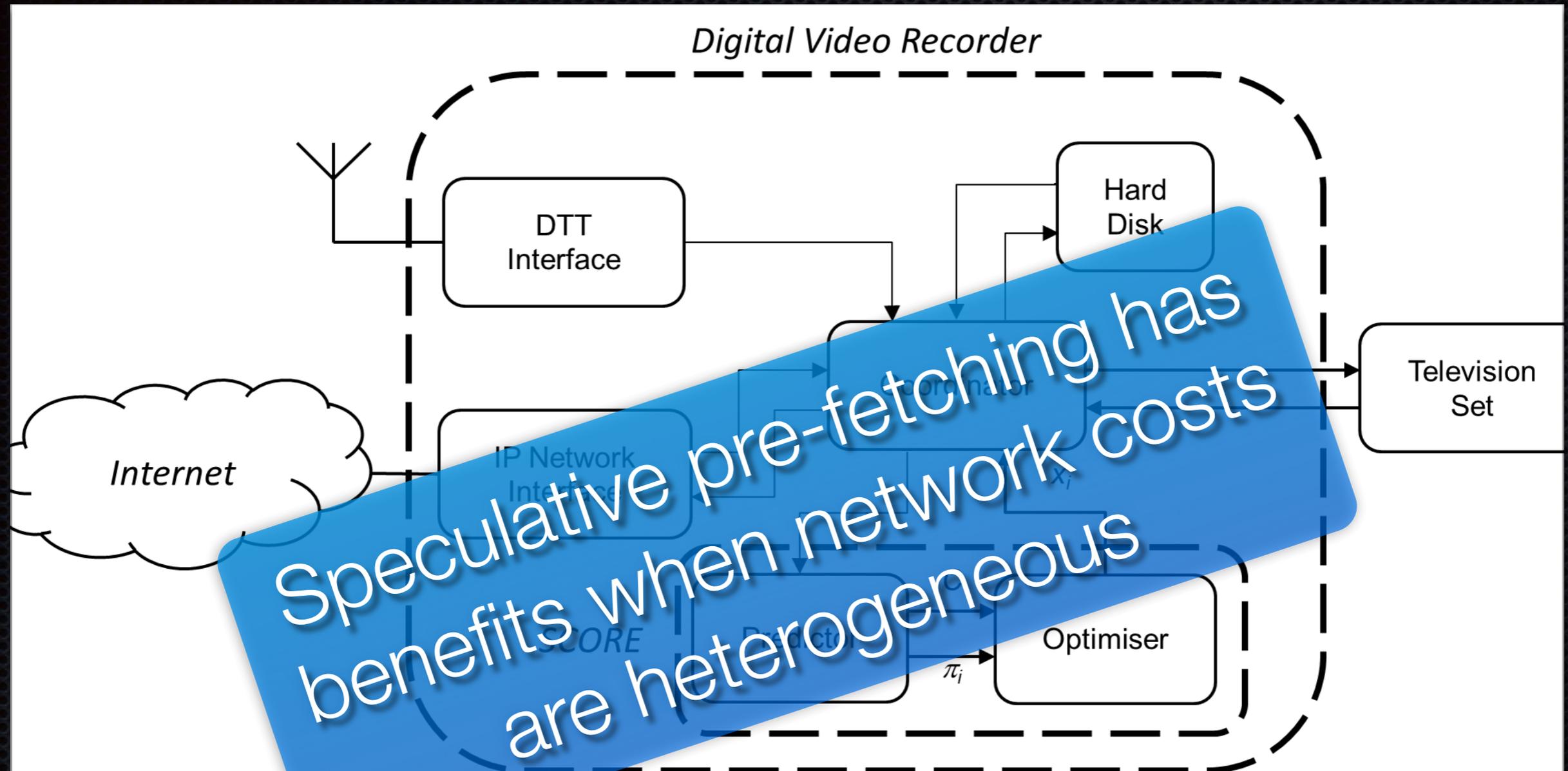
Automatic nudging

Choose the best option for the network by profiling user access patterns

Active nudging

- Offer incentives for good network behaviour:

  - fewer ads, lower pricing, better bandwidth

  - e.g. "Night Browsing" Plans by number of operators

- Network operator can reflect their operating costs

  - e.g., when using 95th percentile SLAs, operators can make incentives higher when monthly peak is close

Summary: On the virtue of ¢a$hes {£¥€}

Killer apps are needed, but also need killer infrastructure

- Copies give failure tolerance + topology independence

- In network-caches enable time-shifted access, staggering peak load

- Pre-fetching can create arbitrage opportunities over costly/variable-quality links, and different types of nets

- Cache copies can be more effectively used by offering incentives, based on ongoing network costs

The Internet is cheaper for Pack Rats (who can be nudged)

Surana, S., Patra, R. K., Nedevschi, S., Ramos, M., Subramanian, L., Ben-David, Y., & Brewer, E. A. (2008, April). **Beyond Pilots: Keeping Rural Wireless Networks Alive**. In *NSDI* (Vol. 8, pp. 119-132).

Tyson, G., **Sastry, N.**, Cuevas, R., Rimac, I., & Mauthe, A. (2013). **A survey of mobility in information-centric networks**. *Communications of the ACM, 56*(12), 90-98.

Nencioni, G., **Sastry, N.,** Chandaria, J., & Crowcroft, J. (2013, May). **Understanding and decreasing the network footprint of catch-up tv.** In *Proceedings of the 22nd international conference on World Wide Web* (pp. 965-976)

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Backup slides

References

- Digital Gangetic Plains

    - http://www.cse.iitk.ac.in/users/braman/dgp.html

- TIER Project: http://tier.cs.berkeley.edu (also for Surana et al, NSDI 2008)

- Meraki: http://www/meraki.com

- Fon: http://www.fon.com

- SBC/Yahoo ToS: http://sbc.yahoo.com/terms

- Drive-by pharming: http://www.symantec.com/avcenter/reference/Driveby_Pharming.pdf

- Architecting citywide ubiquitous Wi-Fi Access: www.cl.cam.ac.uk/~nrs32/pubs/hotnets6.pdf

- Authorization and Charging in Public WLANs Using FreeBSD and 802.1x http://www.tml.tkk.fi/~pnr/publications/Freenix2002-Nikander.pdf