

Towards an efficient, Green Networked Home: A social Gordian knot?

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One Problem or Two?

1. Reduce energy consumption within the home
 - to save money, save the planet.
 - Can technology help? E.g., smart meters, etc?
 2. Share network resources efficiently in the home
 - to get stuff to just work (TV streaming, gaming, VOIP etc)
 - Can technology help? E.g. diagnosis, control, metering ...
- Both need human agents to co-operate

Outline

- The Social Choice conundrum ...
- Economics: the difference between electricity and bandwidth
- Home Power use and monitoring
- Home Networks
- Discussion

The Social Choice Paradox or why families never agree ...

- Three candidates: Al, Barack, Hillary

- Voter (state) preferences

1: $A \succ B \succ H$

2: $B \succ H \succ A$

3: $H \succ A \succ B$

- Majority voting: prefers ...



Marquis de Condorcet

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Marquis de Condorcet

- Majority voting: prefers $A \succ B \succ H$
and... $H \succ A$
- Problem: (Arrow's theorem) Every ("good") social welfare function on a set of more than 3 candidates is a dictatorship

“Goods” Economics 101

	Rivalous	Non Rivalous
Excludable	<p>Private Goods</p> <p>TVs, Internet bandwidth, Clothing, congested roads</p>	<p>Club Goods Natural Monopolies</p> <p>Broad cast TV (satellite) Uncongested toll roads ?Electricity</p>
Non -Excludable	<p>Common Resources</p> <p>Fish in the sea Uncongested nontoll roads</p>	<p>Common Resources</p> <p>Freeview/Freesat (free TV over radio) Uncongested non-toll roads</p>

For our examples

	Rivalous	Non Rivalous
Excludable	<p>Private Goods</p> <p>TVs, Internet bandwidth, Clothing, congested roads</p> <p>Bandwidth in the home/to the Internet</p>	<p>Club Goods Natural Monopolies</p> <p>Broad cast TV (satellite) Uncongested toll roads</p> <p>Electricity/ Power usage</p>
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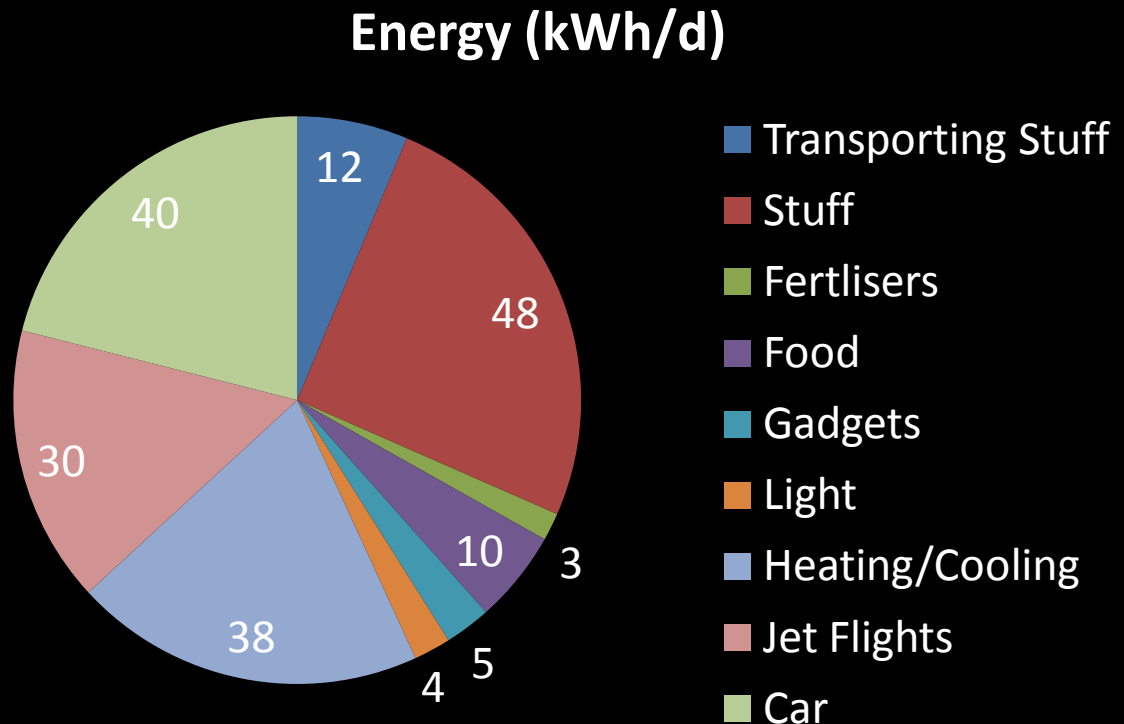
Externalities & Coordination Down (market failure)

- Negative Externalities: – e.g. can lead to mythical “Tragedy of the commons” , rights holders “weak”
 - Internet bandwidth usage in the home
- Positive : network effects, social networks
- “Tragedy of the Anti-Commons” : - powerful rights holders prevent a desirable outcome
 - E.g., Patents pools, family holiday plans ;-)



Home monitoring /power

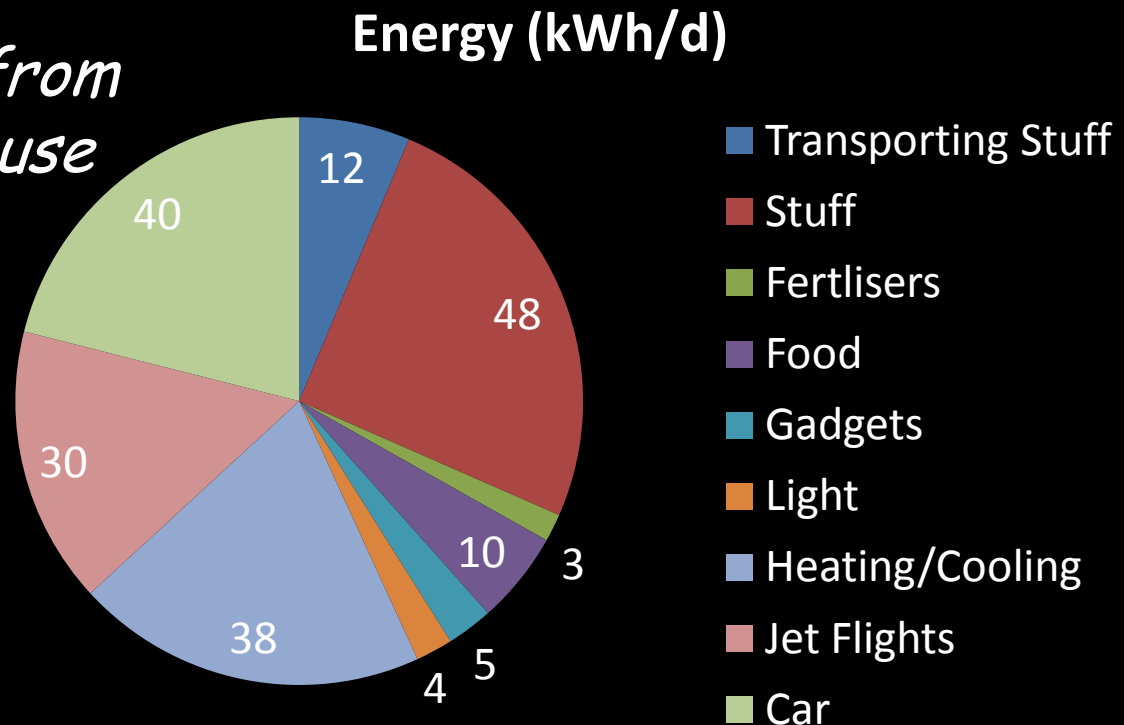
“Average” UK Energy Consumption per *affluent* person
breakdown of 190kWh/day total (= half US figure ...)



Home monitoring /power

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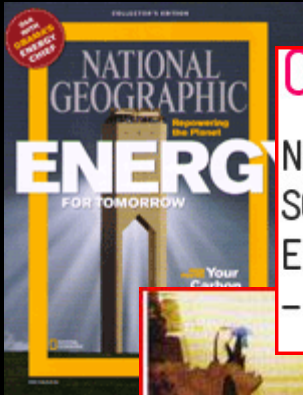
*Roughly 25% comes from
heating, lighting and use
of gadgets*



<http://www.withouthotair.com/>

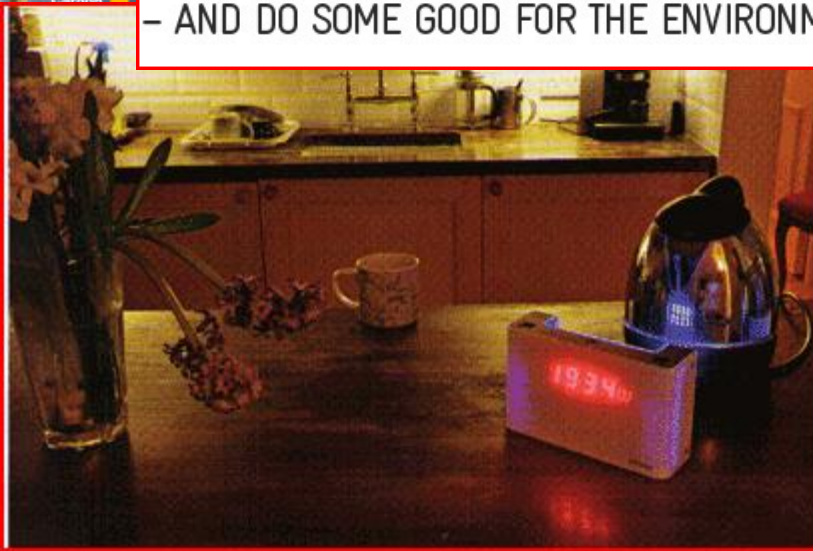
(UK average = 125kWh/d,
US = 250)

Home automation / monitoring



CASE STUDIES.

NOW THAT YOU'VE MET WATSON AND HOLMES, MEET SOME OF THE PEOPLE WHO'VE BEEN USING THEM TO SAVE ENERGY – AND 5% TO 20% ON THEIR ELECTRICITY BILLS – AND DO SOME GOOD FOR THE ENVIRONMENT.



Personal experience of home energy monitoring...



- My electricity bill has *not* fallen by “5-20%” ...
- Problems:
 - No feedback loop on many systems, other than “manual” one (get up and walk and turn off ...) : more useful for highlighting problems
 - E.g. Accelerated my move to efficient lighting
 - Many low-power devices can create significant “background” level in aggregate (green pcs+IGD+NAS+WHS etc)
 - Those that don’t pay don’t feel the pain ... and walk past a display showing outrageous current usage with impunity
 - Teenagers treat power /light switches as one-way devices appearing to need to have the house bathed in light 24/7

Personal experience of home energy monitoring....

- Solutions:
 - Need smarter solutions that are “automatic”, i.e. By-pass humans
 - But still need to retain some level of control & involve people
 - Links to sensors combined with history looks promising
- Bigger issue: the most cost-effective solutions to the real problem are low tech: e.g., improve insulation first

Home/Small networks

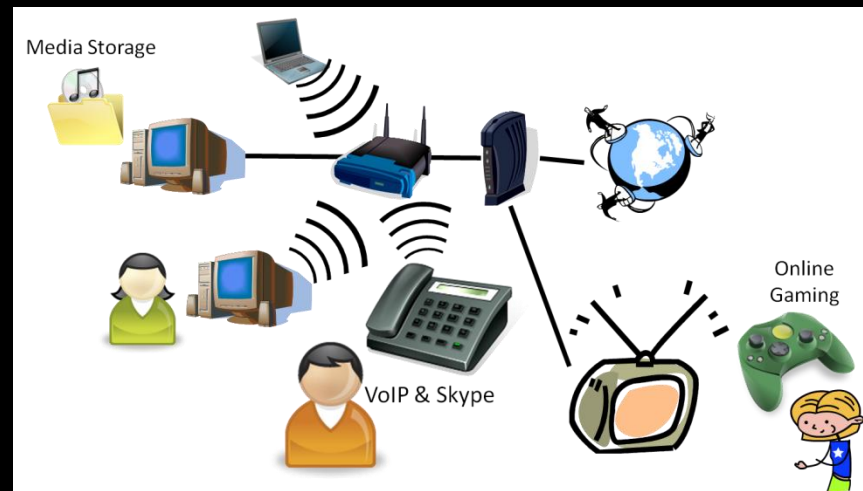
- Tracks b/b growth (currently 5% of world popn)
- Drivers: entertainment networks, media, storage, publishing
- <100 devices (2 to 30 at present), geographically close
- Heterogeneous ecosystem (devices)
 - W.r.t display, processing, apps, etc
- Heterogeneous network technology
- No management
- Context and user prioritisation

We are not supposed to talk about our own research, but

- Have an ongoing project (HomeMaestro/HomeWatcher) involving Systems and Networks People, Computer Mediated Living people (sociologists, designers), and real user trials
- *Collaborators: Christos Gkantsidis, Dinan Gunawardena, Thomas Karagiannis, Richard Banks, Phil Gosset, Richard Harper, Abigail Sellen, Tim Rega, Elias Athanasopoulos etc.*

Our aims in Home Networks

- Detect and resolve **performance** problems
 - “automatically” based on ...
 - little & **intuitive** user input



HomeMaestro



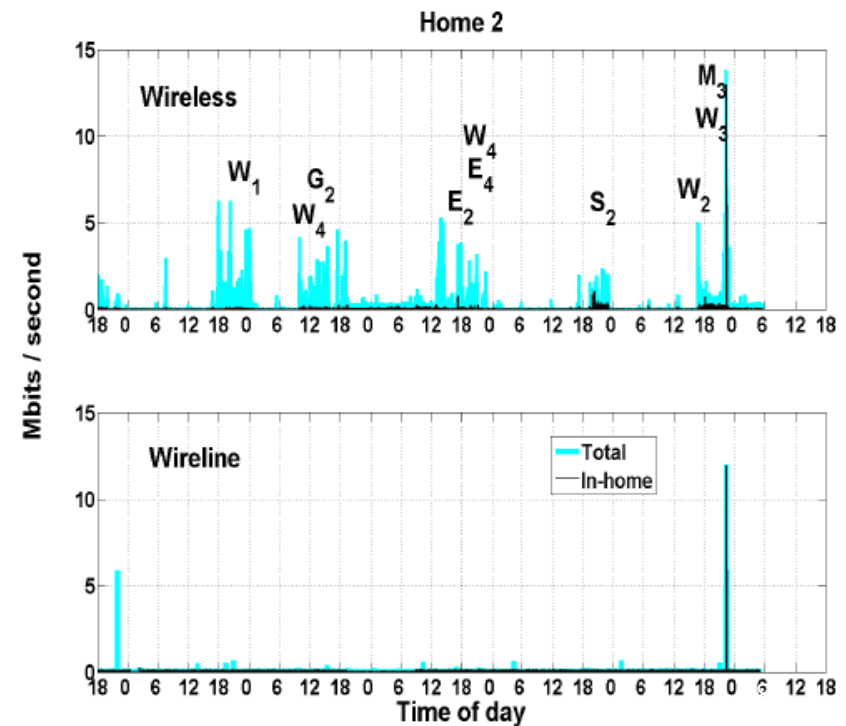
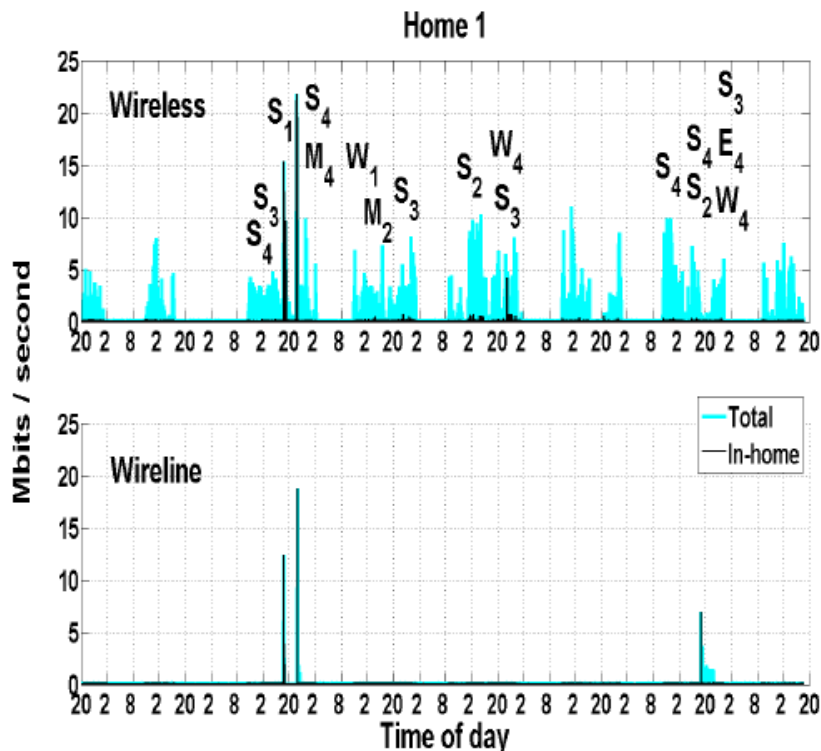
A quick summary of the research

- Users are hitting performance problems in home networks, caused by resource constraints
- We have demonstrated we can use end-host monitoring to identify problems, and ...
- Given a set of relative priorities, we can control per application to create a good experience.
- But ... How to set the priorities?
- Currently running user studies on simple displays and controls



User Study

- Household studies:
 - Home users diaries
 - Wireless and wireline traffic monitoring

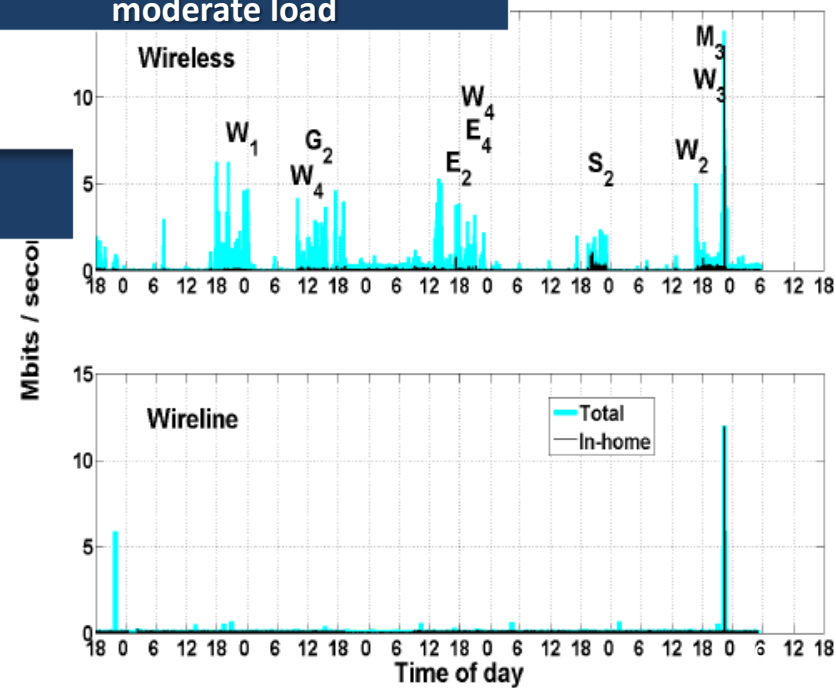
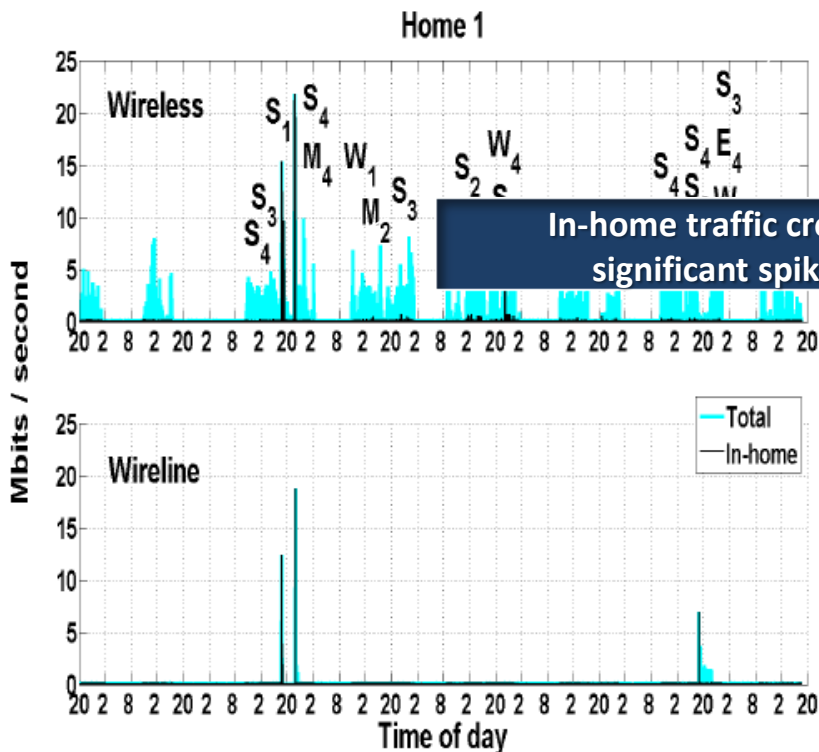




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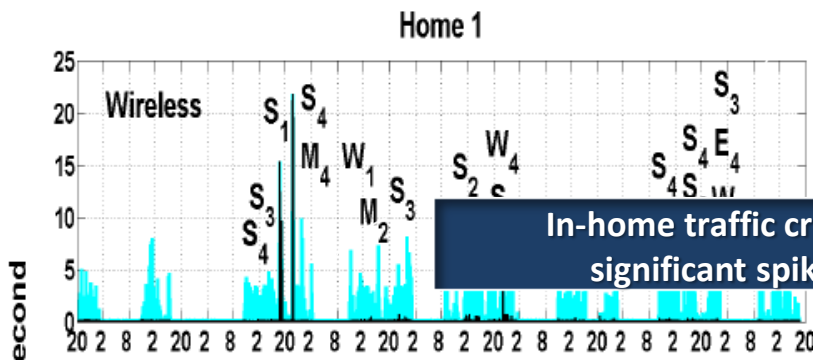
Several reported problems with moderate load



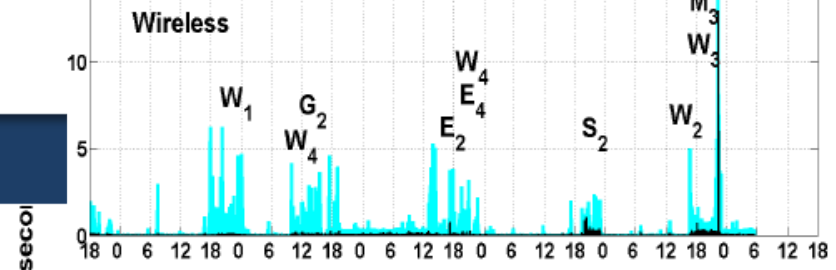


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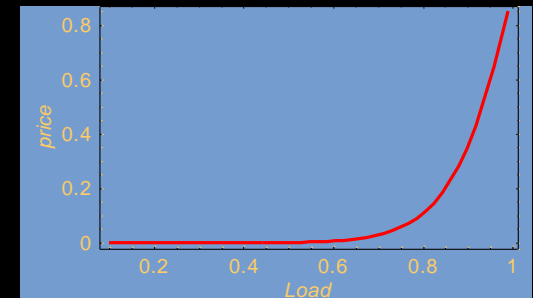
- Lessons learned:
 - Poor user experience
 - Users have limited intuition about the problem source
 - Transparent approach

Resource Allocation – a “smart market”

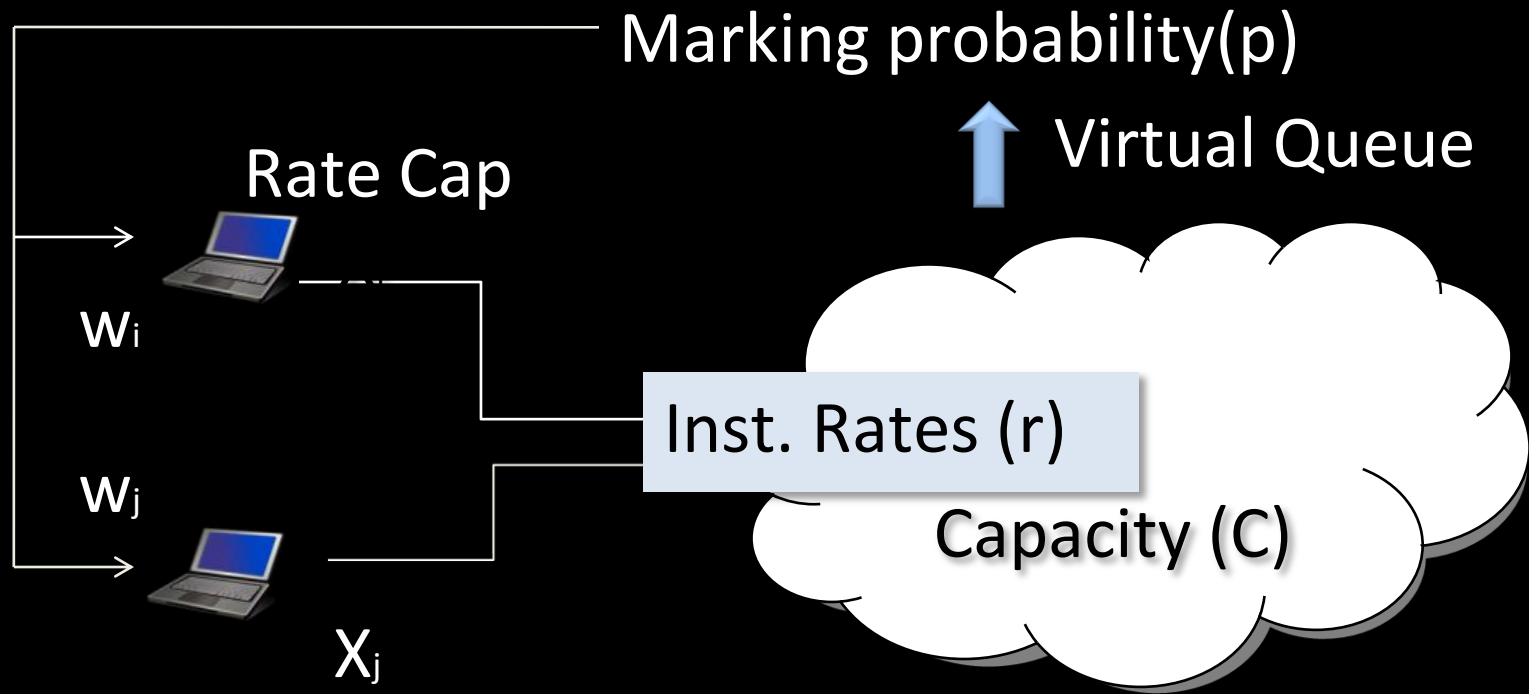
- Weighted proportional fairness:
 - Users have a weight w_i and receive in proportion to this weight
 - as if performing a utility maximisation
- “Price” p is a function of load and capacity
 - Capacity inferred, low load \Rightarrow low price
 - We use a “virtual queue”

- Allocation

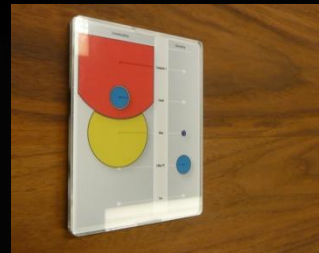
$$x_i = w_i \frac{1 - p}{p}$$



Resource allocation mechanics

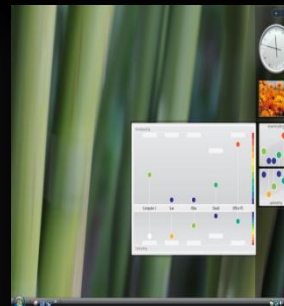
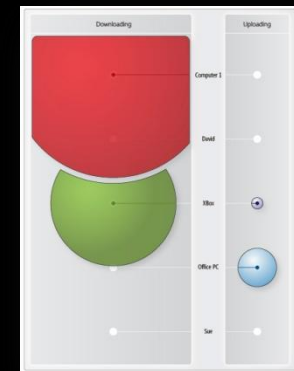


Home Networking Device GUIs



Appliance design

GUI



PC Widget design

How to decide who gets what?

- We have run several user trials
 - Users were not high-tech geeks
- Real users complicate things
 - Users didn't like any automatic prioritization
 - See task priorities as *context dependent*: eg, would depend on whether something was being done for “work” or “play”
 - In a family *work* will most likely take precedence over *play* but in a shared household an online gamer has as much right to access as someone doing work

Wanted: A tool for co-ordination and sharing

- There will be times when several users want to use real-time services like VOIP and streaming when ‘throttling back’ is not an option
- Then people wanted to use the information to co-ordinate and share : NOT an automatic solution
- The most straightforward solution is timesharing *people would adopt this in the absence of the tool once aware of the problem*
- Participants latched on the “history” display as a way to make sharing fair, to see who’s been using the bandwidth and how much

Concluding thoughts

- Home networked resource (wired/wireless bandwidth etc) is fundamentally different from a utility such as electricity
 - Since it is a *rivalous* good
- But is linked to utilities by similarity of usage display and control options
- Enabling “fair” usage in the home is challenging: semi-automatic tools that engage the human user are needed ...
- To enable a *real* social network to decide!

The Alexandrian solution

