# P2P on handheld devices: Energy and other challenges

Jukka K. Nurminen

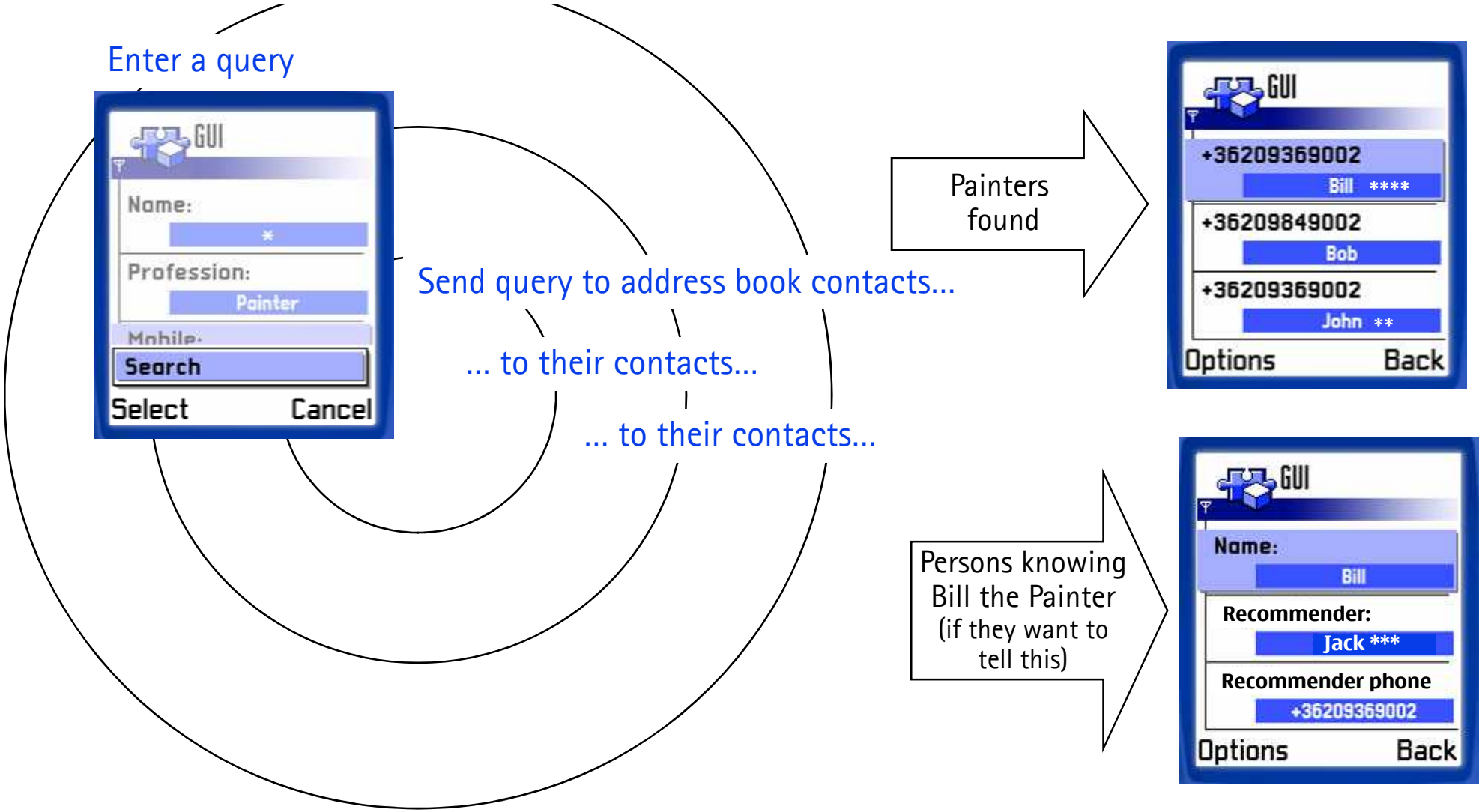
# P2P and handheld devices


- Mainly experimental systems so far.
  - E.g. Symella, SymTorrent, MobTorrent, MobileDHT
  - Paradigm: bring existing P2P applications to mobile devices
  - Available as open source at http://amorg.aut.bme.hu/projects


- Challenges:
  - NAT and firewall traversal
  - Operator co-operation
  - High churn
  - Battery consumption
  - Billing
  - Limited resources of the handheld device

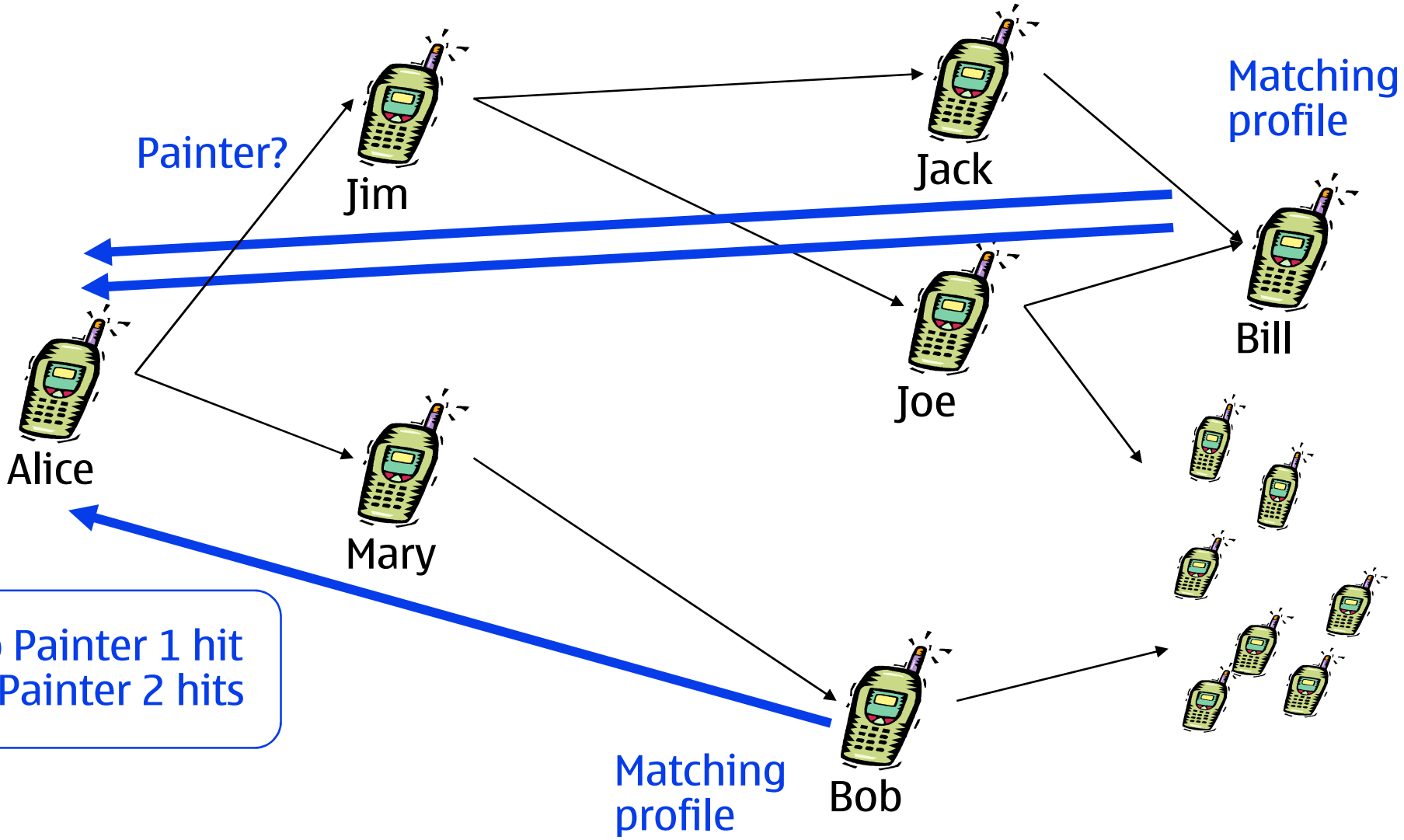
- Possibilities:
  - Taking advantage of phone context
  - Accessing data and functionality of core applications (addressbook, call log, calendar, location, ...)
  - Taking advantage of the human user who can easily be alerted

# Social Network Search with Phonebook
# How to Find a Reliable Painter?



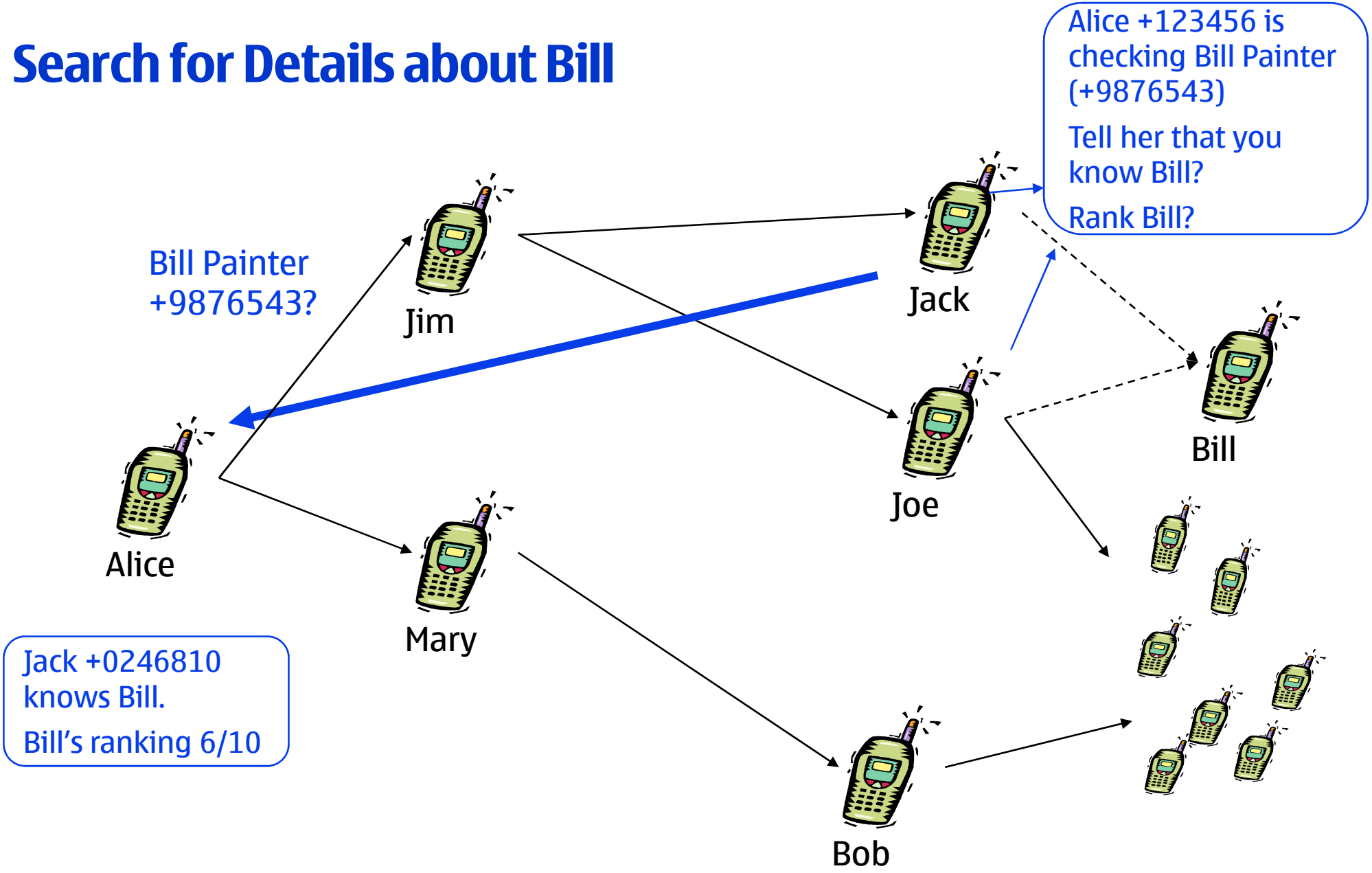

Bakos, B., Farkas, L., and Nurminen, J. K., "Search Engine for Phonebook-based Smart Phone Networks," in Proceedings of IEEE 61st Semiannual Vehicular Technology Conference (VTC2005-Spring), Stockholm, Sweden, May, 2005.

# Alice is Searching for a Painter



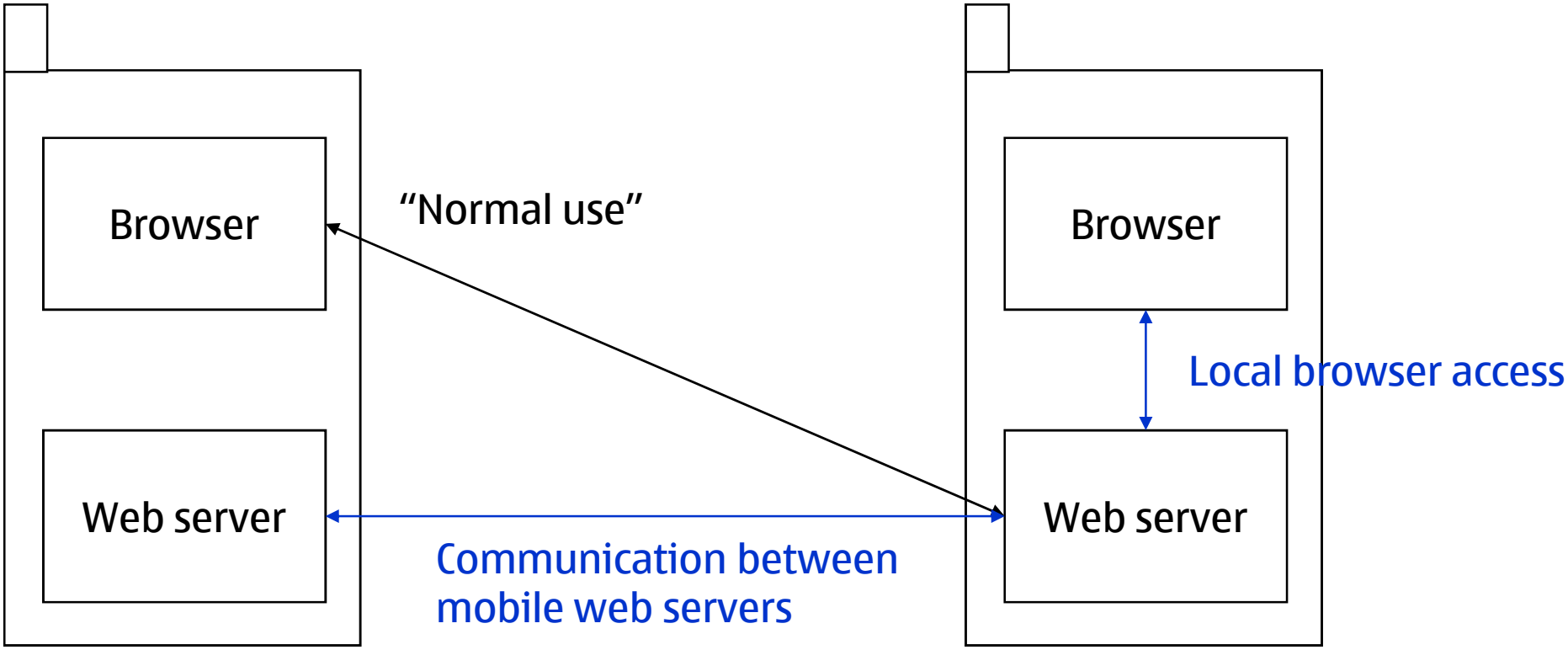

Bob Painter 1 hit
Bill Painter 2 hits

# Search for Details about Bill



# Raccoon – mobile web server

- Same device has both client and server functionality
- Cooperation between the client and server parts?



# Personal Mobsite


Most recent photo taken.

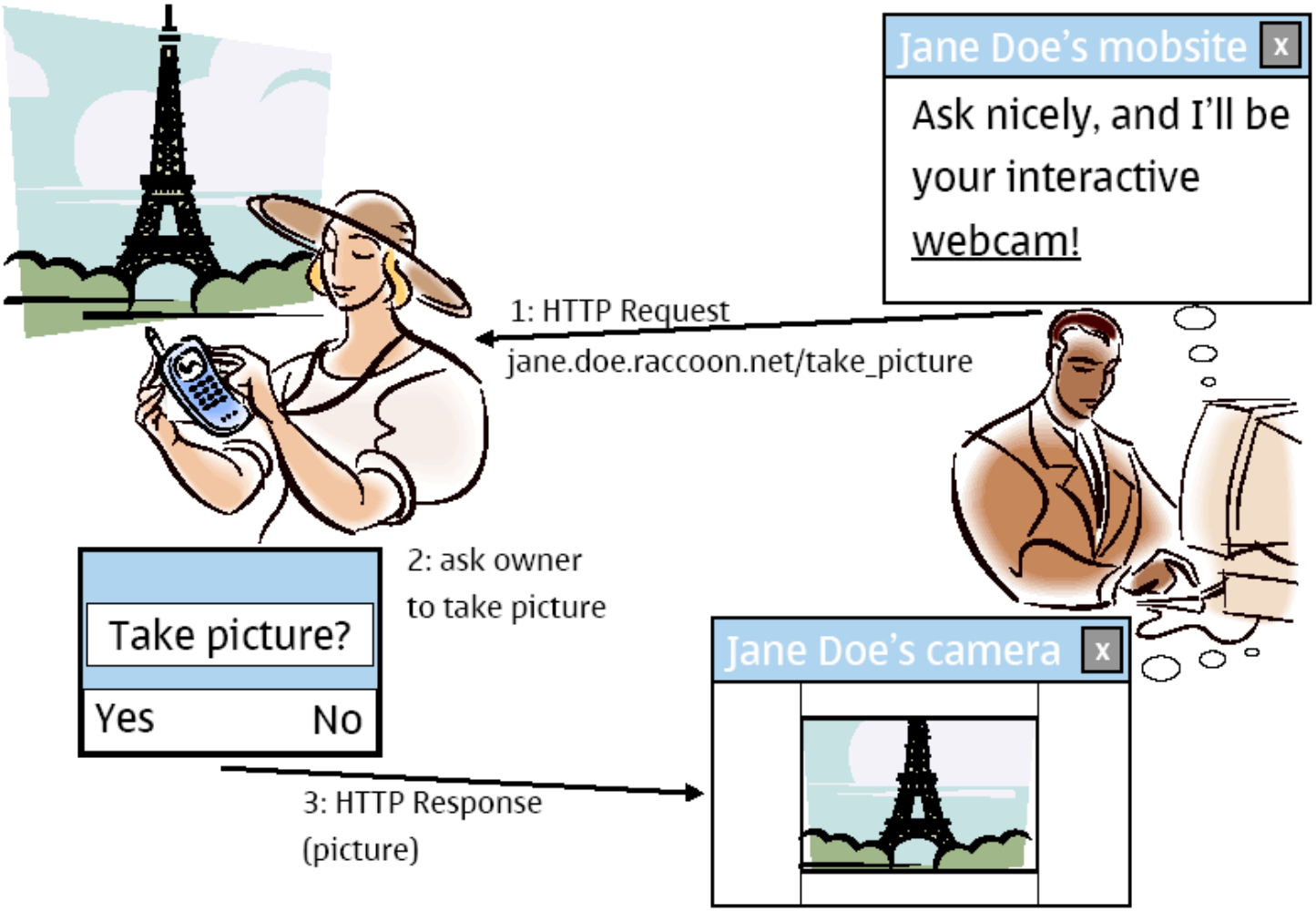
Search your mobsite

Nice to know.

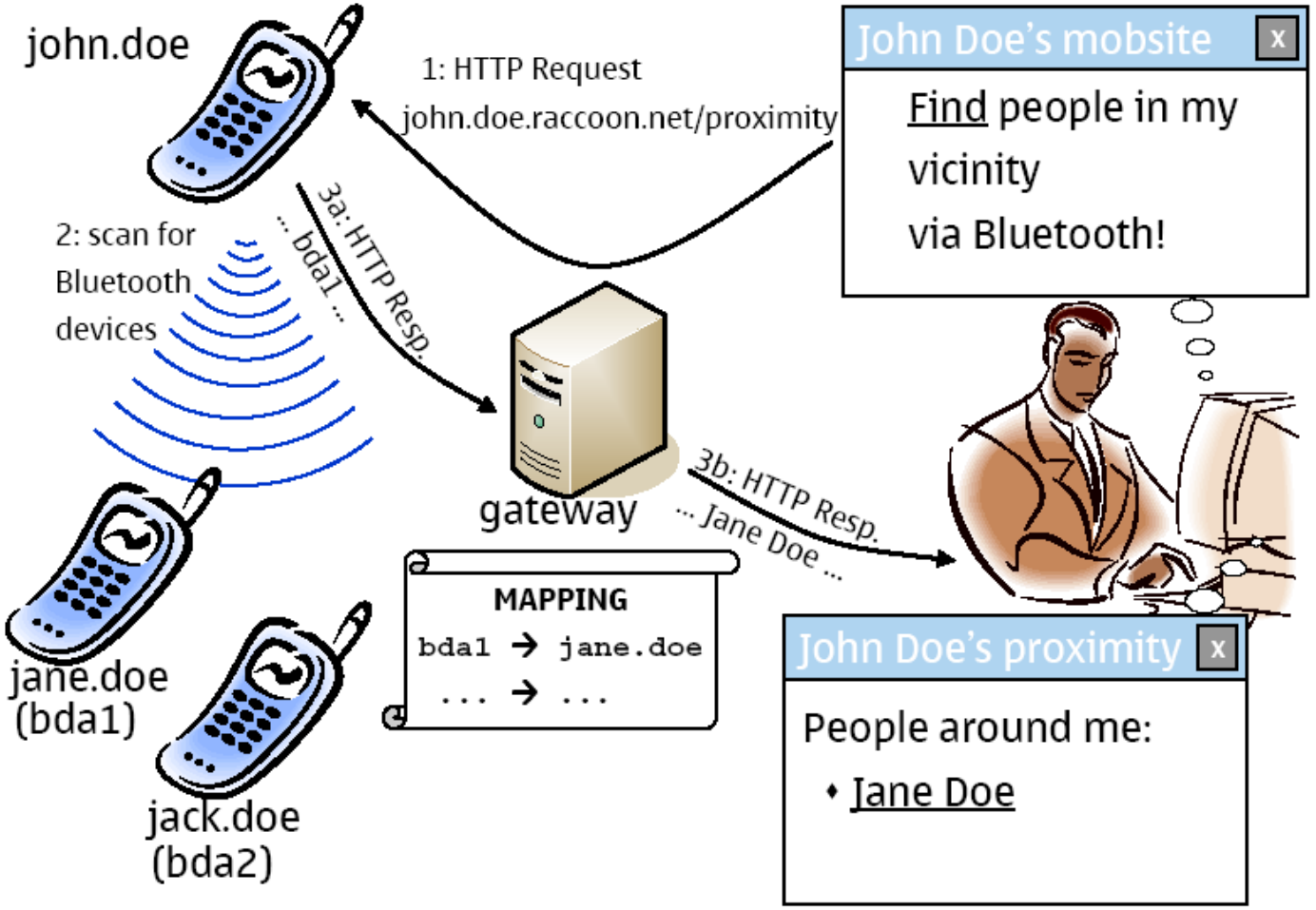
Access to core data:
- Text messages.
- Calendar
- Contacts

By courtesy of
graham@pixel8limited.com

# Interactive Content - Example



# Linking by Proximity – Mobsite Hopping




- A new way for linking websites – they are related because they are geographically nearby each other.

# Grid computing with phones

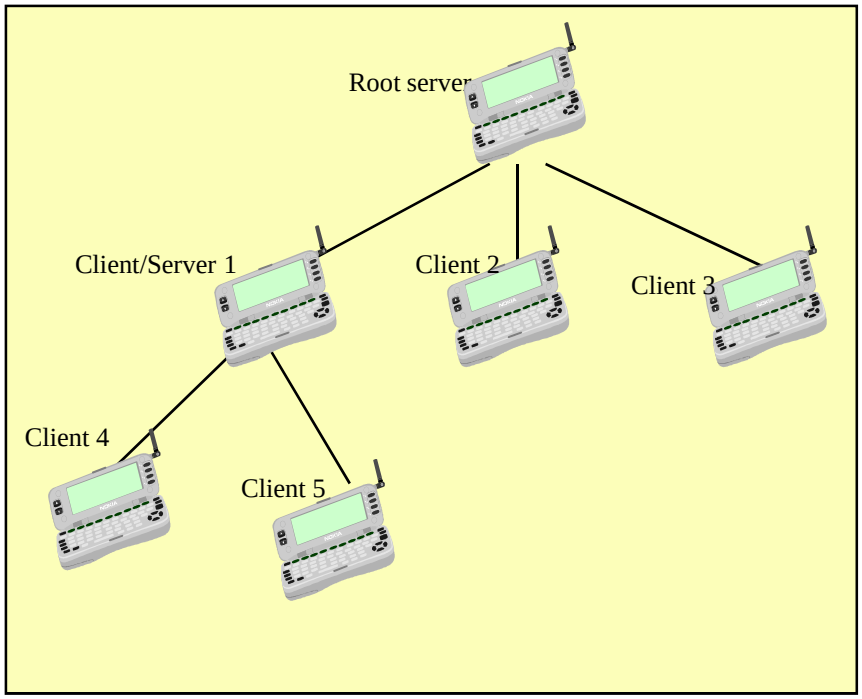
GIMPS

The Great Internet Mersenne Prime Search

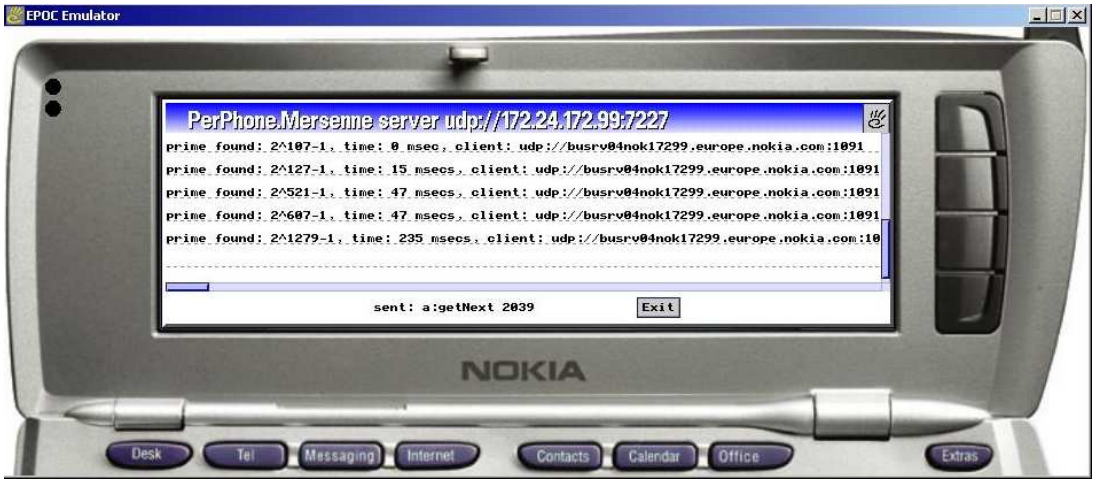
Finding the 5 Largest Known Primes

$2^P-1$ MAY BE PRIME!

\+ mobile phone




Lucas-Lehmer test:
$2^p$-1 is prime if and only if S(p-1) = 0 (mod $2^p$-1),
where S(1) = 4 and S(k+1) = S(k)$^2$-2.




Personal Java on Nokia Communicator

Bakos, B., Fodor, S., and Nurminen, J. K., "Distributed Computing with Mobile Phones: An Experiment with Mersenne Prime Search," short paper in Pervasive 2002 International Conference on Pervasive Computing, Zürich, Switzerland, August, 2002.

# Energy-efficiency issues on mobile phones

Jukka K. Nurminen

# Power consumption of streaming in 3G phone

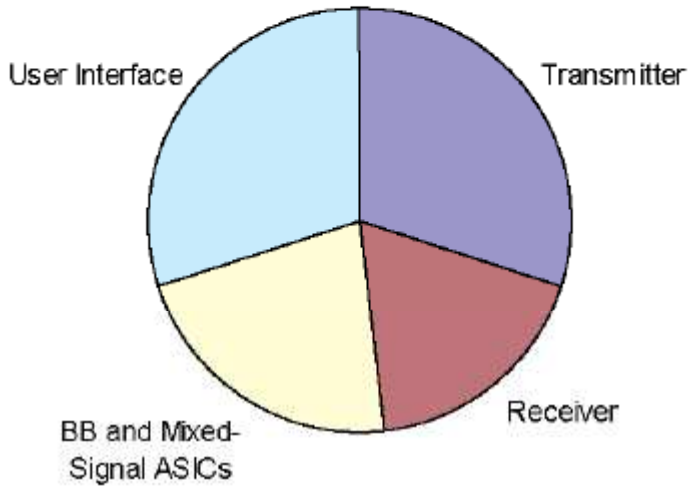



**Figure 1.3.7: Power consumption break down in video streaming in a 3G phone.**

Neuvo, Y., "Cellular phones as embedded systems," *Solid-State Circuits Conference, 2004. Digest of Technical Papers. ISSCC. 2004 IEEE International* , vol., no., pp. 32-37 Vol.1, 15-19 Feb. 2004

# Linear slow growth in battery capacity

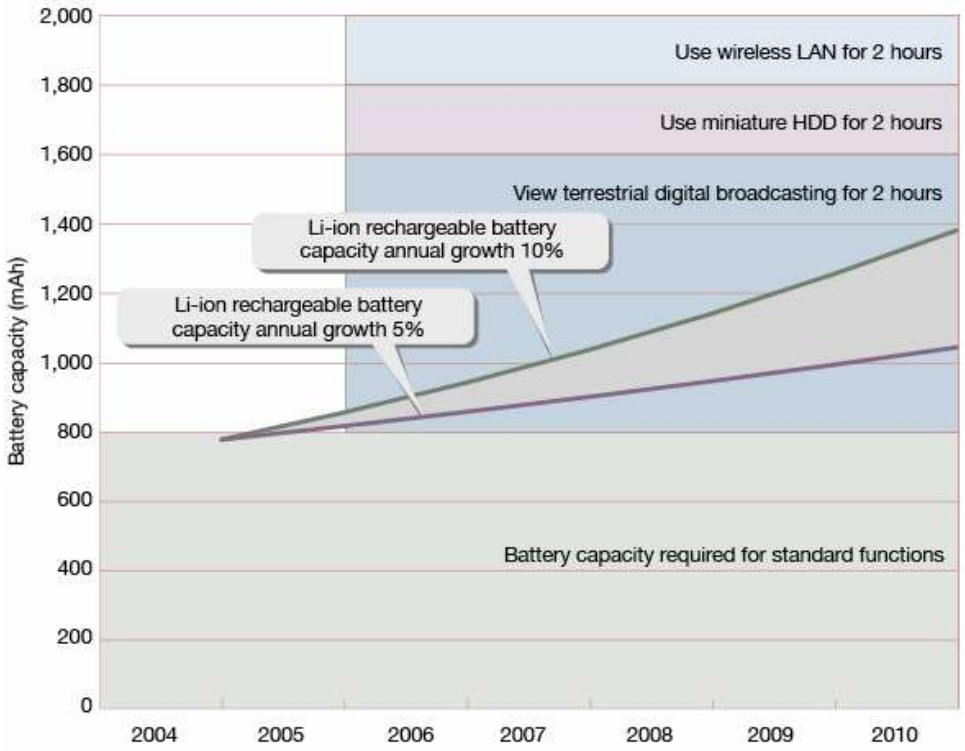
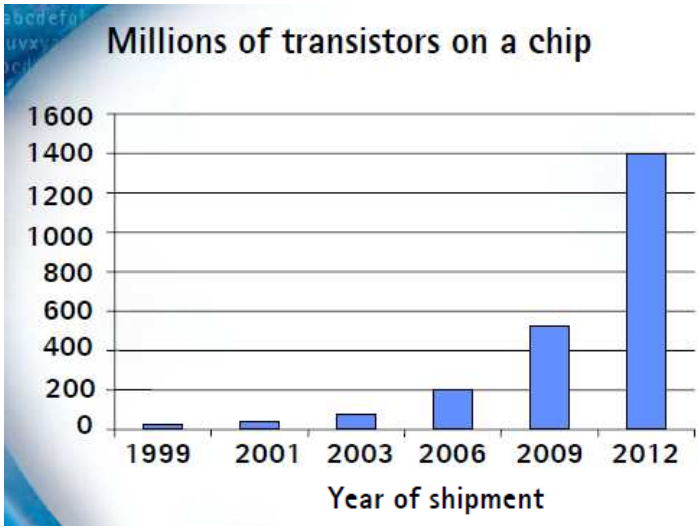


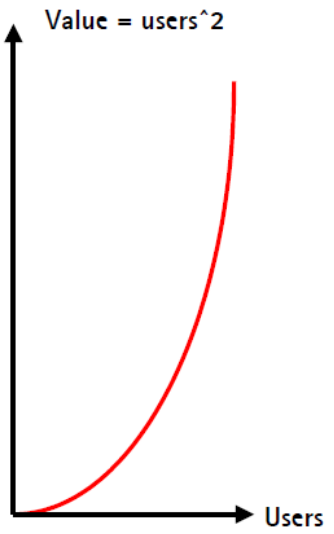

**Fig 2 Underpowered Mobile Phone Batteries** Even if the energy density of Li-ion rechargeable batteries continues to grow at 5 to 10% annually, they still won't provide sufficient power for tomorrow's mobile phones at their present volumes. Viewing terrestrial digital broadcasting for long periods or storing/playing video using internal HDDs will demand roughly double the battery capacity. The diagram indicates the capacity needed to run mobile phone functions for two hours. Capacity would have to be tripled to allow users to watch terrestrial digital broadcasting for four hours.

vs.

Moore's law



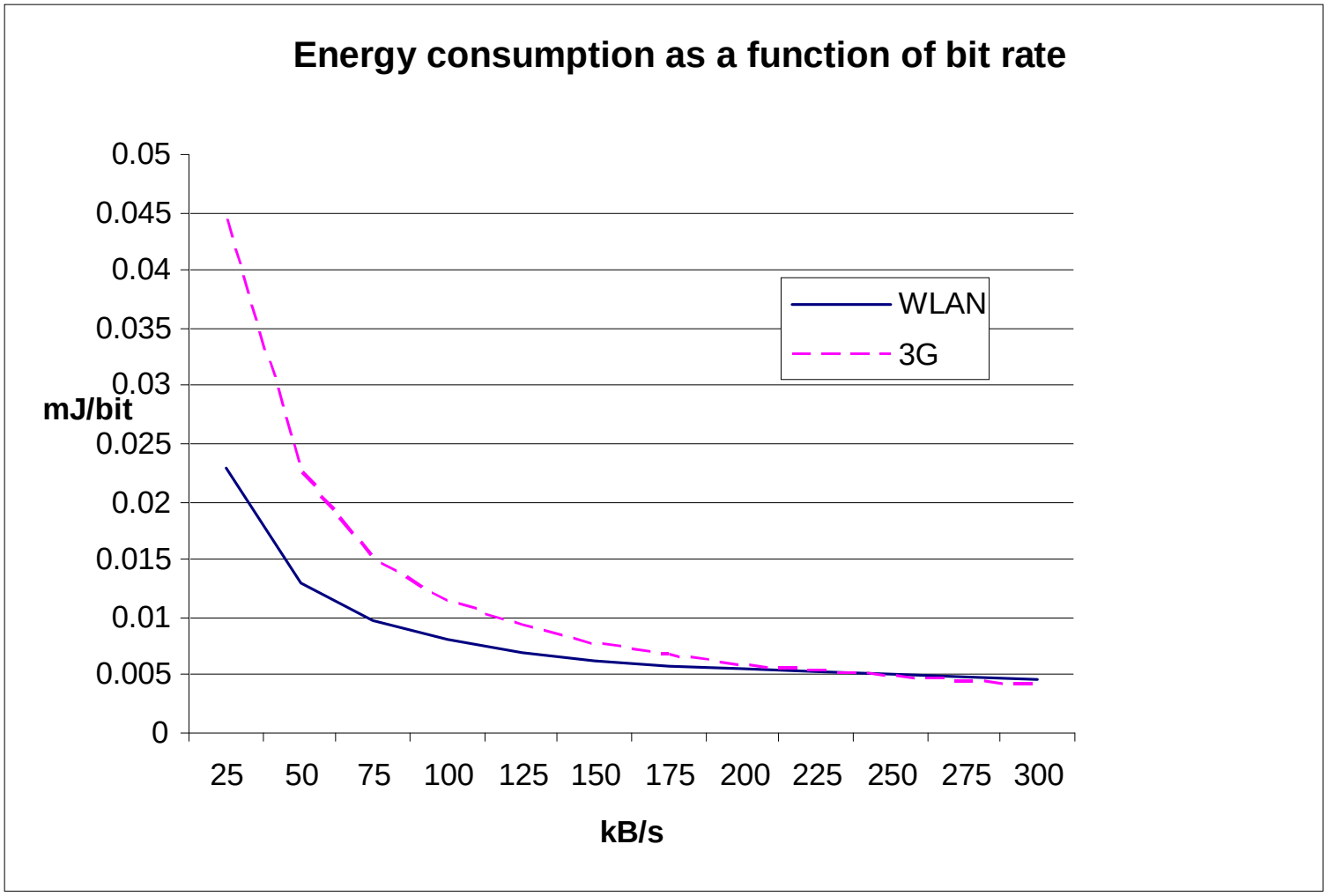

Metcalfe's law



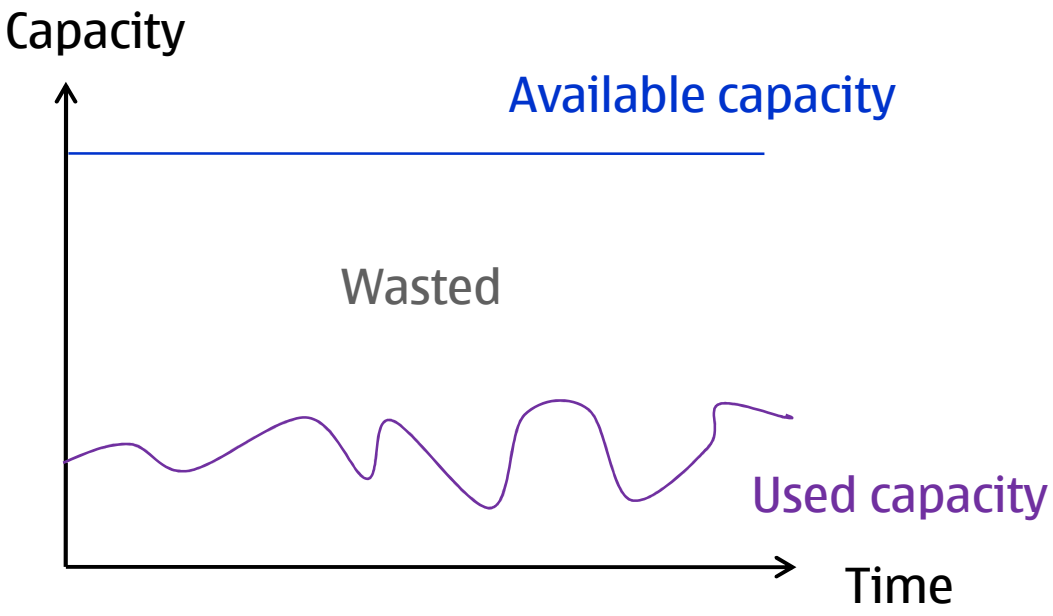
# Problem with connections to mobiles

- Mobile devices have to form the connections. The network is not able to do it.
- An idle TCP (or UDP) connection does not consume energy
- But idle connections do not stay alive for long. Therefore periodic keep-alive packets need to be sent
- Measurements with cellular networks show
  - NAT timeouts for UDP are anywhere between 30 and 180 seconds
  - NAT timeouts for TCP is anywhere between 30 and 60 minutes
  - Sending a keep-alive packet every 20s increases power consumption by a factor of 10 and more
  - Pasi Eronen, "TCP Wake-Up: Reducing Keep-Alive Traffic in Mobile IPv4 and IPsec NAT Traversal," Technical Report, http://research.nokia.com/tr/nrc-tr-2008-002
- This problem exists not only for P2P apps but also for push email, AJAX apps, etc.

# Higher bit rate -> more energy-efficient

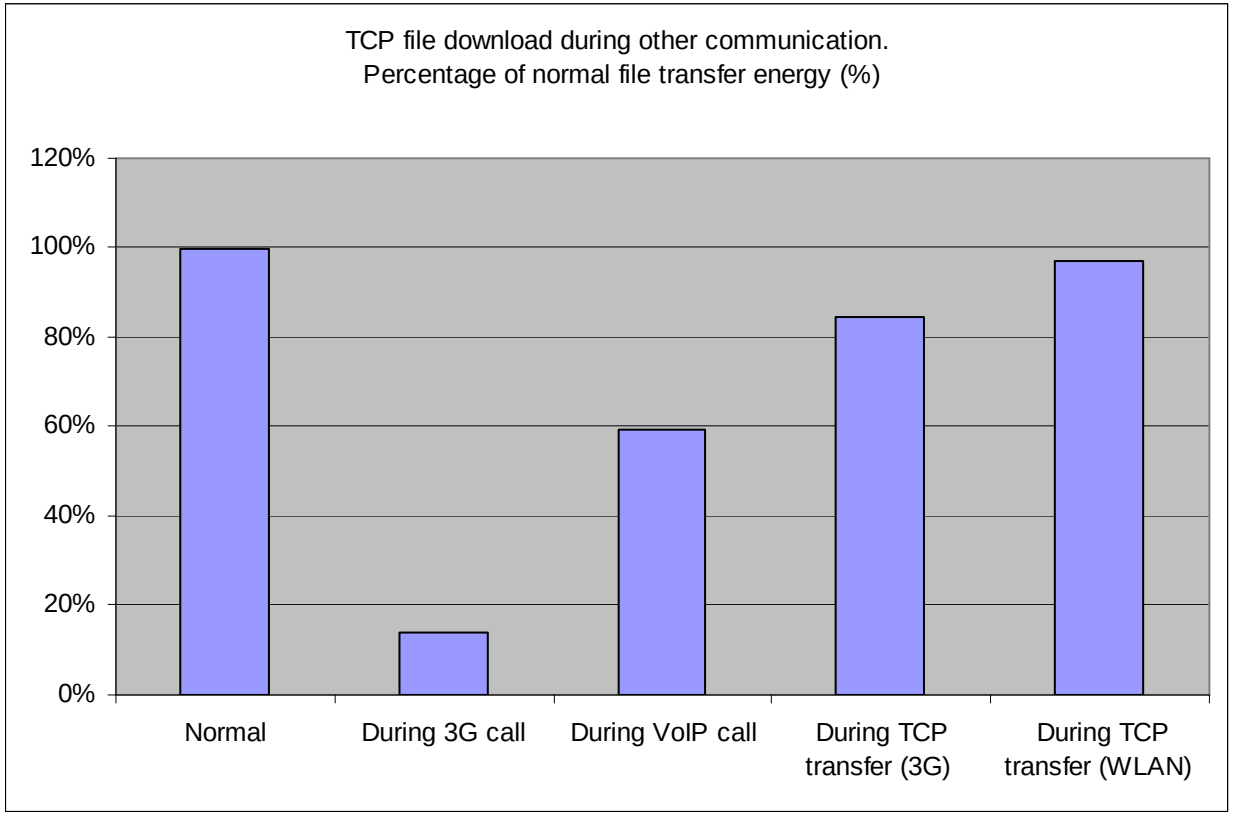


# Energy wasted when capacity is not fully used




- Radio energy consumption is dominated by the power amplifier
- Roughly same power used no matter how much traffic there is (as long as some)
- Continuous low bitrate traffic (e.g. voice, audio) does not allow sleep in idle mode
- WLAN has more aggressive power save mode than 3G

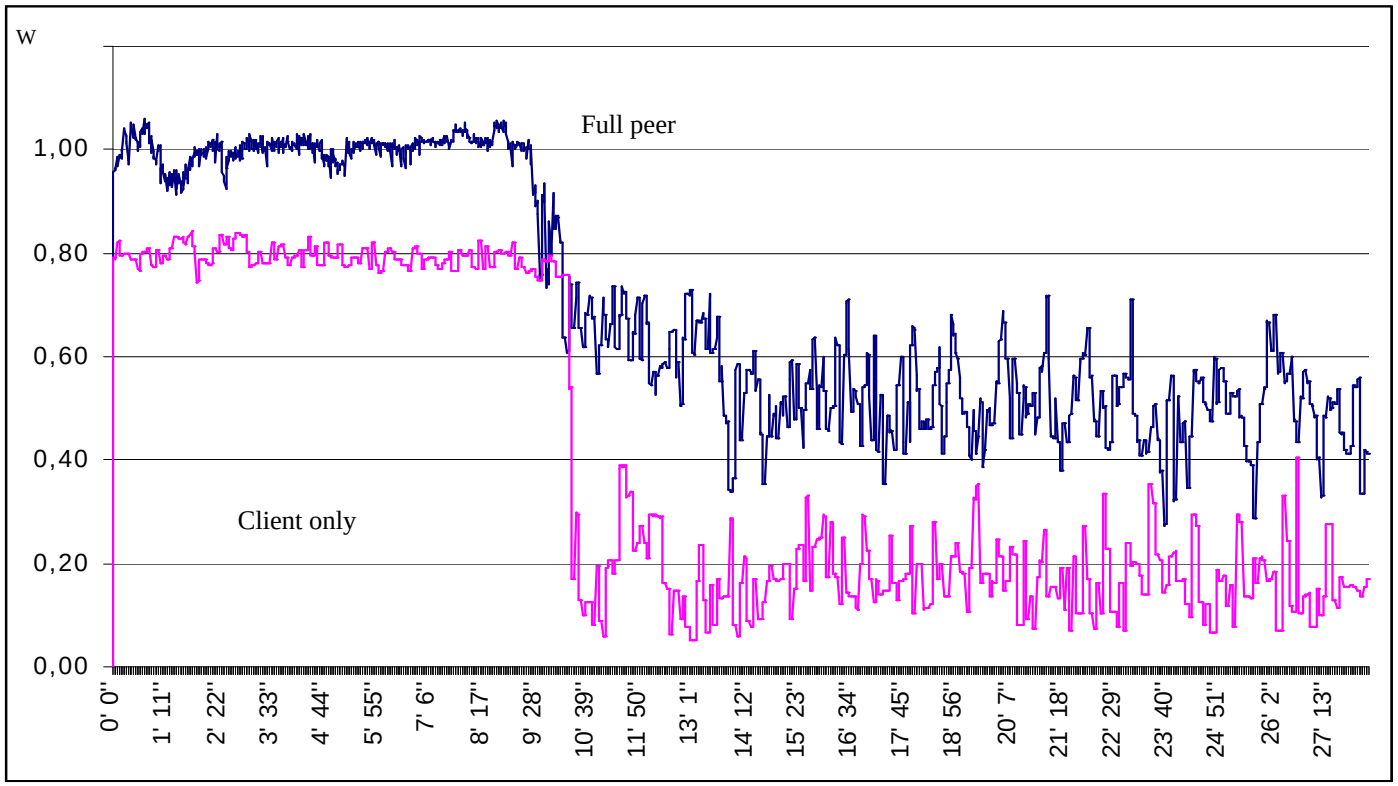
# Strategy 1: Synchronize traffic to fill spare capacity Parallel connections




- The benefit is clear in case of voice call and VoIP call. (in case of VoIP call the effect of U-APSD power save mode was not investigated)
- The benefit of parallel TCP is less clear and depends on the relative speeds of the connections and of the independence of the paths of the TCP connections)
- Measured with N95

Nurminen, J.K., "Parallel connections and their effect to battery consumption of a mobile phone," The Second International ICST Conference on MOBILe Wireless MiddleWARE, Operating Systems, and Applications (MOBILWARE 2009), Berlin, Germany, April 2009

# Strategy 2: Do less work
# SymTorrent power consumption

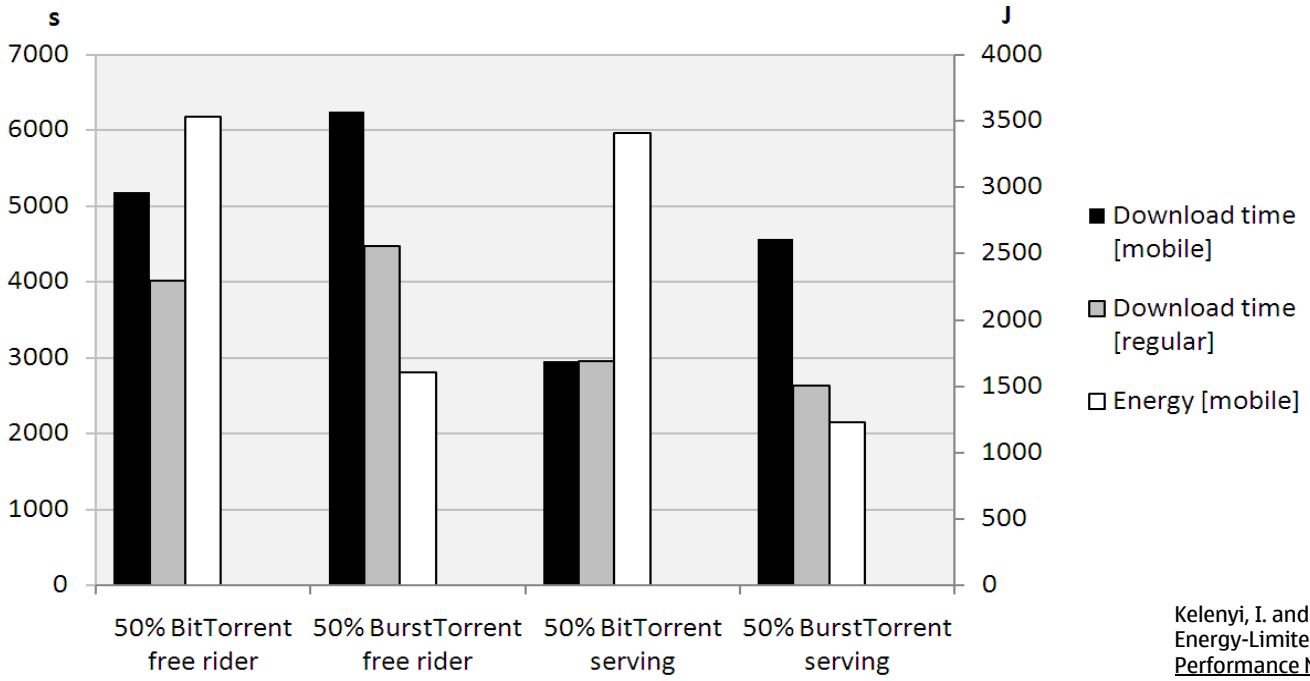



- Only act as a client. Do not server others.
- But you do not save much in the active download phase (~20% less power).
- You may actually loose energy because of the tit-for-tat mechanism as you get slower download speed

Nurminen, J.K. and Nöyränen, J., "Energy-Consumption in Mobile Peer-to-Peer – Quantitative Results from File Sharing," 5th IEEE Consumer Communications & Networking Conference CCNC 2008, Las Vegas, Nevada, January 2008

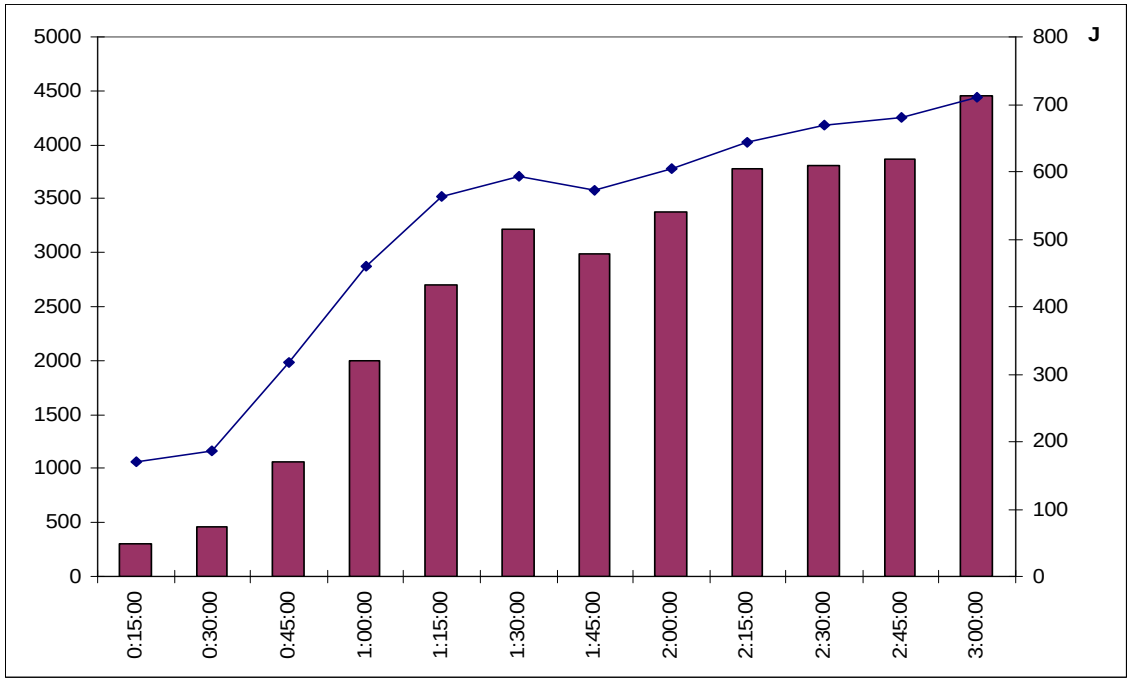
# Strategy 1: Synchronize traffic to fill spare capacity Scheduled bursts

- Transferring data in high bursts brings significant energy saving
  - Power to transmit a bit reduces when the bit rate increases
- BurstTorrent extends BitTorrent protocol to allow scheduled transfers
  - This way the bandwidth utilization is optimized
  - We may also sacrifice download speed in order to save energy




Kelenyi, I. and Nurminen, J.K., "Bursty Content Sharing Mechanism for Energy-Limited Mobile Devices," The 4th ACM International Workshop on Performance Monitoring, Measurement and Evaluation of Heterogeneous Wireless and Wired Networks (PM2HW2N), Tenerife, Canary Islands, Spain, October 2009

# Energy consumption and # of messages in each 15 min interval for a mobile peer in Mainline BitTorrent DHT (Kademlia) over 1 million users

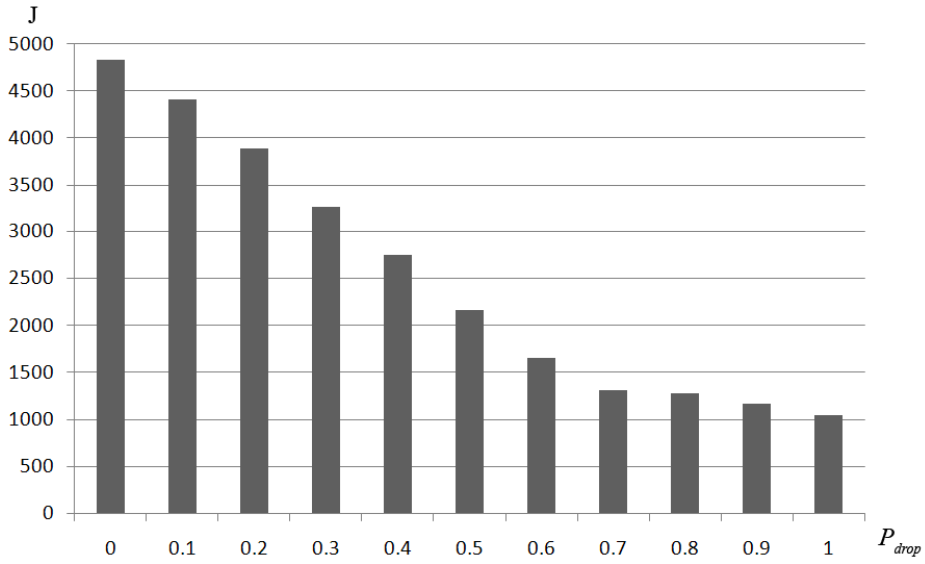




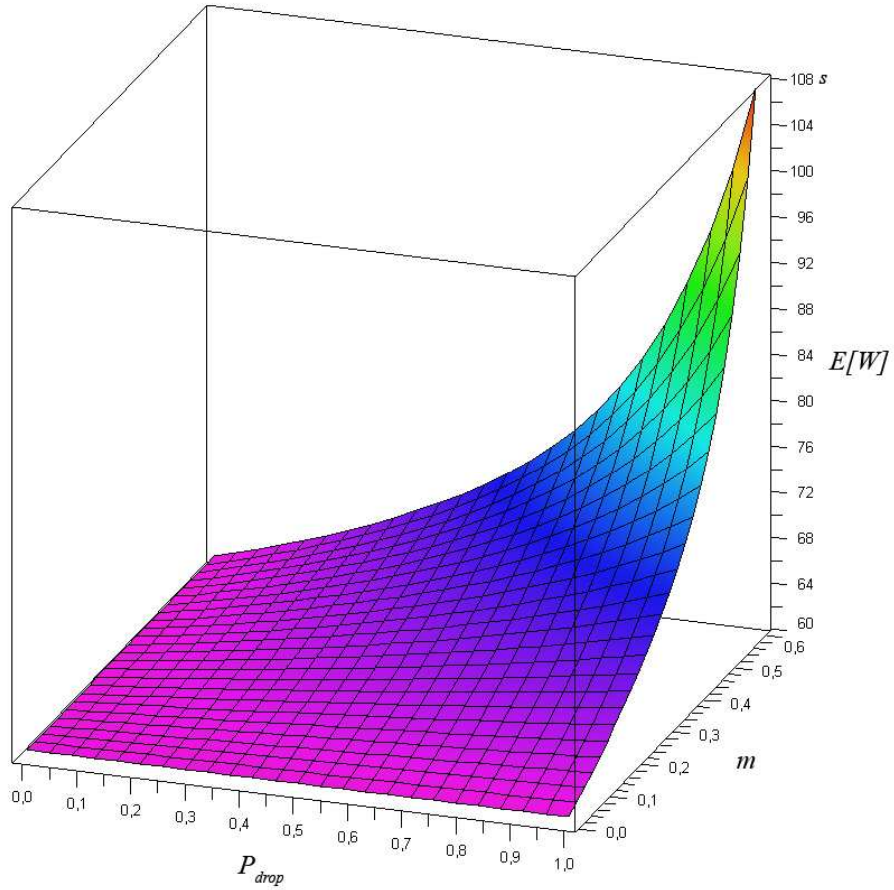
Kelenyi, I. and Nurminen, J.K., “Energy Aspects of Peer Cooperation - Measurements with a Mobile DHT System,” IEEE CoCoNet Workshop 2008 Cognitive and Cooperative Wireless Networks collocated with IEEE ICC 2008, Beijing, China, May 2008

Kelenyi, I. and Nurminen, J.K., “Optimizing Energy Consumption of Mobile Nodes in Heterogeneous Kademlia based Distributed Hash Tables," Second International Conference and Exhibition on Next Generation Mobile Applications, Services and Technologies, Cardiff, Wales, UK, September 2008 (to appear)

# Strategy 2: Do less work
# Do not reply to each DHT request




Energy as a function of dropping probability




Relationship between dropping probability ($P_{drop}$), ratio of mobile and normal peers (m), and expected delay E[W]

# Utility of participating in P2P community

$$U(C) = b(C) - c(C)$$

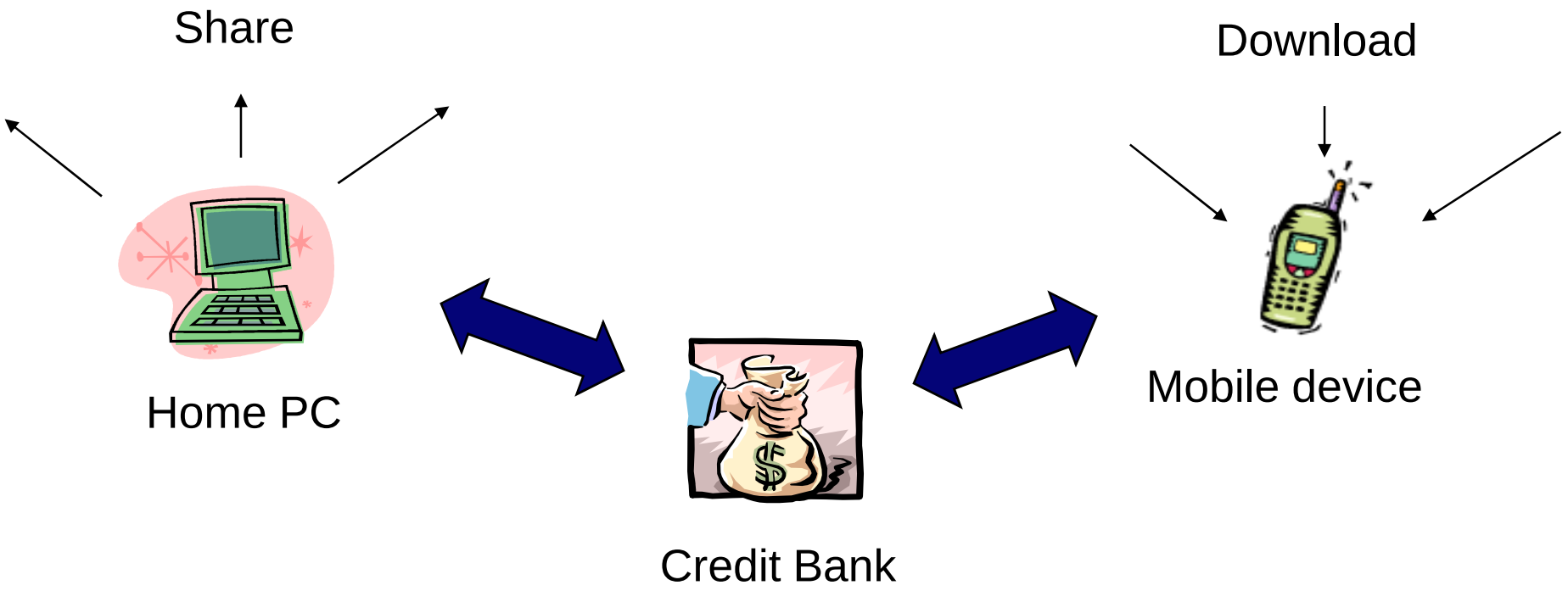
- For PC
- benefit reasonably high
- hardly any cost
- => high utility
- => low threshold to contribute

- For mobile device
- benefit reasonably high
- cost can be quite high
  - Energy
  - Phone bill
- => lower utility, or
- => strong incentive to be selfish

Karonen, O. and Nurminen, J.K., "Cooperation Incentives and Enablers for Wireless Peers in Heterogeneous Networks," IEEE CoCoNet Workshop 2008 Cognitive and Cooperative Wireless Networks collocated with IEEE ICC 2008, Beijing, China, May 2008

Suomalainen, J., Pehrsson, A. and Nurminen, J.K., "A security analysis of a P2P incentive mechanism for mobile devices," 3rd International Conference on Internet and Web Applications and Services (ICIW 2008), Athens, Greece, June 2008

# P2P Credit System




- A group of devices shares the same credit account
- Credits earned with one device can be consumed by another device at a later time (in contrast to most existing incentive schemes)

# Nokia Energy Profiler

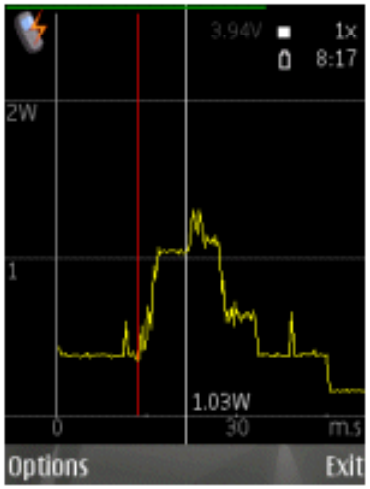
Software application. No special measurement hardware needed.

Accurate enough for most tasks (1-3% tolerance in idle states. More accurate with higher power)

S60 3rd edition and later Nokia phones

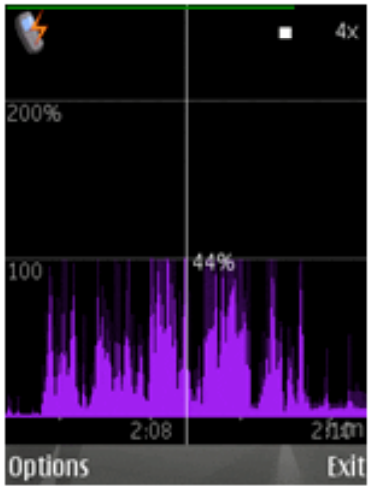
forum.nokia.com

Power

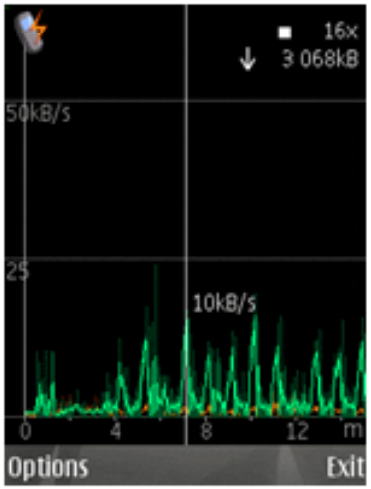



Current


CPU usage




Network



# Research questions

- What kind of P2P techniques make sense in mobile networks?
- Dealing with the limitations of mobile devices
- How will handheld use change P2P?
- What new possibilities it allows?
- Legal use cases and business models for mobile P2P

# Code, tools & further information

- Symella & SymTorrent & DHT for mobile phones
  - http://symella.aut.bme.hu
  - http://symtorrent.aut.bme.hu
  - http://www.aut.bme.hu/MobileDHT
- PAMP
  - http://wiki.opensource.nokia.com/projects/PAMP (code)
  - http://www2.cs.hut.fi/~tge/pamp/index.php/Main_Page (examples)
- Nokia Energy profiler
  - http://www.forum.nokia.com/main/resources/user_experience/power_management/nokia_energy_profiler/
- A number of conference papers
  - Search for authors like “Jukka K. Nurminen”, “Balazs Bakos”, “Matuszewski Marcin”
- Books
  - Ralf Steinmetz, Klaus Wehrle (Eds.): Peer-to-Peer Systems and Applications. Lecture Notes in Computer Science, Volume 3485, Springer, Berlin 2005
  - Andy Oram et al., Peer-to-Peer: Harnessing the Power of Disruptive Technologies, Oreilly 2001
- Personally
  - jukka k nurminen at nokia com