Decomposing power measurements for mobile devices

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31-Mar-2010

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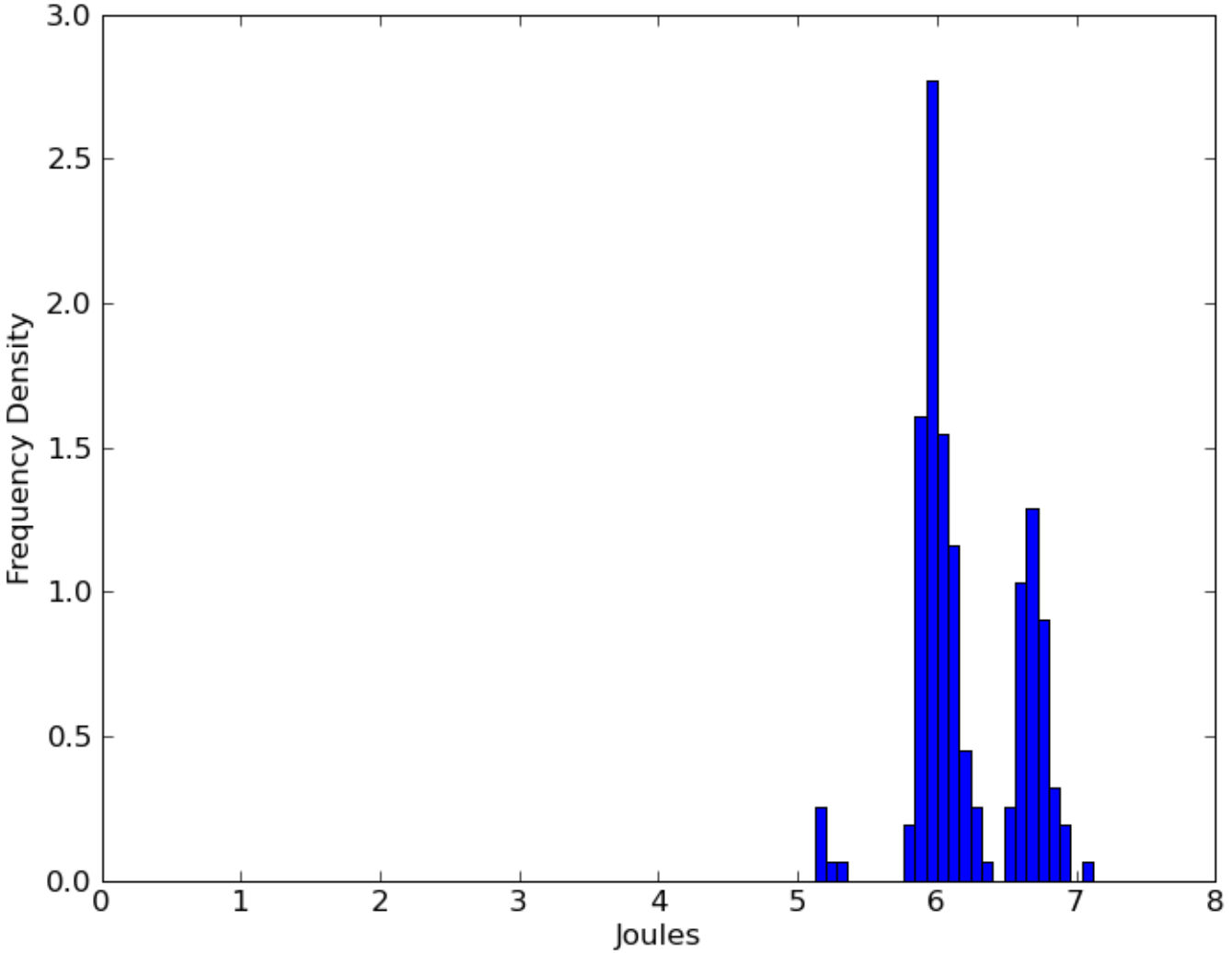
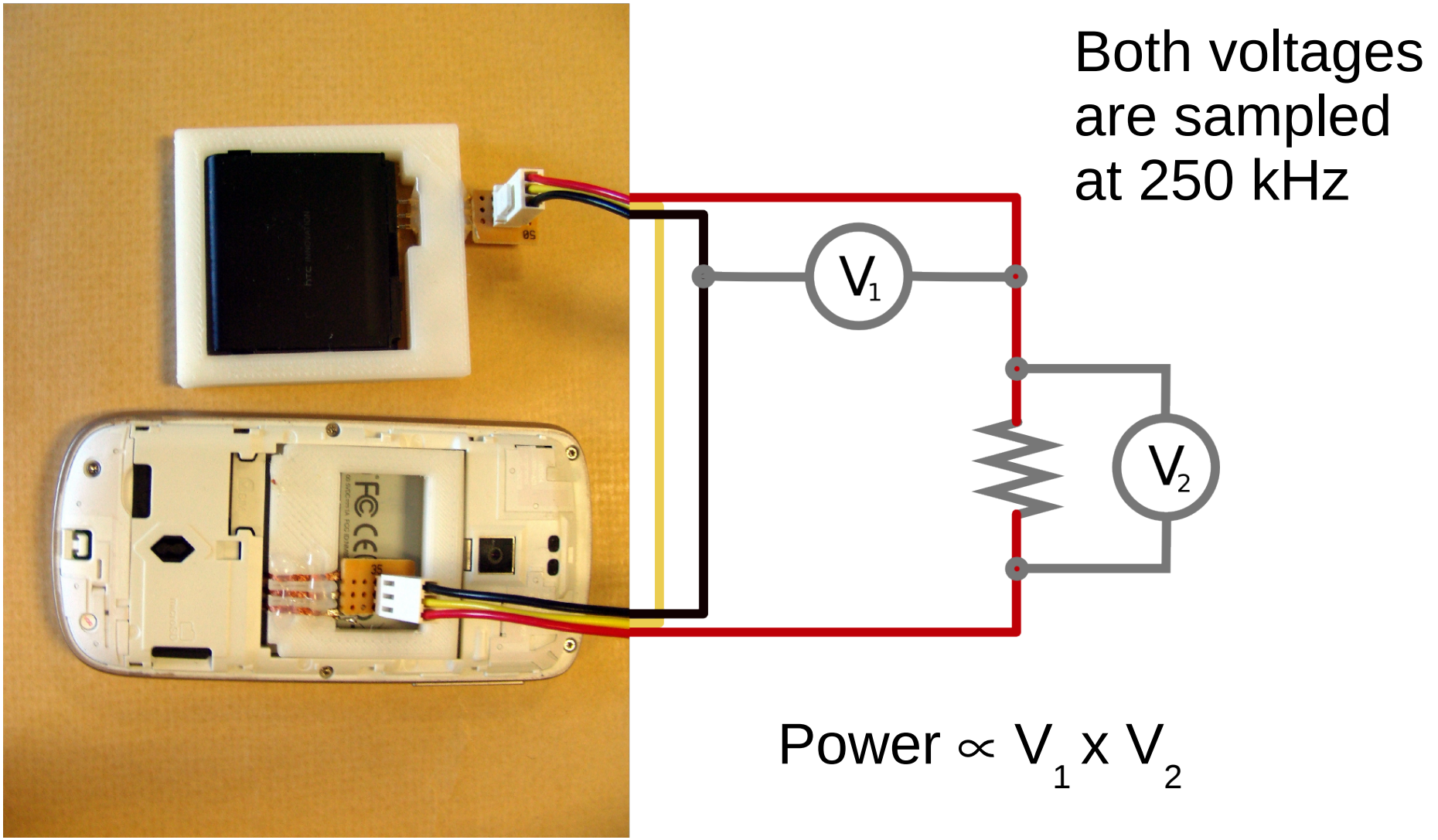
We want to know how much energy a particular ***action*** will consume

Example: joining the wireless network consumes 6 Joules



HTC G1 (or Magic), Android 1.1, 194 trials

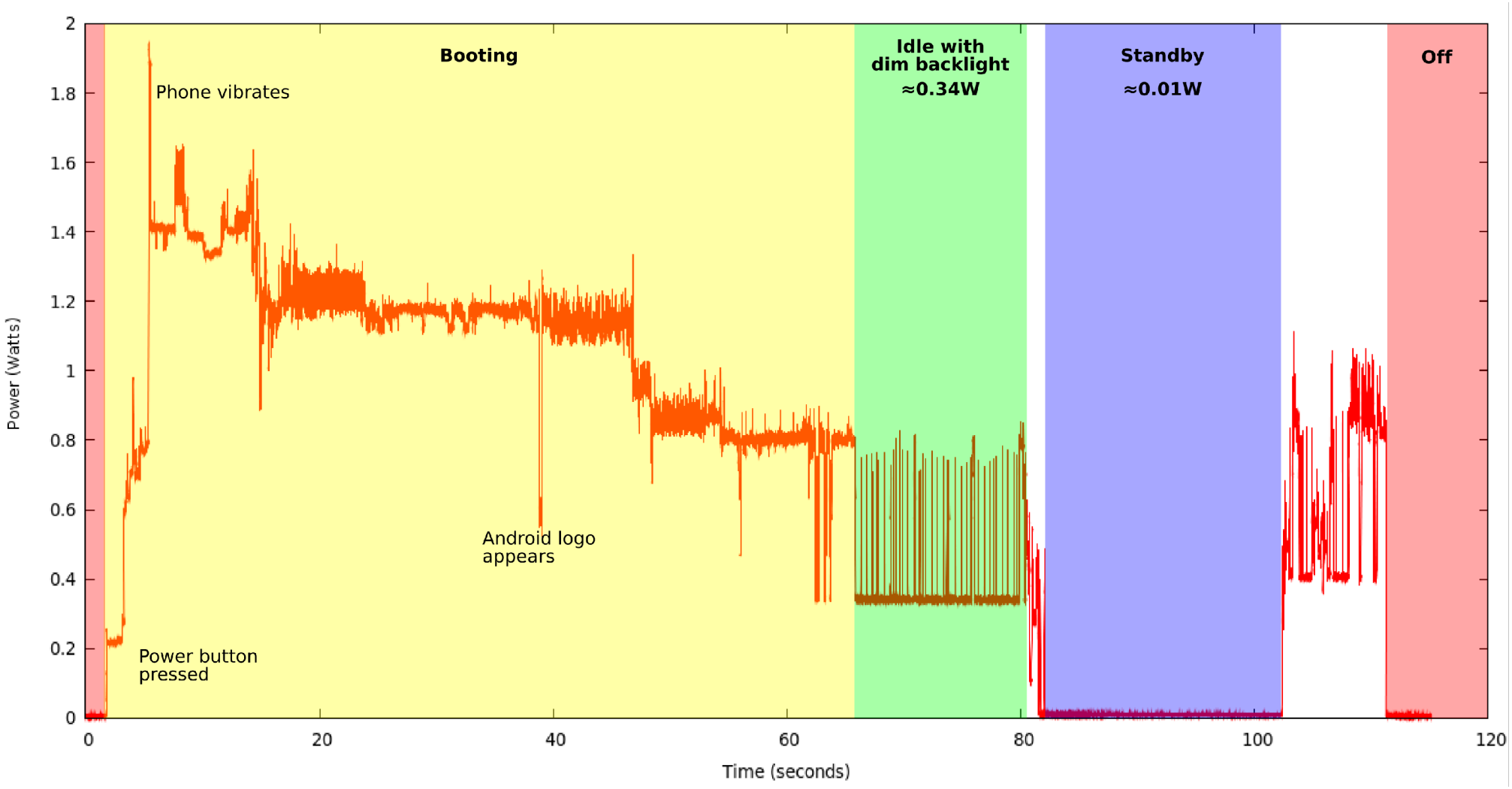
We measure energy consumption by intercepting the power supply



Both voltages are sampled at 250 kHz

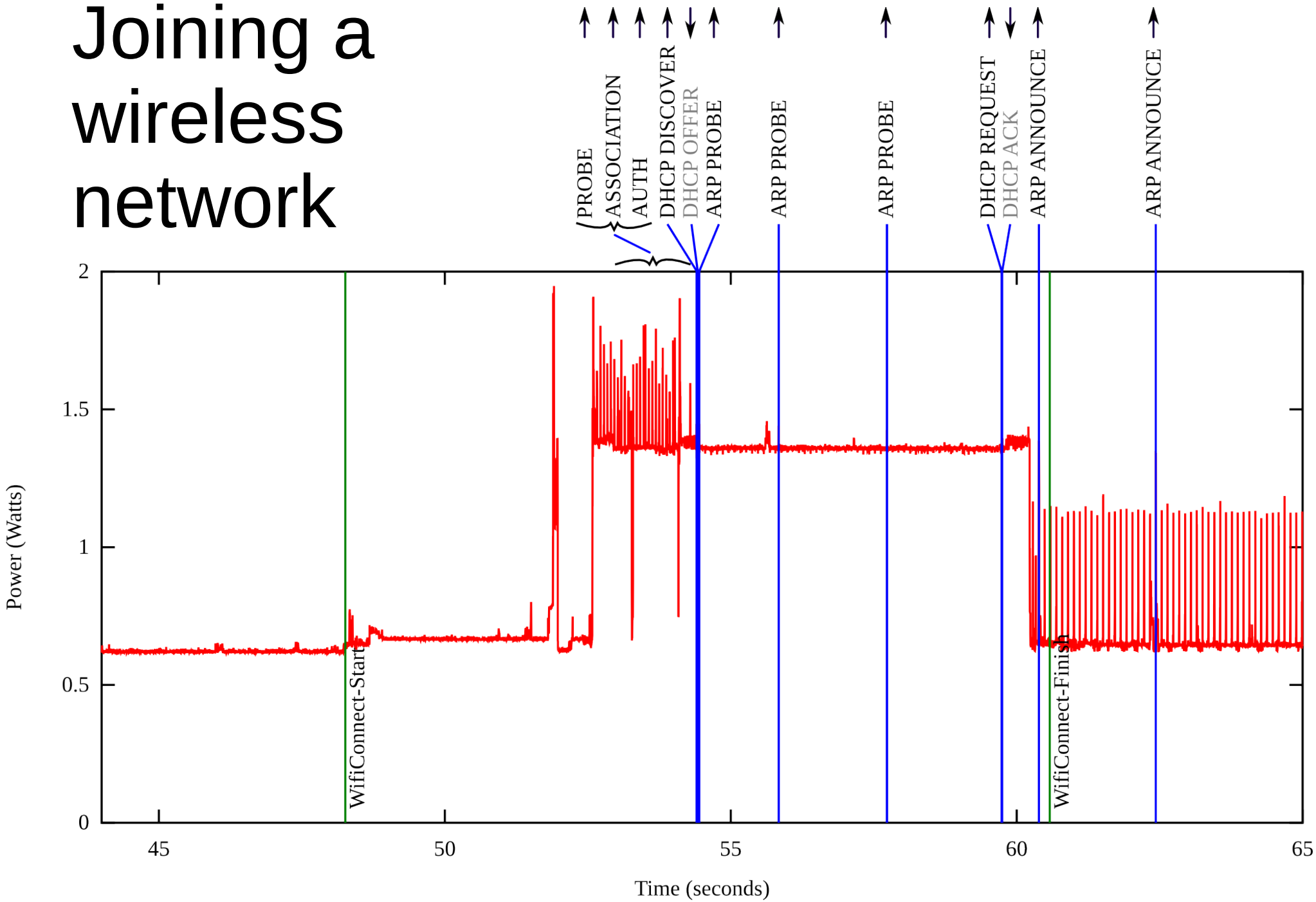
Power $\propto V_1 \times V_2$

Trace of the G1 boot process



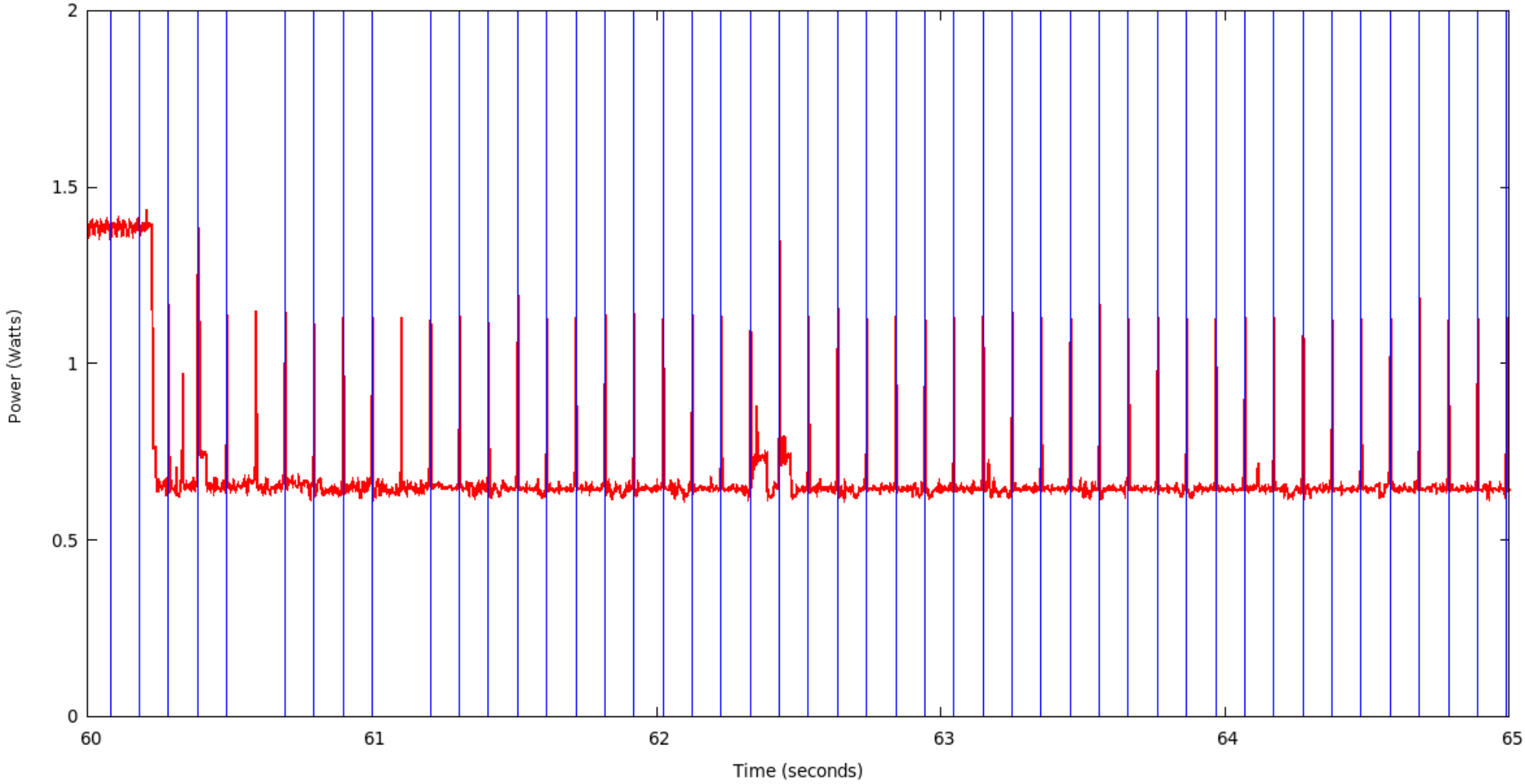
HTC G1 (or Magic), Android 1.1

Joining a wireless network



HTC G1 (or Magic), Android 1.1

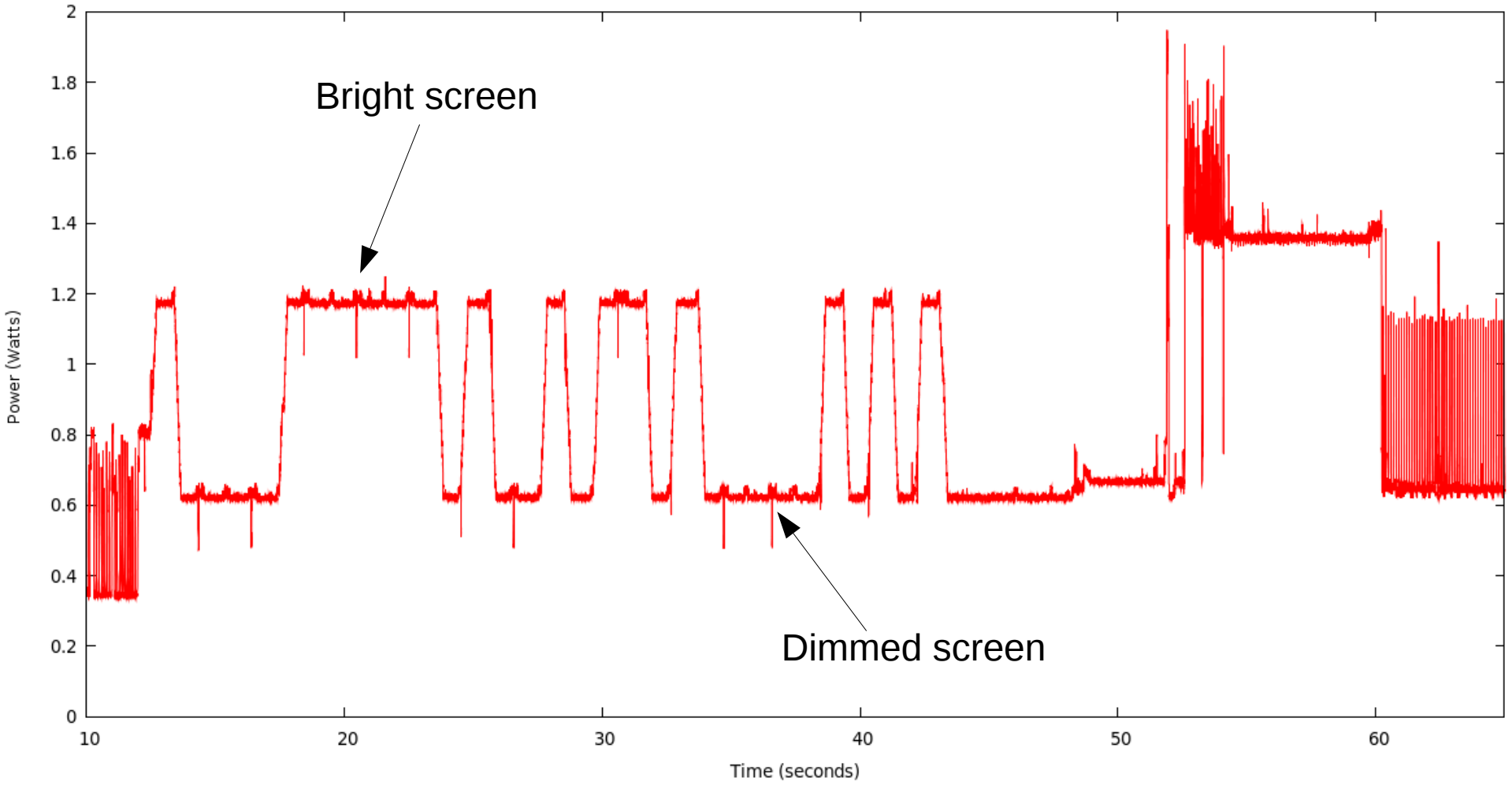
Access point beacons correlate with spikes in the power trace



HTC G1 (or Magic), Android 1.1

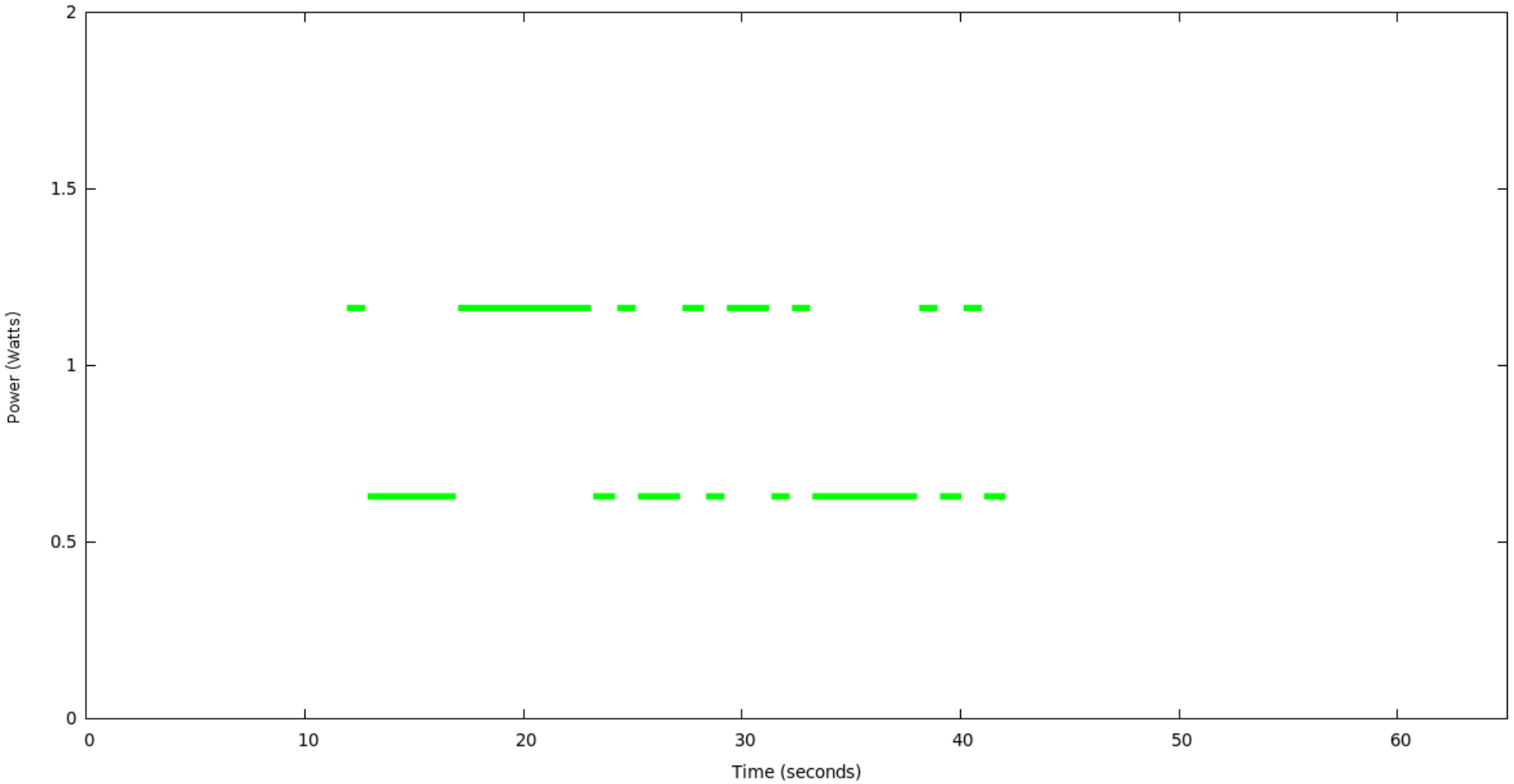
Timestamped events from the phone must be aligned with the appropriate sample points

The synchronization information is embedded in power trace



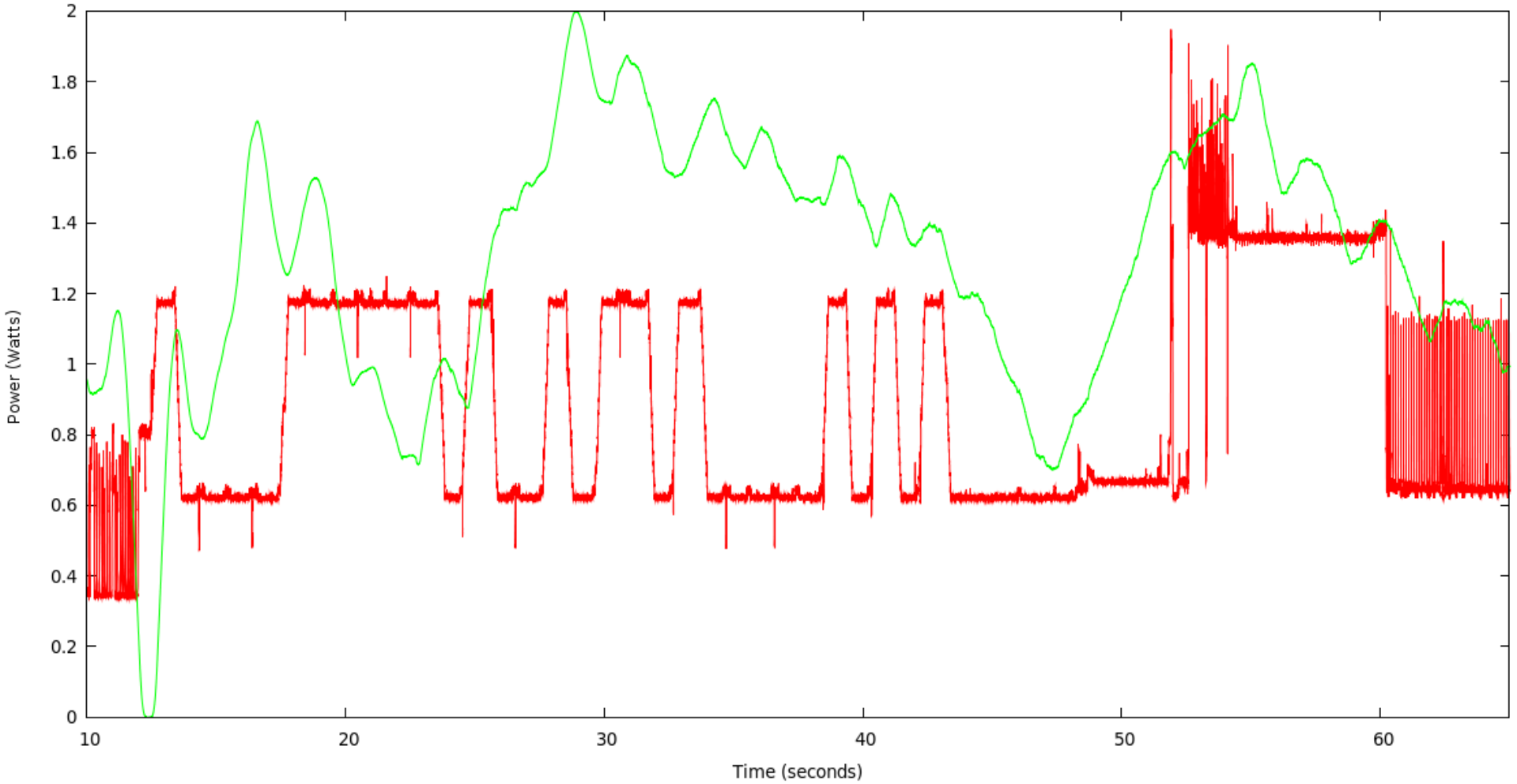
HTC G1 (or Magic), Android 1.1

Hypothesise matching pulses



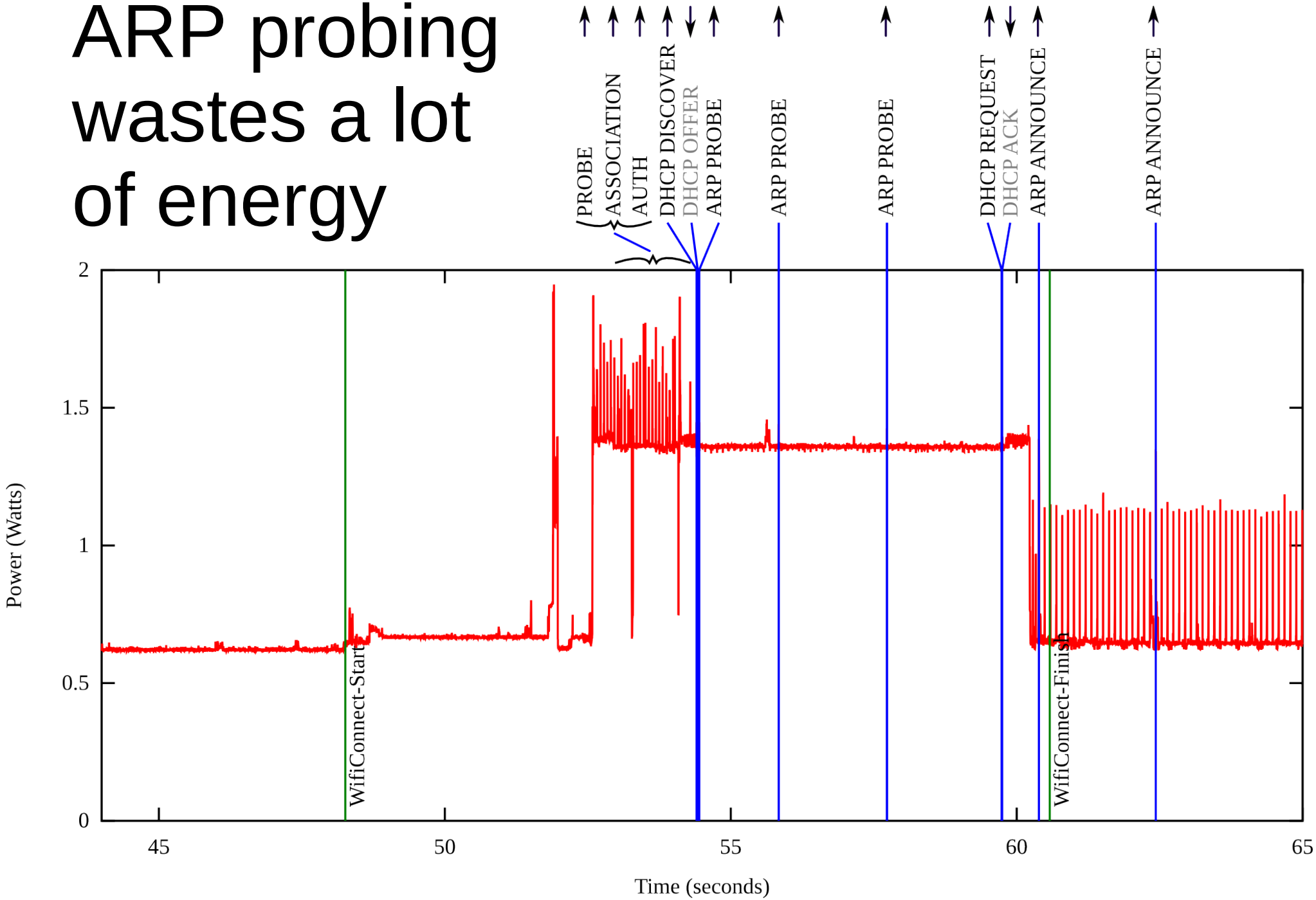
HTC G1 (or Magic), Android 1.1

Find alignment from autocorrelation with a hypothesised signal



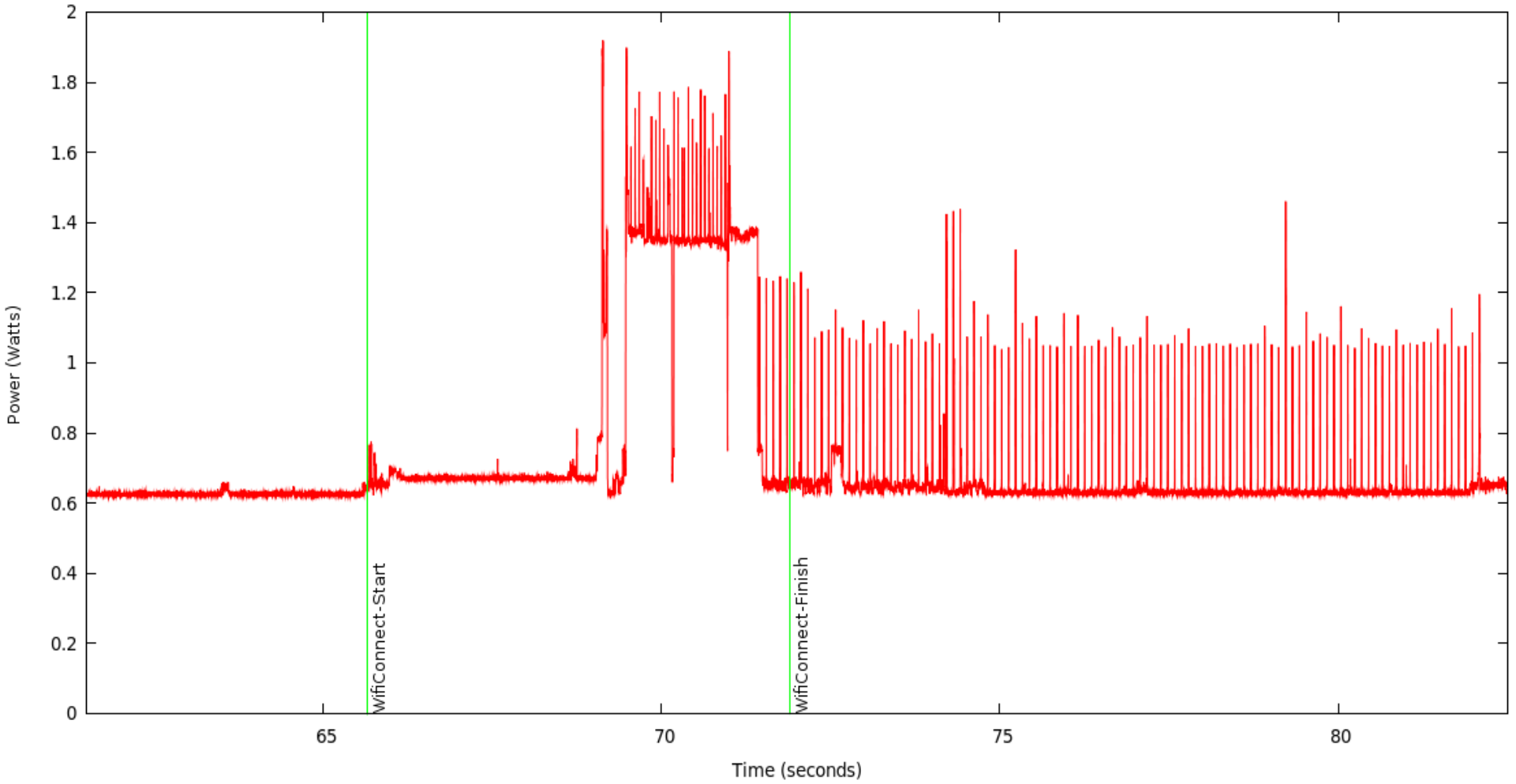
HTC G1 (or Magic), Android 1.1

ARP probing wastes a lot of energy



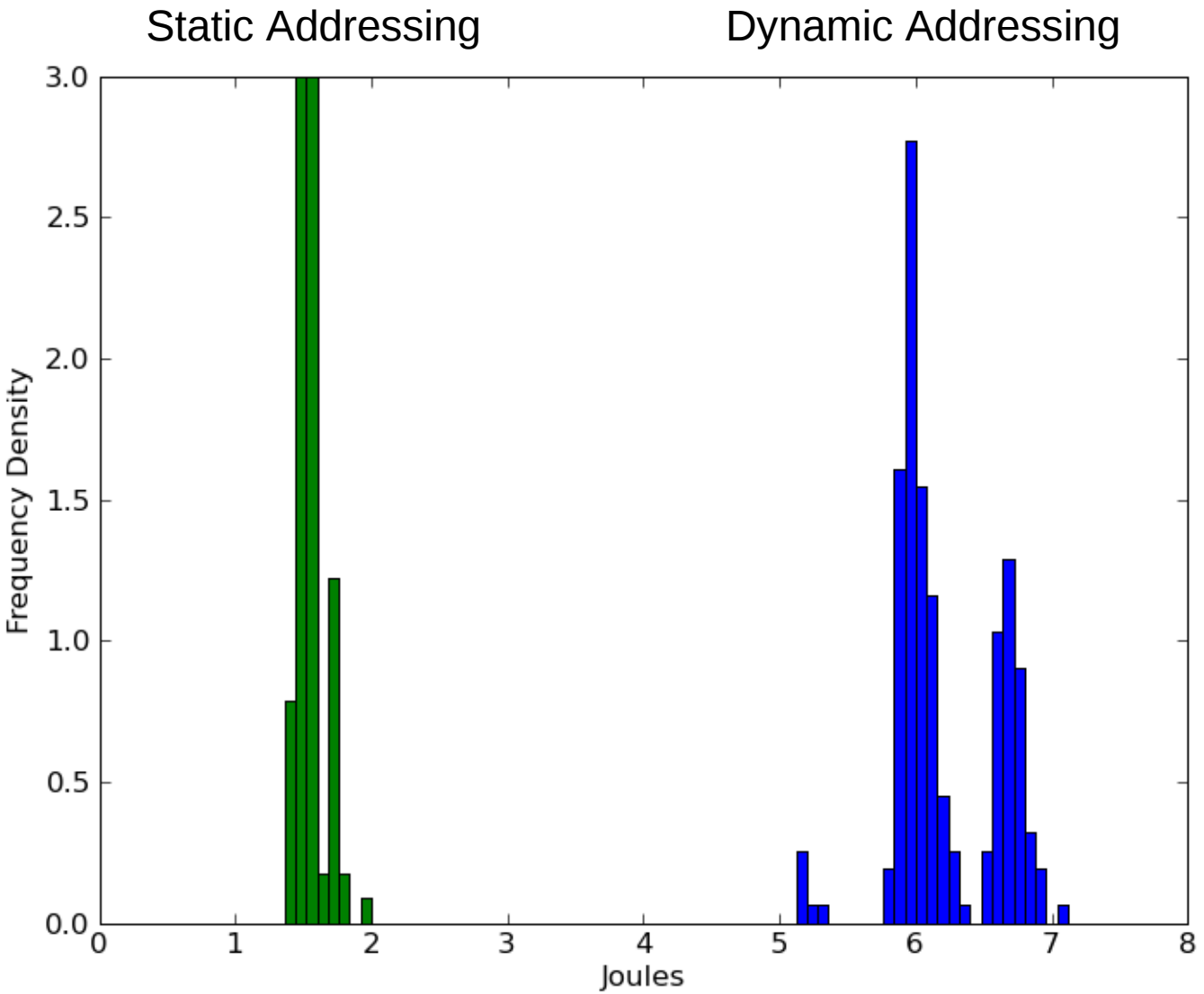
HTC G1 (or Magic), Android 1.1

Remove the DHCP overhead by using static addressing



HTC G1 (or Magic), Android 1.1

Static addressing reduces the connection cost to 1.5 Joules



HTC G1 (or Magic), Android 1.1, Static = 143 trials, Dynamic = 194 trials

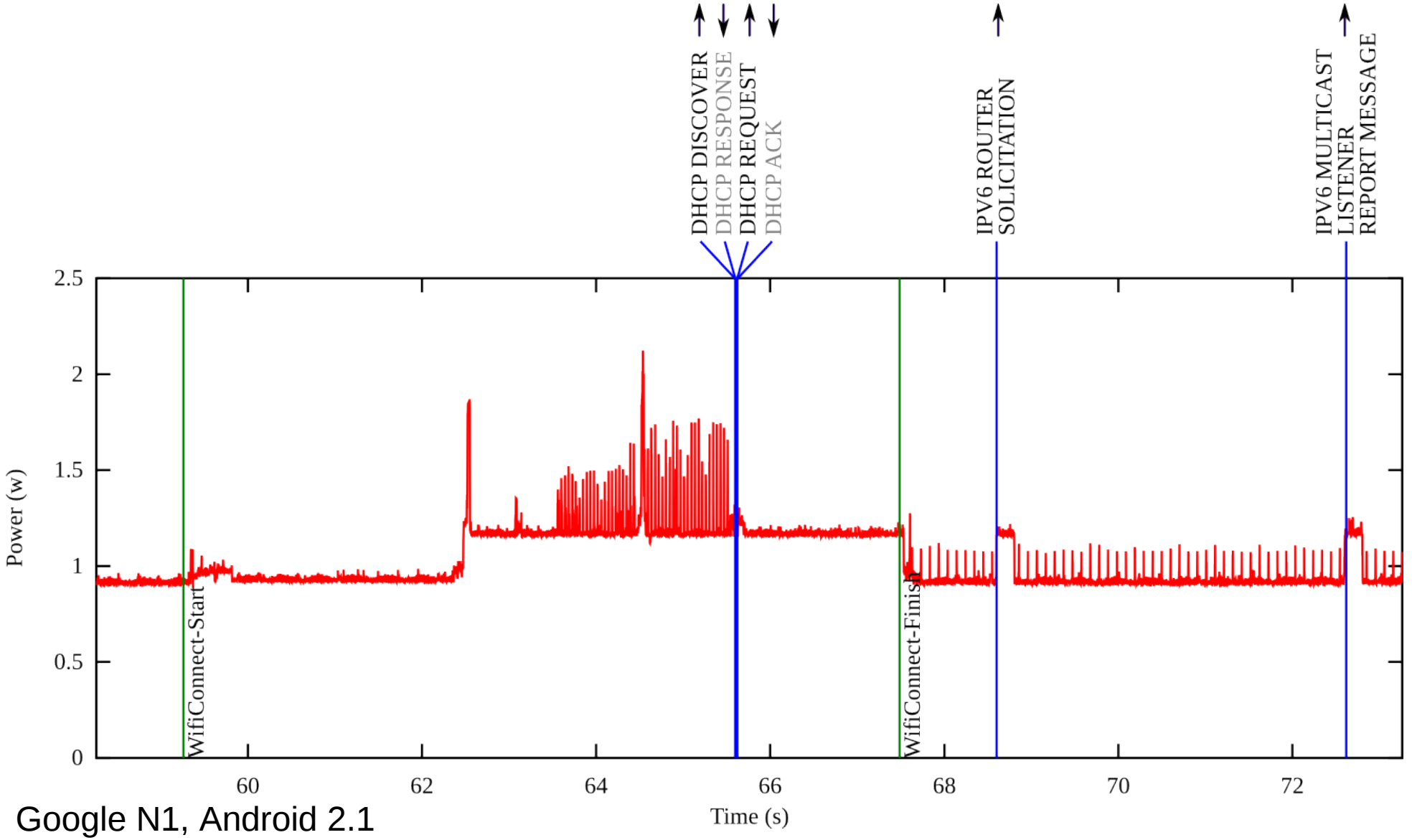
We could remove the ARP probes from our client implementation

RFC2131 “...the client SHOULD probe the newly received address, e.g., with ARP.”

RFC2119 – SHOULD “...there may exist valid reasons in particular circumstances to ignore a particular item”

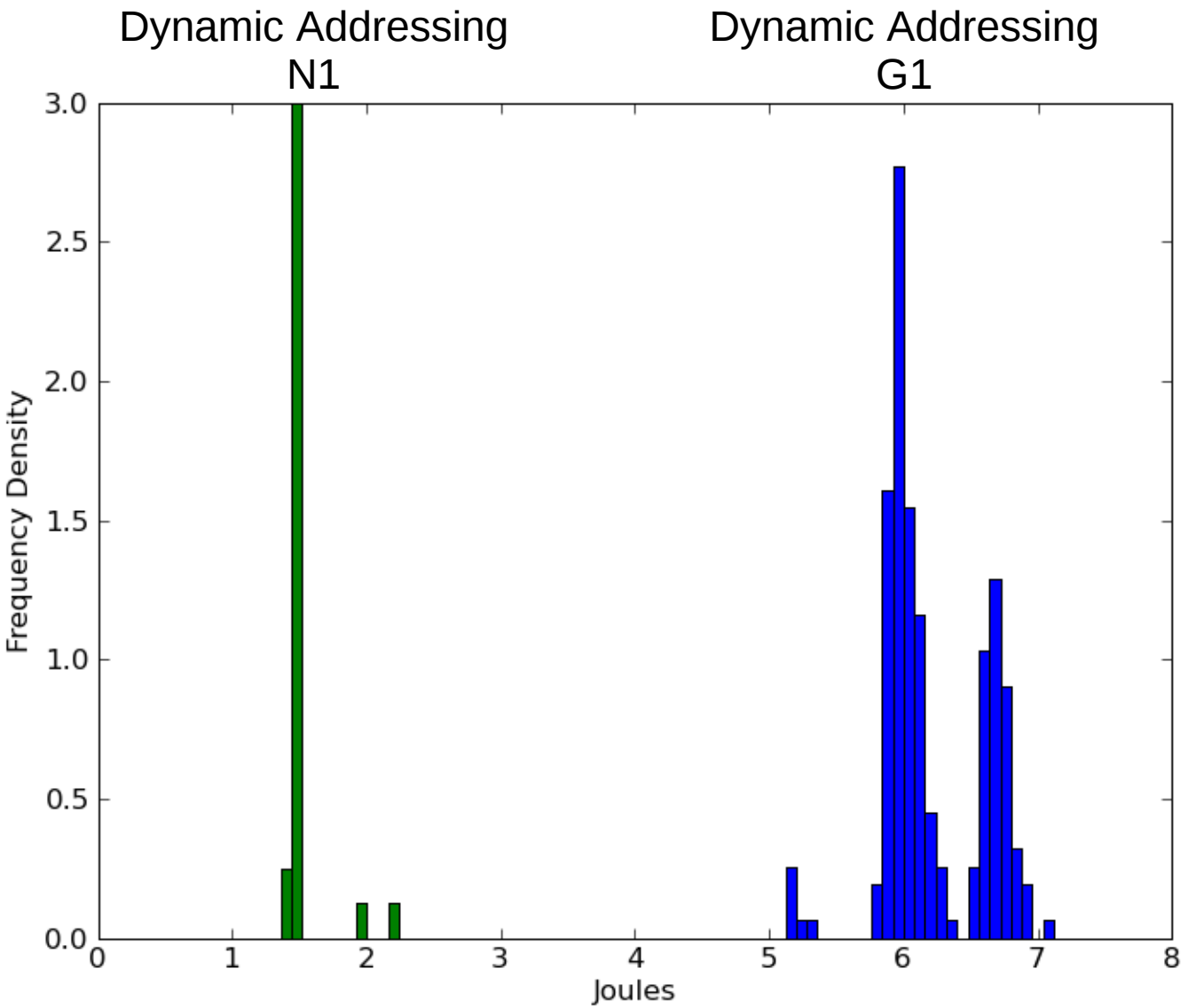
Enter the nexus one™

Android 2.1 doesn't ARP probe in our tests



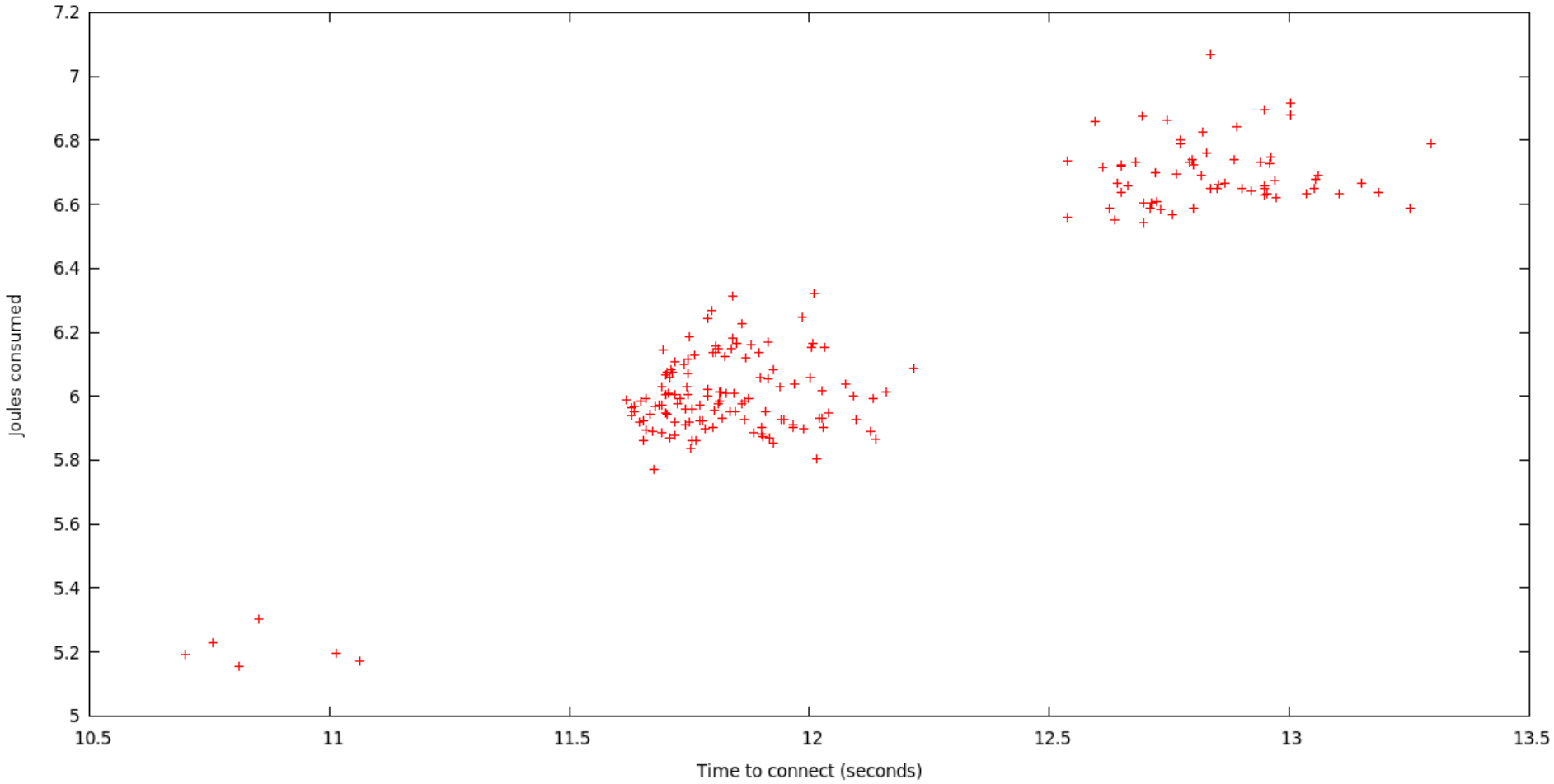
Google N1, Android 2.1

Dynamic addressing now costs 1.5J



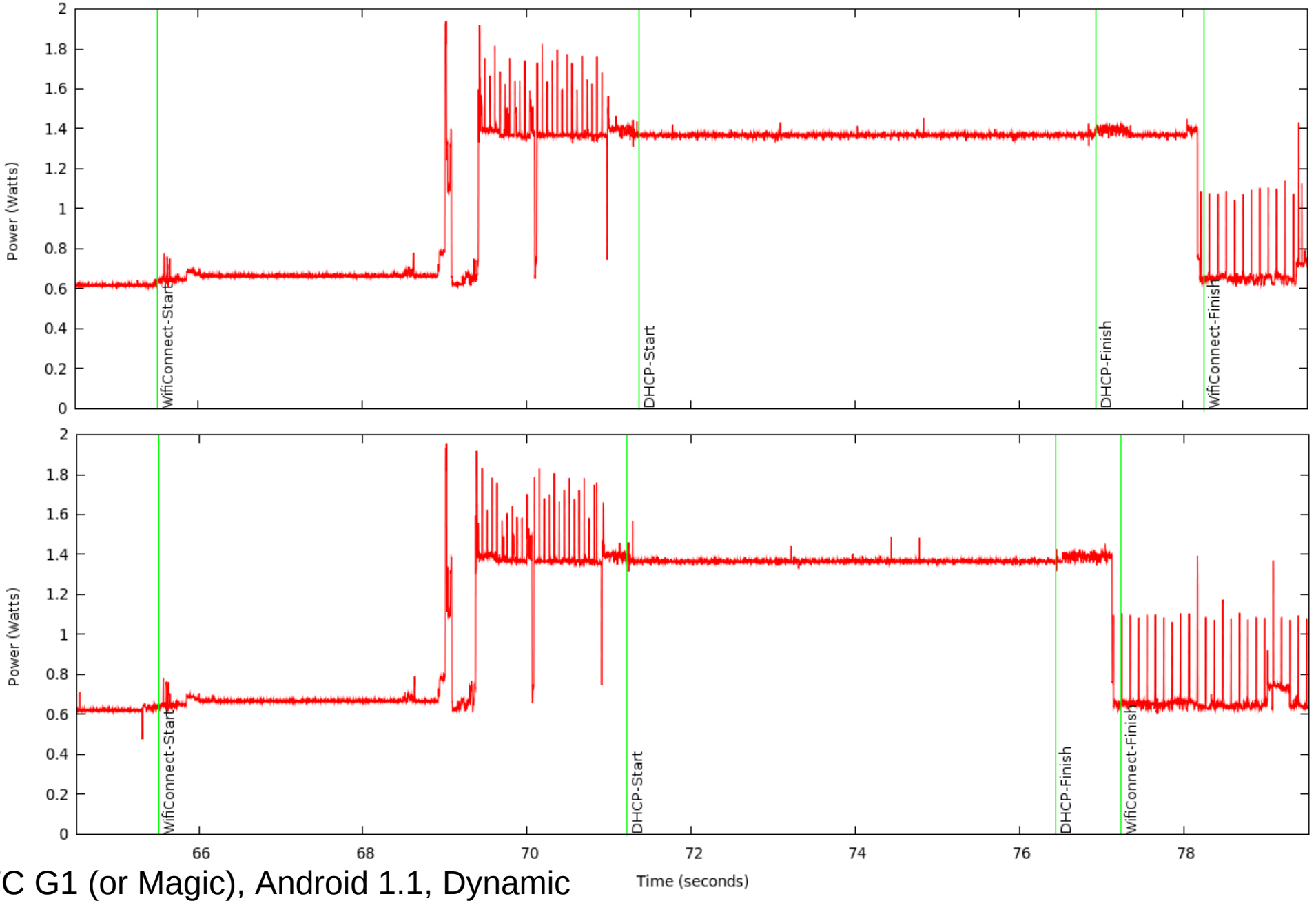
Google N1, Android 2.1, 100 trials / HTC G1 (or Magic), Android 1.1, 194 trials

The G1 histogram peaks are due to discontinuities in connection time



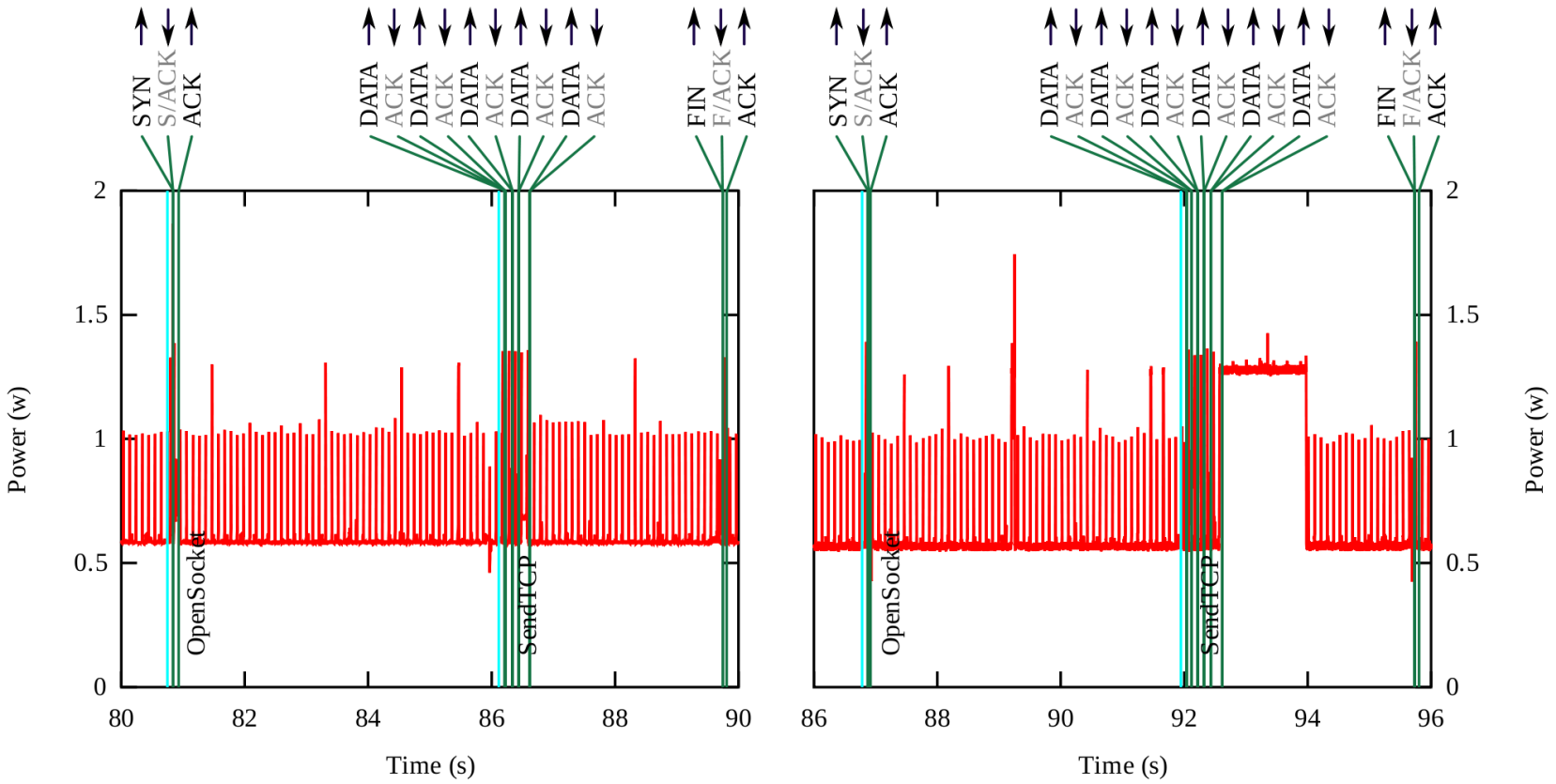
HTC G1 (or Magic), Android 1.1, Dynamic

Caused by power control in radio?



HTC G1 (or Magic), Android 1.1, Dynamic

This power control is evident when sending data too

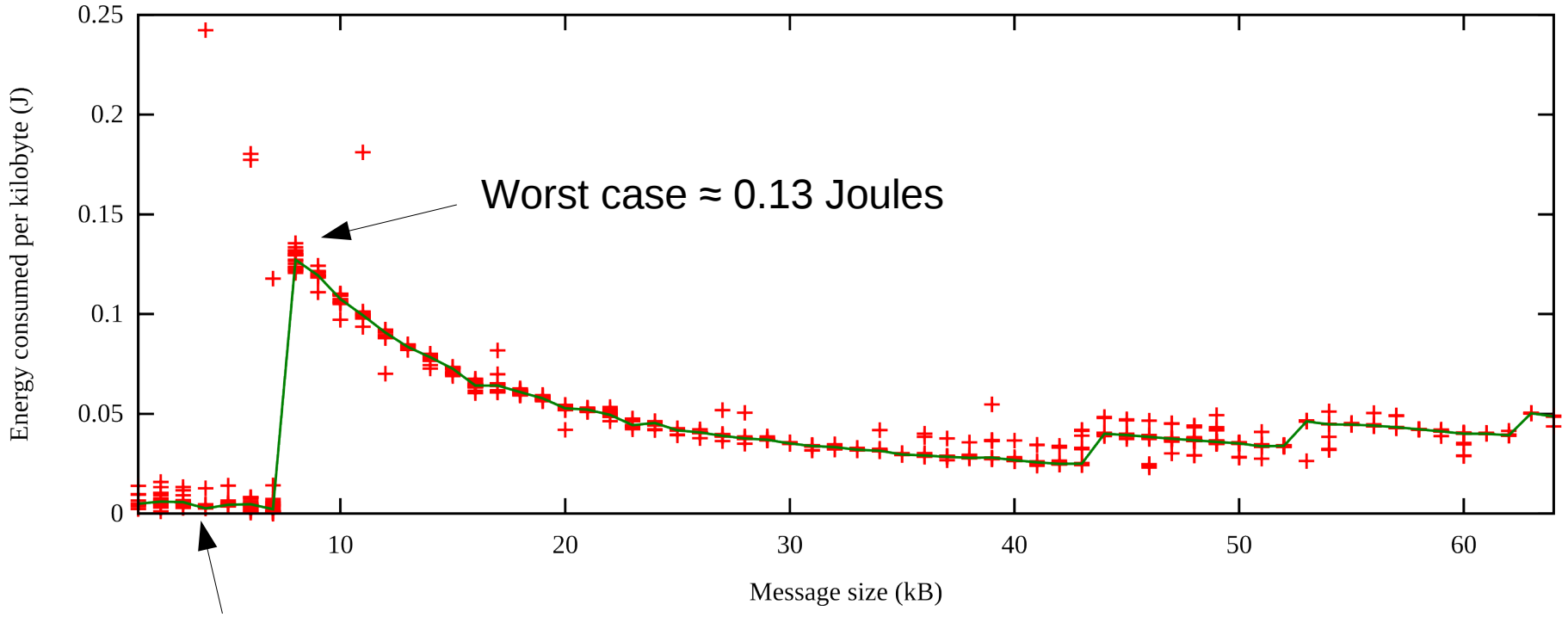


Send 7K of data over TCP

Send 8K of data over TCP

HTC G1 (or Magic), Android 1.1

This effect has a big impact on energy cost

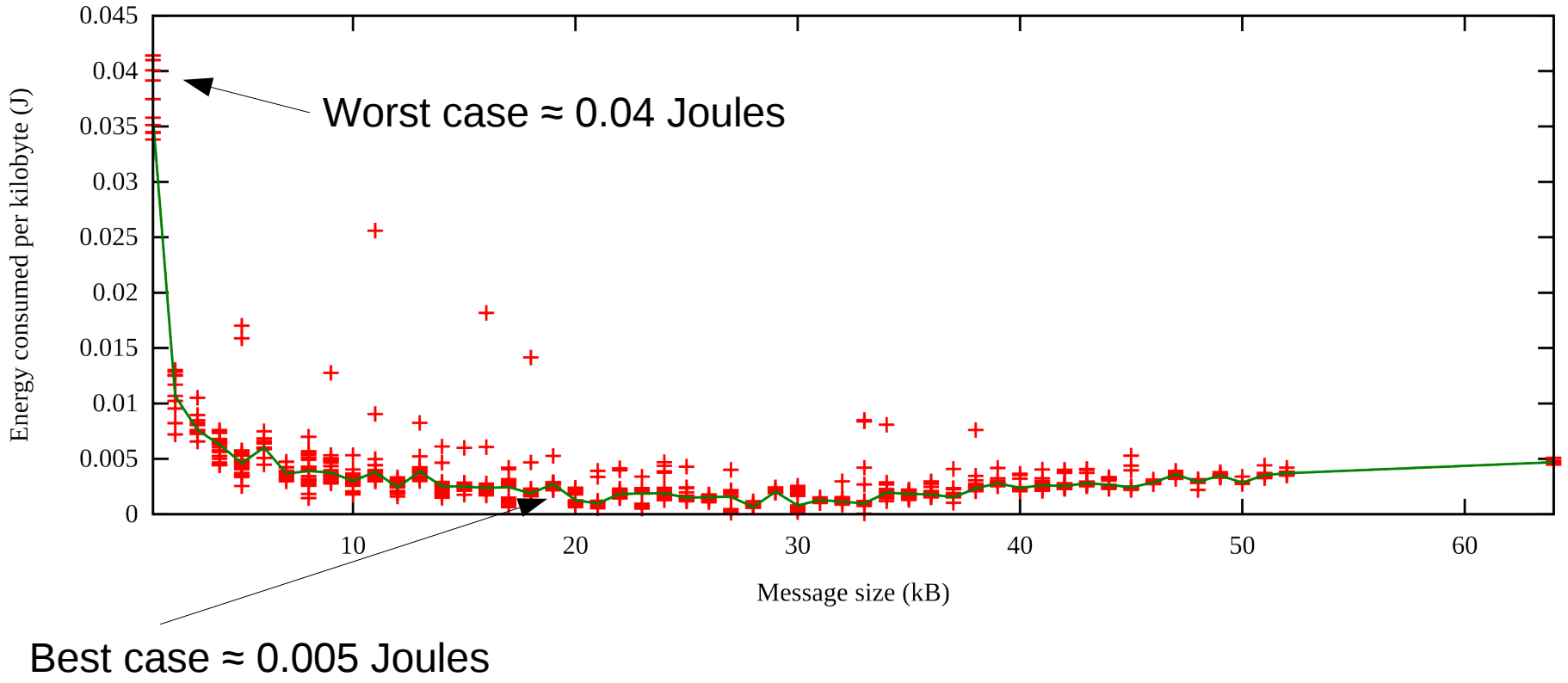


HTC G1 (or Magic), Android 1.1, 1120 Trials (HTC Hero, Android 1.5 is the same)

N1 energy performance

Best case: same

Worst case: much better

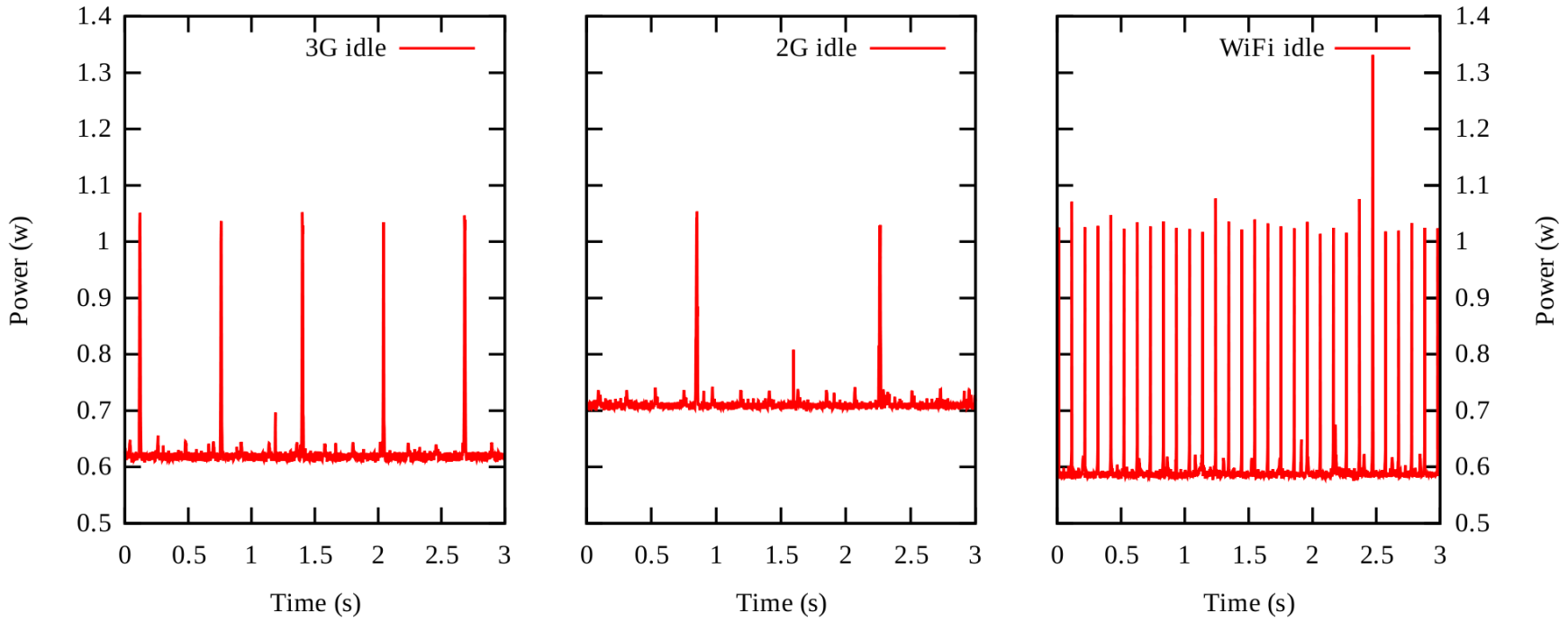


Google N1, Android 2.1, 900 Trials

Applications need to know the quirks of the device they run on

What can we provide in the OS API to make energy saving easier?

Investigating choice of network for future work



HTC G1 (or Magic) running Android 1.1

Thanks to
Simon Hay, Alastair Beresford, Andy Hopper
and Google Inc.

Computing for the Future of the Planet
http://www.cl.cam.ac.uk/research/dtg/planet