Mobile energy sharing futures

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Abstract

We foresee a future where energy in our mobile devices can be shared and redistributed to suit our current task needs. Many of us are beginning to carry multiple mobile devices and we seek to re-evaluate the traditional view of a mobile device as only accepting energy. In our vision, we can leverage the energy stored in our devices to wirelessly distribute energy between our friends, family, colleagues and strangers devices.

In this paper we explore the opportunities and interactions presented by such spontaneous energy transfer interactions and present some envisaged collaborative energy sharing futures.

Author Keywords

Collaborative energy transfer; inductive power transfer; energy sharing.

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

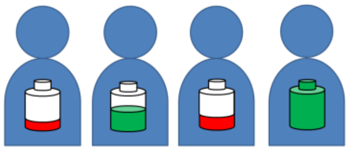

Figure 1: Mobile energy temporally varies between devices and between each other's devices. Mobile energy can be viewed as a collaborative resource, ready to be redistributed to suit our current task needs.

Figure 2: PowerShake prototype allows energy to be wirelessly moved between mobile devices, when in close proximity.

Introduction

We are beginning to carry and wear a multitude of mobile devices on and about the body, from smartphones, tablets, and laptops, to smartwatches, fitness trackers, music players, wireless headphones and cameras. Each of these devices requires its own personal energy store to operate.

Most of us are familiar with the traditional mobile device recharging paradigm; the mobile device is plugged into a larger energy reservoir, we wait a certain amount of time until enough electrical energy has been transferred, and then we can use our mobile devices in the intended mobile scenario; on-the-go.

What happens when our mobile devices begin to run out of energy when we are on-the-go? We might begin to turn off features of our device with high energy consumption, such as mobile data, location services such as GPS, refrain from taking photos, reduce the screen brightness, or simply stop using the mobile device altogether to preserve the precious resource of energy. What if your smartphone is running low on energy but your camera in your bag has full battery? Wouldn't it be great if you could transfer energy from one to the other? This is the scenario we explore, where energy can be redistributed across our mobile devices to suit our changing needs, all without requiring cables or hardware external to the device.

In this paper we examine how mobile energy can be wirelessly redistributed across our own mobile devices and also those of our friends, family, colleagues and strangers devices for collaborative energy sharing, as shown in Figure 1.

Related work

Providing energy in a mobile context is an active research domain. Energy harvesting or scavenging solutions, where energy is reclaimed from our ambient environment, can help to prolong battery life but typically generate limited amounts of energy. For example a wearable solar cell produces between 16.2 to 28.6 mW in direct sunlight luminance [2]. In contrast a typical mobile phone battery stores 19,980 J of energy (3.7V, 1500mAH), so the 28.6mW solar cell would take 194 hours to completely charge the phone battery.

Many commercial hardware based solutions exist such as external power packs, hand cranked generators and solar cells. These solutions all require hardware external to our mobile devices which can be easily forgotten (or forgotten to be charged) and rely on standardization of connectors, (e.g. micro-USB). They do not afford ad-hoc, spontaneous, energy sharing between devices.

Inductive power transfer can support spontaneous energy transfers, using a time-varying magnetic field to transfer energy from a transmit coil to a receive coil [3]. Inductive power transfer to on-body garments has been previously proposed [3] to help power a growing wearable infrastructure on the body. We build upon this growing of body of literature to allow on-the-go wireless mobile energy sharing between devices using inductive power transfer.

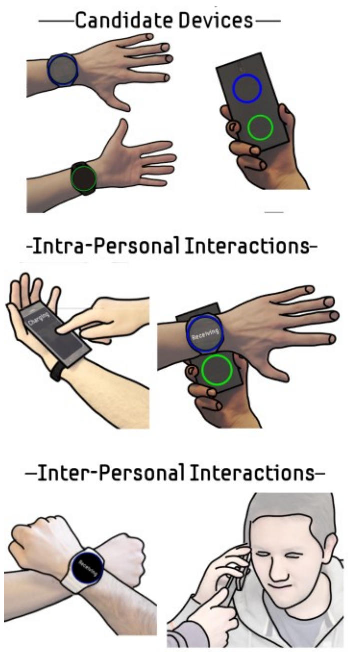

Figure 3: One of the PowerShake candidate designs, developed by interaction designers, with the location of a transmit coil (blue) and receive coil (green) on a smartwatch and smartphone. The coil locations enable a range of collocated power sharing interactions to support common mobile tasks.

PowerShake: mobile power sharing between wearables

In PowerShake [4] we presented a prototype system which affords users the ability to wirelessly redistribute their energy across multiple mobile devices using inductive power transfer, as shown in Figure 2. We termed energy transfer between devices a power transfer interaction. Two types of power transfer interaction were identified during the research, *intra-personal power transfer* where energy was distributed between a single user's devices and *inter-personal power transfer* where energy was transferred between two different users' devices.

PowerShake allows collocated users to share power even whilst carrying out a task, such as making a phone or video call. Since the mobile device could be in close proximity to the body during a power transfer interaction, the design of PowerShake emphasized compliance with guidelines on time-varying magnetic fields. A separate transmit and receive circuit was used for PowerShake to allow the receive coil to fit inside the transmit coil, or to dock with a target device, to maintain a high power throughput. Six interaction designers took part in two workshops to decide where the docking mechanisms should be placed on the device and to explore the interactions afforded by different coil placements, see Figure 3. In an open workshop of 24 participants at a creative hub for artists, designers and technologists, participants explored collocated interactions enabled by PowerShake. The participants role played a variety of scenarios, such as charging during a phone call from phone-to-phone and found the interactions for both designs to be comfortable for short periods. As such PowerShake can be viewed as a method to support a critical task with low battery, such as a phone or video call. The PowerShake circuitry can be constructed in a surface mount form factor and use flexible coils, allowing easy integration with current smartphones, smartwatches and mobile devices, thus affording spontaneous, ad-hoc power transfer interactions.

Garment based energy transfer

In addition to PowerShake, we developed a system which allows energy to be transferred between a single user's mobile devices using the garments we wear as a backbone for coils connected using conductive fabric [5], see Figure 4. The system uses bi-directional inductive power transfer meaning only one coil is used to transmit and receive energy.

Power sharing futures

The workshops conducted while designing our systems highlighted interesting user behavior around power sharing behaviors. We saw altruistic power sharing between friends, family members, colleagues and even unknown colleagues in certain controlled situations, such as a board room. Participants were reluctant to give energy to a stranger however, from a fear of physical or digital theft or as a consequence of today's 'personal and precious' view of energy. Incentivisation for energy transfer between strangers was discussed at the workshop, such as trading energy for money. One participant suggested a points based system for how much energy you have taken and how much you have given.

Combining the findings of PowerShake and garment based energy distribution, provides an interesting perspective on future power sharing. First, mobile devices could remain in a user's pocket with an exit /

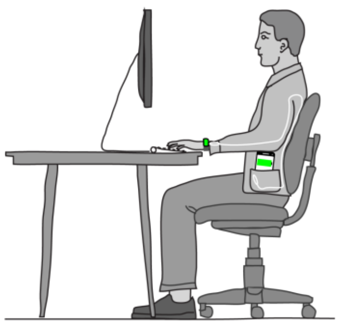

Figure 4: Garment based energy sharing example scenario where a mobile phone in the user's pocket is transferring energy to a fitness tracker on the wrist.

entry point for energy taking place between garments, such as on the wrist. In this way trust concerns, (i.e. device theft), could be mitigated for interactions between strangers. To further mitigate device proximity issues a mobile variant of the MagneticMIMO system [1] could be developed. MagneticMIMO uses multiple coils to 'steer' a magnetic field toward a target device. A mobile variant would have the significant disadvantage of the transmit surface being mobile, although devices would not have to be directly docked together. Compliance of this system with international guidelines on magnetic fields would, similarly to PowerShake, be of paramount importance.

Allowing energy to be redistributed between mobile devices carries the caveat of colocation. However, perhaps energy can be 'left behind' for a specific person, in effect exploring temporal collocation. For example if the bus a user catches is an electric vehicle, they may be able to transfer energy to the vehicle for retrieval by another user of the bus at a later date, or another user of another bus, since the net energy in and out across the transport network would be zero. Energy could also be traded with the transport network as a form of payment.

Conclusion

We envisage a future of wireless mobile energy transfer, where device energy can be shared between collocated parties. No longer would energy be a per-device, personal concern, but would rather become a community resource. Through incentivisations, users would be encouraged to support the energy requirements of friends, colleagues and strangers. Furthermore, these spatial transfers need not occur only when collocated. Users could also 'leave behind' energy stores in specific locations, either for their friends or as a style of charitable donation.

As the community continues to explore collocated sharing of data and information, our work looks to the sharing of resources that enables and supports other mobile interactions. Our work in this area has highlighted a range of considerations in the designs of power transfer interactions that we believe generalize across collocated interactions.

Acknowledgements

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