Harvesting the Future of Mobile

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It's been a great summer day, and your mobile phone has played many hours of music during this long day at the beach. It's time to go home, and your battery is still full. Sounds impossible with today's batteries and devices? Well soon this experience could be part of your everyday reality.

Improvements in batteries have lagged behind the increasing power requirements of other components inside the mobile phone but other technologies have emerged to deliver on the promise of always-on mobility. Power harvesting, the technique of collecting alternative energy sources and managing them, has rapidly evolved and is poised to be a key technology of future mobile devices.

With over 6 billion subscriptions and more than 1 billion smartphones forecasted by most analysts in 2014, the incredibly fast innovation of the past 10 years has put amazing new capabilities in the hands of consumers. Devices are expected to offer faster processors, bigger screens, and high quality cameras while being always connected. The latest augmented reality applications, 3D game or social network sites demand always more performance. But all the more, they need to achieve it with no need for a charge every half day.

The semiconductor industry has made amazing progress in making devices more efficient, and capable of delivering ever higher performance at low power consumption. However, despite this progress the gap between the energy need and the energy available is continuously widening.

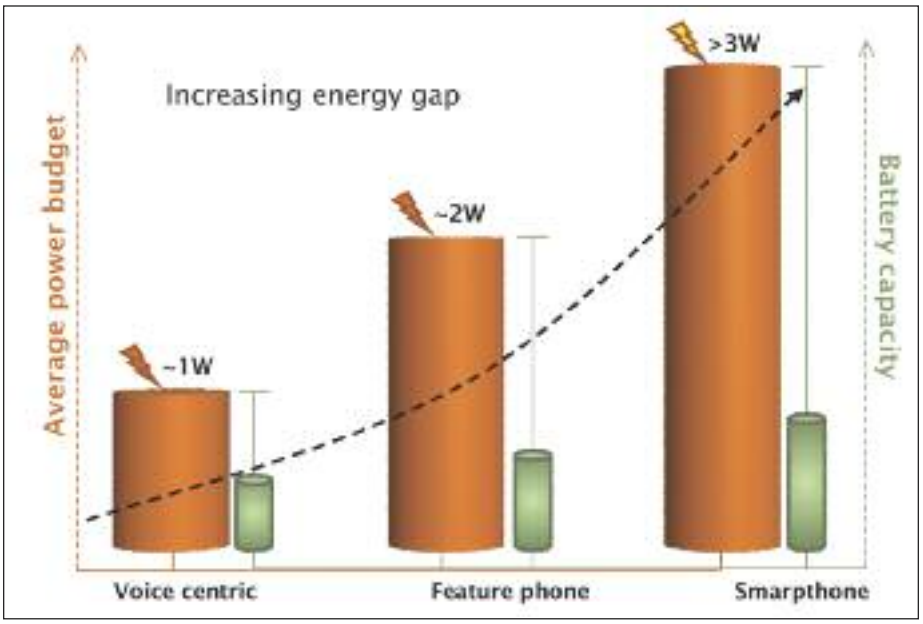

Figure 1: As devices evolve, the gap between power budget and battery capacity increases

To address the energy gap relying only on battery evolution is not enough. Following the trend of development of sustainable energies in other industry sectors, the wireless industry is also looking at alternative sources and power harvesting to solve the battery life issue of future devices.

Power management is an essential and integral part of any mobile device. There are three angles from which the power cycle in a mobile device can be addressed: collection, distribution and consumption.

Consumption is an area where we've seen some great improvements in recent years, especially with the ARM® architecture. As smartphones evolved so did highly clocked processors which today offer attractive performance, smoother applications, high-quality multimedia and support complex use cases. However, as we've seen in the PC world, there is a design point where pushing frequency beyond the sweet spot does not bring the right returns. This is where scaling performance through multi-processing becomes a must. With designs such as the recent multicore processors offered by ARM (e.g. Cortex-A9), mobile platforms can deliver a perfect balance between scalable performance and low-power consumption, making an ideal solutions for thermal and cost constrained devices. Using a dual-Cortex-A9, a platform like ST-Ericsson's U8500 can achieve 120 hours of audio playback of 12 hours of HD video, numbers which are today not even expected from standalone music or video players.

Now the parts of the process which have seen little or no improvements in the past 5 years are collection and to a larger extent distribution.

Energy Harvesting

Energy harvesting (also known as power harvesting or energy scavenging) is the process, by which energy is derived from external sources, is collected, and stored. There can be a variety of energy sources such as solar power, thermal energy, wind energy, salinity gradients, and kinetic energy). Frequently, this term is applied when speaking about small, wireless autonomous devices, like those used in wearable electronics and wireless sensor networks (source: Wikipedia). Harvesting is interesting for the wireless industry for two reasons: Firstly, it could solve battery life problems and deliver more energy to applications. Secondly, it contributes to reduce use of carbon energy by using alternative green sources. In this article we will focus on the first benefit.

Although being a relatively new technology, it is already used in other industries. The sensor industry is the forerunner: today standalone sensors are using alternative energies such as solar or wind for an unlimited use. The proliferation of solar lamps for the garden is a good example of how widespread this technology has become. Innovative use-cases are starting to appear as well with devices using kinetic energy while you run to recharge your music player.

Integrating the collection of alternative energy sources to a mobile device brings a number of challenges. External look & feel,

Figure 2: Multiple energy sources available for use in future mobile devices

Energy	Description	Market status
Contactless supply	Wireless chargers can become an alternative to the standard charger. One wireless charger can be used for all mobile products in a family.	Commercialized
Kinetic energy	Energy from movement or vibration. The increased use of MEMs in mobile is reinforcing this harvesting concept.	Development
Fuel cells	Fuel-cell technology is an interesting source of energy which has been demonstrated but is not yet ready for broad use in mobile and industrialization.	Development, potential commercialization 2012/2013
Micro-battery	A good candidate for mobile application. Small size and flexible use make it very easy to use.	Research
Thermal harvesting	Thermal harvesting is really interesting as it is a source of energy available everywhere, inside the phone, at ICs level or system level and outside the phone.	Research
Radio waves	Would be a new area for investigation. We all are surrounded by RF microwaves and being able to harvest this energy would generate a significant source of energy for a mobile application.	Research
Solar energy	Commonly used in other industries and introduced in production in wireless. A big potential lies in transparent flexible solar cells.	Commercialized

form-factor, cost, portability, are only a few of the inherent constraints brought by the device. If we add in the different maturity levels of the technologies and the need for co-existence then it's easy to understand that this is not a simple problem.

Multiple technologies and energies are being investigated for power harvesting in mobile (see table), but one of the most advanced is solar. Despite low efficiency of current photovoltaic cells, the use of solar energy in houses and multiple other fields has clearly proven the interest and popularity of this technology. In the coming years we will see photovoltaic cells with higher efficiency and more attractive cost enabling a wide deployment in mobile equipments.

Solar has already made some appearances in mobile; in the Samsung Blue Earth, a solar panel is added on the back of the phone to be used as a charger for the battery. The phone may be used in developing countries with poor access to electricity.

The next step is to allow the solar energy to power the different parts of the phone and not only be used to charge the battery. When improving the energy path and distribution, one can use specific energy sources to power selected areas of an application.

At the Mobile World Congress this year, ST-Ericsson demonstrated a use-case called "endless mp3 playback". Using only solar energy, the system would directly power an audio component to deliver mp3 playback without a need for the device's battery (figure 3 next page).

It is important to understand that energy harvesting is unpredictable in contrast to a battery or USB charger. One cannot know how much energy will be available to gain and for how long. Therefore, the distribution part of the system must be smart and built in order to:

- Gather the harvesting energy when it is present with the best possible efficiency
- Mix the harvesting energy with the other usual energy
- Partially (when possible) replace entirely the standard energy (battery) to fully power a use case as explained above with the music playback.

Once a better distribution mechanism achieved, one can only imagine the possibilities opened by energy harvesting. All basic use-cases could be powered by different types of alternative technologies and your wireless device could recharge while you are walking or standing anywhere in the sun.

All the sources are available in or around mobile phone and can be used to supply or charge. Every source brings its set of advantages and disadvantages and probably none will yet replace the battery. However, being able to collect and manage them all in a smart way will make the difference. The optimal energy harvesting system should be simple, automatic and smart with the capability to supply energy to the right components when and where required. The harvesting can therefore not be considered as a standalone solution, but must be integrated in the whole process of saving, managing and distributing the power to the application.

Semiconductors have also made tremendous progress on the ICs power consumption, but also on the software managing smartly the power in the platform.

Conclusion

While the current solutions are not yet optimal, there is a bright future for the vision of the "always connected" device. Thanks to advances in power management and processors we've reached amazing performance with low power consumption in today's devices. Energy harvesting, is one of the next steps in making phones complete power efficient systems. As the technologies evolve, challenges will have to be solved; how will each energy source be integrated into the device or what cost will it add to the bill of materials.

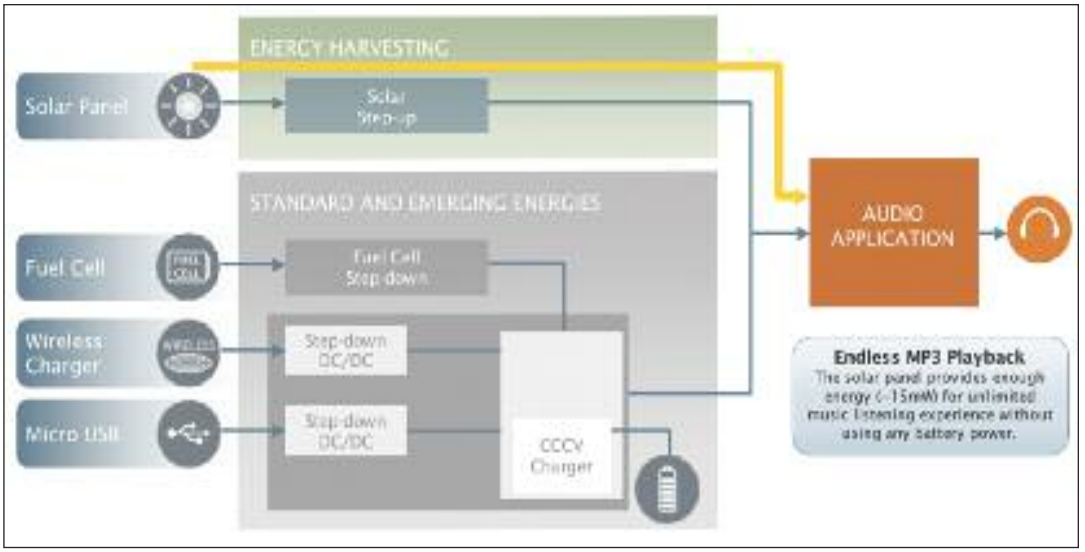

Figure 3: Endless mp3 playback using solar as the only energy source

With the growth of mobile broadband and the vision of 50 billion connections in 2020, the environmental impact of the wireless industry will be closely watched and power efficiency will be a measurable factor of it.

During 2010, we should see the first energy harvesting components coming to market; ST-Ericsson is actively involved in developing energy harvesting technologies and believes it is a critical area for a future green wireless industry.

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