



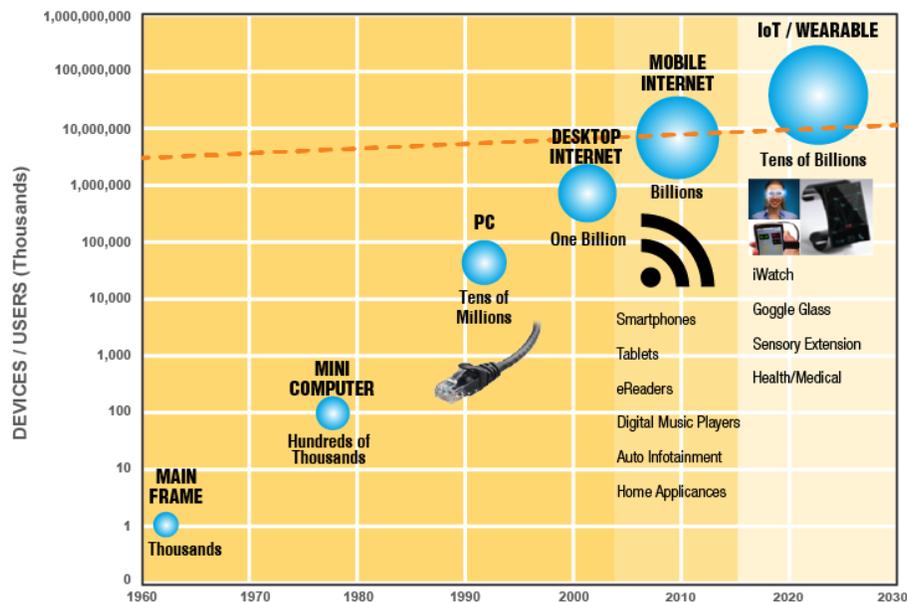
# Energy Efficiency: The Common Denominator in the Internet of Things

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## Energy Efficiency and the Internet of Things

The Internet of Things (IoT) has become a wildly popular term these days often used to describe a world in which virtually every electronic device connects to the Internet and each other. It comprises a staggering list of applications—everything from smart consumer appliances and vehicles to wearables—and that list will only grow as mobility continues to explode (Figure 1). It's these devices, and the ecosystem they are helping to create, that is promising to transform everyday life. For individual consumers that might mean making them more efficient and cost-effective in their daily tasks, keeping them safer, or even helping ensure they live healthier lives. For businesses, the IoT promises significant advantages in terms of automation, energy efficiency, asset tracking and inventory control, shipping and location, security, individual tracking, and energy conservation.



**Figure 1.** Shown here are the computing growth drivers. Mobility is driving the IoT, which in turn, is driving a growing list of applications.

With such an array of benefits, it's easy to see why the IoT has become such a popular concept. However, these benefits will not be fully realized without industry first overcoming a number of critical challenges, perhaps the most significant of which is energy efficiency.

### Defining the IoT

The IoT is a term that's bandied around quite a bit these days, but what is it exactly? Simply put, the IoT consists of a patchwork of hardware, software and services—the bulk of which are the latter two—all working together to gather and transport information, analyze data, and then use that data to make decisions that improve the efficiency of specific tasks (Figure 2). In the case of one's own health, for example, the IoT might provide a more efficient way to relate

information to a doctor regarding the effectiveness of a prescribed medication or therapy. In a home setting, the IoT might help consumers keep their refrigerators better stocked by letting them know when food is nearing its expiration date and ordering its replacement, or other food stuffs, online for home delivery.



**Figure 2.** *The IoT brings together multiple ecosystems.*

The devices that populate the IoT ecosystem range from smart appliances (e.g., refrigerators, toasters and HVAC systems) and automobiles, to wearables and everything in between. While they may differ in application and use, each of these devices makes use of four critical components: sensing, data collection, connectivity, and data processing. Essentially, an IoT device senses something. It then collects data on what it senses. Finally, that data is communicated via an Internet connection to another device or location where it is processed or analyzed.

Most devices comprising the IoT ecosystem will be battery powered and must operate for several years without any maintenance or replacement. To survive for long periods of time on a single battery charge, these devices must consume minimal power. Other IoT devices will be powered by energy derived from an external source, a process known as energy harvesting. In both instances increased energy efficiency is absolutely essential to bringing the full potential of the IoT to life.

### **Energy efficiency: A Key IoT Challenge**

The IoT is a powerful concept with capabilities promising to literally transform the way society lives and works. In fact, development is currently underway in a variety of areas that will make many things look very different than they are today—and not just from a consumer perspective. Consider, for example, that wearable devices like the Nike FuelBand often require

eight or nine components. Three to four years from now, those same devices may only require one component and be available at a significantly lower cost (Figure 3).



**Figure 3.** Reduced power, size and cost are key challenges for the IoT.

Driving this trend is the consumer need for smaller, thinner devices, especially in the case of wearables. It's a trend that's all the more complicated by the significant increase in transistor count that occurs roughly every 18 months (Moore's Law). Getting those eight or nine components down to one will require high levels of integration. However, as you integrate more functionality on a single chip, you also have to add more memory, which in turn consumes more power, and that does not mesh well with the need for IoT devices to exhibit greater energy efficiency.

In coming years, the IoT will also provide a very different user experience. It will offer better connectivity, be simpler, more convenient, and always on, or at least give users the perception of always being on. Why push a button to activate an IoT device when it could be on all the time, listening and waiting to act on the user's behalf? A wearable fitness tracker is a prime example of this. It tracks things like a user's heart rate and sleep/activity cycles all day, every day. Future IoT devices will need to find a way to deliver this same sort of "24/7" support.

Of course, it's exactly this "always-on" functionality expectation that's driving the need for greater energy efficiency. If IoT devices cannot operate on very little power, whether supplied by batteries that last for several years or derived from an external energy source, then the idea of them being always-on will simply not be possible.

An "always-on" IoT device poses another interesting dilemma. Working around the clock, IoT devices will amass a startling amount of data; making sense of it will become overwhelming. In other words, collecting the data will become the easy part, while actually using it will be the hard part.

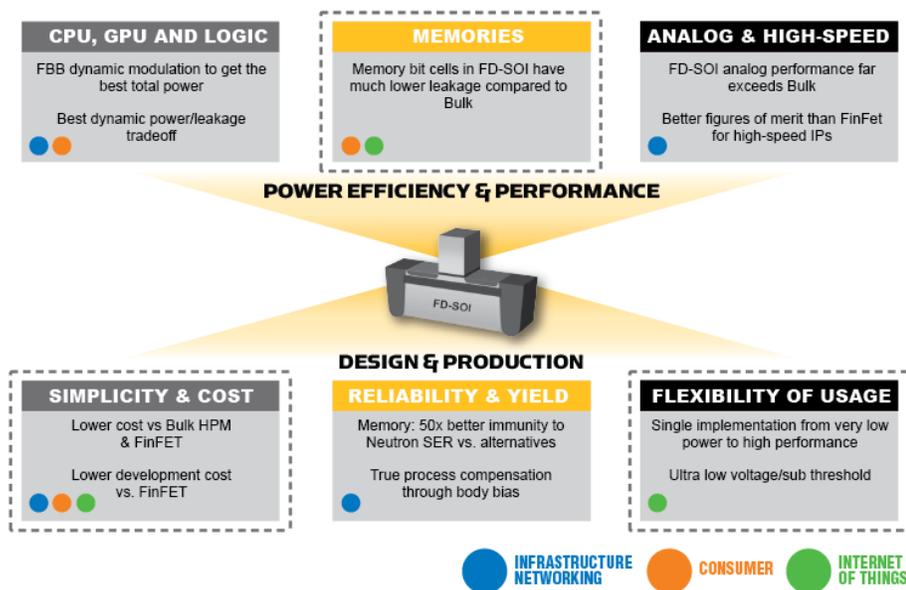
Intelligent sensing and big data analytics will play a critical role here by allowing data to be more intelligently captured and for correlations to be found in larger data sets so that trends

or important events can be quickly identified and acted on, as necessary. Here again though, energy efficiency is essential since data collection needs power, as does the memory needed to store the data.

## Overcoming the Challenges

Achieving the energy efficiency necessary to enable IoT devices to run for years on a single battery will not be an easy task. It demands the use of low-power components and more efficient power systems. And, it will require changes at both the architectural level and silicon level.

Today, virtually every aspect of the design of IoT devices is focused on making sure they are as energy efficient as possible (Figure 4). For a smartphone, for example, that might mean an order of magnitude better, but this won't happen overnight. On the contrary, it will happen in steps over multiple generations of products.



**Figure 4.** IoT devices must be created with energy efficiency as a prime concern at all levels.

As the leader in energy efficient programmable silicon, Lattice Semiconductor is working to lower power in IoT connectivity devices. Its efforts are currently focused on researching new ways to improve energy efficiency, including process technology innovation and transistor devices. It is also working on introducing a degree of freedom to system designers to support power gating, and programmable speed and power capabilities; not only low power, but a unique architecture enables modal state power management with some granularity on what mode the device is actually in—is it on or off, is it sleeping or partially awake—allowing it to dynamically go from one phase to another.

Lattice is using advanced process technology and its inherent speed/power flexibilities to extend its fundamental power advantage over processor-only based components. Leveraging

integrated silicon and software solutions, Lattice is focused on delivering an order of magnitude improvement in component power efficiency.

The IoT is a compelling idea promising to transform virtually every aspect of daily life. Much progress has been made to date, but much more is still ahead. Realizing the full potential of the IoT will require the devices that populate its ecosystem to be smaller and cheaper, which is why higher levels of integration will be critical. It will also require device developers to give users an always-on experience and find ways to more intelligently sense and analyze data captured by the devices. The common thread running through each of these areas—integration, always-on user experience and intelligent sensing/data analytics—is energy efficiency. It remains the single-most critical factor in bringing the grand vision of the IoT ecosystem to life.

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