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Internet of Things (IoT) Ecosystem Study

Executive Summary

Broadly speaking, the Internet of Things (IoT) is a system consisting of networks of sensors, actuators, and smart objects whose purpose is to interconnect “all” things, including everyday and industrial objects, in such a way as to make them intelligent, programmable, and more capable of interacting with humans and each other.

The IoT ecosystem is hard to define, complex, and difficult to capture due to the vastness of possibility and the rapidity with which it is expanding. There is no common definition of IoT; current definitions vary so much that they are reminiscent of the old story of the blind men and the elephant. IoT is shaping the evolution of the Internet. It is creating numerous challenges and opportunities for engineering and science. And the success of IoT depends strongly on standardization, which provides interoperability, compatibility, reliability, and effective operations on a global scale.

Recognizing the value of IoT to industry and the benefits this technological innovation brings to the public, the IEEE Standards Association (IEEE-SA) has a number of standards, projects, and events that are directly related to creating the environment needed for a vibrant IoT. In 2014, the IEEE created an IoT Initiative to coordinate its IoT efforts. As a part of this Initiative, the IEEE-SA developed an IoT ecosystem study.

IEEE-SA engaged stakeholders in key regions of the world to obtain the input that shaped the study. This engagement was in the form of a series of roundtable discussions held by IEEE-SA. The study was augmented by input from IoT-related workshops held by IEEE-SA and the IEEE Communications Society.

The structure of the study comprises three principal areas: Market, Technology, and Standards. After each of these three areas is examined, the role of academia and research as a contributor to the three areas is discussed. Finally, the importance of user acceptance is addressed.

IoT is the subject of a great deal of hype and many bold predictions about where it will eventually take us. However, there is no question that IoT is changing the world. In addition to connecting people, anytime and everywhere, it is connecting IoT products to humans and other IoT products, and it is putting these products at the service of humanity. This transformation has already begun; it will only continue to accelerate.

Note that there can be many IoTs. There is the global IoT (evolving from the global Internet) as well as local and private IoTs. The term “IoT” encompasses all of these.

IoT products include devices, apps, and services (e.g., smart phones, tablets, intelligent networks, big-data analytics, and cloud storage). A key aspect of IoT is the intelligent connectivity of these products. (It is likely that there will be situations where devices will be more rigidly constrained to satisfy safety, legal, and regulatory obligations.)

The Market for IoT

The IoT market is burgeoning but fragmented. Early players are active and currently creating products for which they see a market. These players include government and academia as well as business and industry.

In order to get products to market, these players are implementing proprietary solutions, some of which may evolve into *de facto* standards. Currently, IoT is trending toward vertical applications. Verticals showing early growth are consumer-goods, eHealth, transportation, energy and industrial automation.

IoT development and deployment is motivated by the desire to provide existing goods and services more efficiently (cheaper, faster, better) and by the desire to create new goods and services that will drive new revenue streams. Connecting things and allowing data to move will open new markets, just as the Internet did.

New products and business models will disrupt traditional business models; some of these new products and models will be created by unintended consequences of technologies being deployed.

The study examines three market-related topics:

- Players positioned to shape the IoT market
- Market segments and verticals poised to drive the growth of IoT
- What is missing from the business-model point of view

IoT Technologies

Technological advances are fueling the growth of IoT. Improved communications and network technologies, new sensors of various kinds, improved—cheaper, denser, more reliable and power efficient—storage both in the cloud and locally are converging to enable new types of products that were not possible a few years ago.

The study examines two technology-related topics:

- Technologies enabling the growth of IoT today
- What is missing from the technology point of view

IoT Standardization

The study examines four standards-related topics:

- Standards bodies doing important work to enable IoT
- Specific standards activities related to IoT

- What is missing from the standardization point of view
- Global standardization

The study also examines how academia and research organizations have contributed to the current state of IoT, and it addresses the key role of user acceptance. Finally, the study offers conclusions for what is needed for the broad-based adoption and use of IoT.

The ***Internet of Things (IoT) Ecosystem Study*** is available from <http://standards.ieee.org/innovate/iot/study.html>