The Internet of Things (IoT) was all the rage at the 2014 International CES, staged by the Consumer Electronics Association, in Las Vegas, United States, from 7 to 10 January. Essentially, IoT describes the integration of any object, whatever its size or nature, into the communications space.

Thanks to the timely convergence of many technologies, anything can now be reached and interfaced with, anytime, anywhere. This is fertile ground for application developers. But as electronics are increasingly embedded in the economic and personal fabric of society, we will need to manage these devices beyond their useful life, both to protect the environment and to maintain our supply of materials.

**Internet of Things fuels e-waste**

The National Strategy for Electronics Stewardship, a report by the United States Interagency Task Force on Electronics Stewardship, acknowledges that “these technologies have become critical to our way of life and to our growing economy”. It also warns that “with these technologies, however, comes the increasing challenge of protecting human health and the environment from the harmful effects associated with the unsafe handling and disposal of these products.”

Mercy Wanjau, Principal Legal Officer at the Communications Commission of Kenya, already noted in 2011 (see ITU News,
No. 9, 2011) that “e-waste is one of the fastest growing waste streams.” Today, according to United Nations University estimates reported by ITU, 67 million metric tons of electrical and electronic equipment were put on the market in 2013. In the same year, 53 million metric tons of e-waste (waste electrical and electronic equipment) were disposed of worldwide. With the pervasiveness of IoT, the production of e-waste is bound to accelerate.

As a result, e-waste is receiving a lot of attention not only at the national level (for example, the United States Congress introduced on 24 July 2013 a bill on toxic e-waste, the Responsible Electronics Recycling Act), but also at the international level. For instance, ITU is working with the Secretariat of the Basel Convention on controlling transboundary movements of hazardous wastes and their disposal, and with the United Nations University, in collaboration with the Solving the E-waste Problem (StEP) Initiative and the Centre for Environment and Development for the Arab Region and Europe (CEDARE), to raise awareness of the dangers of e-waste and to encourage the inclusion of e-waste management in the design of national policies for information and communication technologies (ICT).

ITU maintains a comprehensive reference site on e-waste, and has published a toolkit on end-of-life management of ICT equipment. This toolkit was developed in partnership with more than 50 ICT companies and environmental organizations, and generated new technical standards, such as Recommendation ITU-T L.1000 “Universal power adapter and charger solution for mobile terminals and other hand-held ICT devices”. This standard sets out technical specifications for a universal charger compatible with a variety of consumer electronic devices, reducing waste and improving user convenience. When fully implemented around the world, the new standard will eliminate an estimated 82 000 tons of redundant chargers and at least 13.6 million tons of CO2 emissions annually.

While governments are looking closely at the impact of IoT on society, notably on security and privacy, the consequences of IoT on environmental sustainability are not being treated with the same degree of urgency.

Electronic equipment used throughout the IoT value chain will eventually end up as e-waste. A TreeHugger article by Elizabeth Chamberlain and Kyle Wiens of iFixi, published on 9 January 2014, comments on a recent study by Huabo Dunn and colleagues at the Massachusetts Institute of Technology on “Quantitative characterization of domestic and transboundary flows of used electronics — Analysis of generation, collection, and export in the United States”, released on 15 December 2013. That article sees the rise of computerized basic IoT elements as an emerging culprit in losing the war against e-waste: “and as more and more objects — fridges, toys, household appliances, and accessories, for example — become computerized, less obvious forms of e-waste will be hitting the market. It’s easy to make the connection between a giant CRT monitor and e-waste; it’s less easy to make that connection with singing birthday cards. Nobody thinks twice about trashing them, but they’re e-waste.”

Building environmentally friendly IoT devices should become a top priority. Researchers at Université Catholique de Louvain in Belgium (June 2013) made the argument for this clearly: “The vision of the Internet-of-Things (IoT) calls for the deployment of trillions of wireless sensor nodes (WSNs) in our environment. A sustainable deployment of such a large number of electronic systems needs to be addressed with a Design-for-the-Environment approach. This requires minimizing 1) the embodied energy and carbon footprint of the WSN production, 2) the ecotoxicity of the WSN e-waste, and 3) the Internet traffic associated to the generated data.”

**Environmental management through the Internet of Things**

IoT technologies, such as machine-to-machine (M2M) communications are already being used to improve the environment, for example rubbish collection, oil recycling, light bulb recycling, reduction of CO2 emissions, control of noise pollution, wastewater management, and even removal of cooking grease in restaurants.
At an IoT Workshop in Beijing, China, in August 2013, Li Haihua, Senior Engineer of the China Academy of Telecommunication Research, Ministry of Industry and Information Technology, and Deputy Director of the Department of Internet of Things and Service & Resources, reported that in China “IoT has been applied in the automatic monitoring of more than 15,000 key pollution sources.”

In a paper on “Adopting the Internet of Things technologies in environmental management in South Africa”, presented in April 2012 at the 2nd International Conference on Environment Science and Engineering, Nomusa Dlodlo, a Senior Researcher at the Council for Scientific and Industrial Research’s Meraka Institute in Pretoria, shows the linkage between IoT and environmental management across many domains.

**Internet of Things and e-waste management**

Considering that discarded electronics components within IoT-enabled objects are a significant source of e-waste, providers of IoT equipment must increasingly take account of dangers arising from the use of hazardous material in the production of devices.

Products should be designed and manufactured to reduce their lifecycle environmental impact. Environmental concerns should also be an integral component of smart manufacturing, which has a symbiotic relationship with the Internet of Things. As an example, the Georgia Institute of Technology’s Manufacturing Institute, which is closely associated with the United States Advanced Manufacturing Partnership, considers the environment as a central concern of modern manufacturing.

There are benefits in tracking e-waste. In 2011, the Massachusetts Institute of Technology’s Senseable City Lab project BackTalk clarified the “convoluted path of e-waste”, highlighting glaring economic inefficiencies. Better remote tracking would improve the accuracy of e-waste data; for example, the United States Environment Protection Agency “has recognized the need for a scientific-based approach to getting better information on e-waste flows from the United States.”

The emphasis of current work on defining standards, protocols and specifications in the IoT space is on interoperability, because there is no common language for machines and objects across a wide range of markets. No specific consideration has yet been given to integrating environmental concerns into IoT standards.

**What now?**

If IoT-enabled objects were to have not only a standardized Global Positioning System (GPS) tracking capability but also some sort of universal e-identification, it would facilitate recycling, reuse and end-of-life management. This could help to overcome the cost challenges of collection and recycling, and open up new opportunities for the private sector, such as the recovery of rare-earth metals. It would also facilitate the enforcement of regulations restricting the use of certain hazardous substances. Identification systems such as the Universal Product Code (UPC) and the International Standard Book Number (ISBN) are widely used; a similar system could surely be developed for electronics products.

Some tools are already available. An environmental procurement tool known as EPEAT helps buyers identify, compare and select environmentally preferable products, and provides manufacturers with environmental criteria for the design and development of products. Also, the e-Stewards Initiative has created an e-Stewards Certification for electronics recyclers, integrating the requirements of the ISO 14001 standard on environmental management. And there are a wide range of services to support effective electronics use and management.

We are on the cusp of widespread deployment of IoT technologies. The attractive possibilities are masking unintended
consequences, including e-waste. Policy-makers need to consider the environmental component. The time to act is now.

**About the authors**

*Alain Louchez* is the Managing Director of the Center for the Development and Application of Internet of Things Technologies (CDAIT) at the Georgia Institute of Technology.

*Valerie Thomas* is the Anderson Interface Associate Professor of Natural Systems in the H. Milton Stewart School of Industrial and Systems Engineering, with a joint appointment in the School of Public Policy at the Georgia Institute of Technology.

“Internet of Things — Trends and Challenges in Standardization” was the theme of an ITU workshop in February 2014. More information is available at: http://www.itu.int/en/ITU-T/Workshops-and-Seminars/iot/201402/Pages/default.aspx

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