2017

Internet of Things

John Ritz
Old Dominion University, jritz@odu.edu

Zane Knaack

Original Publication Citation

Ritz, J., & Knaack, Z. (2017). Internet of things. *Technology and Engineering Teacher*, 76(6), 28-33.

A cow is tagged so the rancher can monitor its whereabouts. Great white sharks are also being tagged so researchers can track their migration patterns. Dog owners can get fitness collars for their pets to monitor their activity (amount of exercise they receive). *Credit: Wikimedia Commons.*

internet of things

This RITE will further explain the Internet of Things and what you might see it perform in the near future.

In the 21st century, electronic connectivity is a major component of everyday life. One expects to have mobile phone coverage and to have access to log a computer or tablet onto the internet. This connectivity enables users to keep track of personal affairs and conduct work from remote locations. Designers and manufacturers are also connecting many other products to the internet so their performance can be monitored and controlled externally. Examples include remote-controlled door locks and thermostats, shopping online using smartphones and electronic wallets, and tracking fleet trucks on the highway and in freight yards. Today, by placing sensors on animals such as sharks, researchers can study the migration and activities of wild animals.

This 21st century phenomenon of electronic connectivity is known as the Internet of Things (IoT), which involves the internet, computers, software, network connectivity, sensors, and actuators. It enables the control of products and other transactions over the internet. This article will further explain the Internet of Things and what you might see it perform in the near future.

Products

Currently many consumer and industrial products are being manufactured that can be classified as Internet of Things products. This means that they have embedded electronic systems manufactured into them that enable these products to connect to the internet to be controlled by other devices such as computers and mobile phones. The modern automobile is an example of a connected product. When the engine is on, monitors and displays show that it is perform-

by
John Ritz, DTE
and
Zane Knaack

ing properly, if the tires hold proper air pressure, and how many miles remain until gasoline is needed or oil should be changed. By signing up for OnStar or other automotive communication packages, diagnostic reports can be regularly emailed to the car owner. There are many more connected devices that can be manufactured into modern cars. Music, mobile phone Bluetooth, and navigation are just a few of these systems. One consumer add-on product that is currently being advertised is Hum, an internet-connected device that monitors a car's performance, can contact assistance if the car breaks down, and even monitor the speed and location of the car remotely so parents can track the location of their driving teenager or senior parents.

Currently IoT products are classified by market segments including:

- Consumer goods
- eHealth
- Smart transportation
- Energy distribution
- Smart cities
- Distribution and logistics
- Public safety
- Industrial and manufacturing
- Agriculture and natural resource management
- Big data analytics (Transportation Research Board, 2016)

The current big growth areas for IoT products are consumer goods and eHealth products. Examples of IoT consumer products are the Amazon Echo and Dot and Google Home. The Echo and Dot have a voice-activated assistant, Alexa, who can select your music from mobile phones or other music services, order pizza or locate local restaurant types, provide sports scores, weather, or news, and control other smart products such as lights, fans, portable heaters, thermostats, garage-door openers, and other appliances. It should be noted that Echo does not work with all smart products, but Amazon continues to expand its capabilities by developing many more externally controlled IoT products.

Nest, by Google, has a smart thermostat that can be controlled by the user via smartphone or computer app. It is useful for controlling home temperatures when you are away or even when you are on another floor of the property. It is extremely useful for a vacation home where the owner can heat or cool the property before arriving or while away. Nest also has webcam connectable products, so homeowners can have surveillance both inside and outside the home from remote locations, using a mobile phone or computer for viewing.

Other consumer products that have IoT features include washing machines, toasters, and refrigerators. These products have increased expenses associated with their purchase due to their connectivity and monitoring capabilities. However, one needs to question the real value of some IoT products. Yes, you can tell what cycle your washing machine is in during operation, but you still have to go to the washer to put in the clothes and detergent and load and unload the clothes. Maybe someday a washer and dryer will be combined into one unit that can both wash and dry and then become an IoT product that has value from being externally controlled while you are not standing next to it.

eHealth is another growing use of IoT connectivity. One area that has grown over the past several years is fitness wearables (bracelets). For those who are health conscious and want to keep track of step counting and sleep tracking, or seek other features such as GPS for running, advanced resting heart rate and VO_2 max data (maximal oxygen uptake), these products might be right for you. Mobile apps and iWatches can perform similar functions.

Photo 2. Amazon Echo. The Amazon Echo and Dot are Internet of Things devices. Google Home is a similar product. These products can control home products such as lightbulbs and fans. They can also provide information by asking their assistants questions such as the latest sports scores. *Credit: Amazon.*

Photo 3. Nest Thermostat. Nest by Google has several IoT products on the market. These include a thermostat, home protect (smoke and CO_2 alarm), and surveillance cameras. *Credit: Nest.*

Photo 4. Fitness Wearables. Various companies produce sports bracelets to monitor one's physical activity. Apple Watch Nike allows you to monitor distances, vital signs, and has GPS to guide you home. Samsung, Fitbit, and Garmin are some of the many companies that make these fitness wearables. *Credit: Apple, Inc.*

Photo 5. Advanced Driver Assistance System. The Controller Area Network (CAN) is an IoT automobile computing system. The illustration shows how the system can warn of a stopped car and automatically break to avoid an accident. *Credit: Wikimedia Commons.*

Photo 6. Turbine Engine. Jet engines fly for many hours and encounter various environmental conditions (dust, sand, humidity). By monitoring each turbine blade with IoT sensors, engine maintance can be better planned. *Credit: Tony Hisgett, Wikimedia Commons.*

Pacemakers have long had remote monitoring and control via telephonic methods. Medical personnel can read and adjust the heart rate of patients and adjust these from a distance without the patient returning to the hospital to have a pacemaker calibrated. Other eHealth IoT products include connected medical wearables such as pain and insulin pumps. Doses of medicine can be monitored, and medical personnel can remotely decrease or increase the amounts.

There are also IoT talking medical products. These products provide oral messages to patients, reminding them to take a dose of medication, check their blood pressure or sugar levels, take a walk, or do cardio exercises at a scheduled time. These devices can also be programmed to train patients about a medical procedure by caring for themselves or providing other health-related information. Hospital beds can be IoT monitored to notify nurses that patients are trying to get out of bed (some patients need human assistance to do this). Such IoT devices can be used to reduce patient falls.

The Internet of Things can also assist in making smart transportation systems viable. In automobiles, one far-reaching development is the self-driving or autonomous vehicle. Various automobile companies in North America, Europe, and Asia are working on such vehicles, and there have been recent examples of Google cars driving across America, a blind man being driven by such a car, Uber cars picking up clients and driving them to their destinations, and truck deliveries to warehouses. It may soon be possible for drones to deliver packages from Amazon or Domino's Pizza. Medicine has also been delivered to people in remote areas using drones. All of these are examples of IoT.

IoT is currently being employed in many automobile models. Applications include navigation, climate control, and ADAS (advanced driver assistance systems). ADAS examples include vehicle avoidance, automatic braking, and alarms that notify drivers when they are crossing highway lines or when other vehicles are driving in their side blind spots. All of these ADAS features are part of the systems needed for autonomous vehicles currently being designed and tested.

In addition to vehicle safety designs, IoT will contribute to transportation enhancements in other ways. Currently navigation systems are capable of warning drivers of traffic congestion on highways, bridges, and tunnels and providing alternative routes. EZ Passes allow drivers to travel on toll roads, going through booths without stopping, while the tolls are electronically deducted from bank accounts or credit cards. In addition, smart parking is a technology now available in some cities, where mobile apps alert the driver where parking is available and the cost incurred for parking at certain city parking complexes. This saves time by reducing the human effort to search for open parking spaces. This is possible by using large data analytics to predict where parking will be available through the collection of data on past driving habits of large groups of people.

Industrial products are starting to take advantage of the remote control and monitoring capabilities of IoT-designed products. General Electric has begun to manufacture jet engine turbine blades with IoT sensors to transmit data back to the company (Engebretson, 2016). GE can now better monitor and predict from the collected data when the turbine blades should be replaced, reducing the likelihood of serious breakdown problems that could cause a jet to malfunction or crash.

Placing smart sensors on piping can also be used to monitor liquid flow such as water and oil. These IoT products can monitor pipes for leaks and other potential environmental and health problems. Such sensors can now be placed in elevators for remote monitoring and inspection. This can reduce the time an

elevator would need to be out of service for projected repair, and inspections could be conducted outside of an elevator's peak service hours. The future will find endless applications of IoT to make industry more efficient and operations cost saving.

How IoT Works

With all of these internet-connected wonders and others that will be developed in the near future, one may wonder how these devices work. To better understand the Internet of Things, it is important to understand the base technological developments that enabled remote control and monitoring via the internet to occur. The wave of this new technology started with companies needing to expedite product logistics (location and estimated time of delivery). To assist with inventory management and reduce product theft, products or their packaging were designed to include RFID tags. RFID stands for radio-frequency identification. These are rice-size microchips with built-in antennas that can be programmed with up to 2000 bytes of information (Transportation Research Board, 2016). RFIDs can be manufactured into the product (automobile or other machine parts), packaging, and even used for animal tracking. Today the cost of these devices can be as low as $10 per unit. Using scanners, workers can track products or have cash registers read the tag information and add it to checkout receipts. It enables producers to track products from manufacture to point of sale. This same technology has been added to toll road EZ Pass systems and to passports issued by many countries. In the passport technology, the RFID also contains a digital picture of the passport holder.

The next step toward IoT was document management (Transportation Research Board, 2016). With the collection of data from products or products with built-in markers, such as RFID, barcodes, or digital watermarks (e.g., cash), scanners collect and process large amounts of data and make this data available for management decisions. The data can assist with supply-chain management. Trucking containers can be monitored, as can airline baggage and express packages to be delivered to customers. This type of document management enables companies to notify clients where their airline luggage is and notify people when packages are expected to be received. Food safety can be improved with this type of data management. If food-borne health threats exist, consumers can be told which products purchased from certain food suppliers during certain dates might be contaminated.

Next in the progression of smart product development was electronic miniaturization with more efficient internal power sources. This technology enabled the development of microprocessors that could be embedded into products to transmit signals and be controlled from remote locations. Along with miniaturized electronics and more efficient power devices, the development of the internet and the meshing of these miniature electronics became possible (Transportation Research Board, 2016). Imagine what microelectronics enables in the form of mobile phones (e.g., smaller size, increased applications, quality cameras, Bluetooth connectivity, longer battery life). This miniaturization enabled the control of products from a distance. With the development of advanced software agents and sensor fusion into products, signals can now be received and transmitted, so one can control and monitor products from smart devices.

This is how the Internet of Things progressed and developed to where it is today. It is simply things communicating with things via the internet. In most cases it involves the internet, software, and sensors connecting products, animals, and humans, making them smarter and able to share information and operate at optimal efficiency.

Photo 7. RFID Tagged Truck. Before the advent of IoT sensors, railroad and trucking companies attached RFID (radio-frequency identification) tags to trailers and railroad cars to track them. RFID has short range connectivity. IoT monitors can be tracked using the internet from much greater distances. *Credit: U.S. Marine Corps.*

Photo 8. Bicyclist Helmet with IoT Connectivity. Helmets worn by bicyclists and football players can be monitored for head injuries and increased safety. *Credit: Wikimedia Commons.*

Concerns

As our society and our technology develop, it is estimated that one billion IoT products will be developed within four years (Martin, 2016). This will generate almost $1 trillion in North America by 2020. The Internet of Things can make life more efficient and take us away from having to process all incoming information that can affect us. We can have small machines and their supporting systems take over and control some of the options available within our environment (e.g., home and workplace temperatures, traffic routes, food safety and inventory, lighting, package delivery, car driving). However, letting technology take over our lives can be dangerous. If our smart devices are sending and transmitting data, is this data transmission safe? Can others use IoT to take our private information and potentially compromise us, our products, or our finances?

Software flaws have already been identified where programming of a car's onboard information center can cause some cars to speed up and/or their braking systems to fail. In October 2016 there was a Dyn Cyberattack (denial of services attack). Using Internet of Things products, a group known as New World Hackers compromised popular websites such as Amazon, Netflix, Twitter, and others by placing malware on IP cameras and digital video recorders (television control boxes). The malware directed these products to repeatedly contact these popular websites over a nine-hour period of time. This demand caused these systems to become overloaded and deny customer services (Readwrite, 2016). Why can attacks like these happen? Currently many internet-connectable products use an IP address as a unique identifier. However, these products can be easily hacked and controlled since they operate on Wi-Fi systems, many with shared product passwords, so technicians can collect data and access them to improve their operation remotely. Currently governments are setting up standards that manufacturers will need to follow to protect consumers: the public, industry, and government. This must happen so that hackers cannot use IoT products to spy on consumers (e.g., those with webcams in their design and operation) or target consumer personal or financial information.

A major consumer and industry problem is connectivity of products. Companies need to work together to develop software standards so there can be free, open-source software and a standard can be set so that newly developed products will be connectable no matter who the manufacturer is. Reflecting upon the automobile industry, not all products are compatible between manufacturers. Special wiper blades and oil and air filters are needed for different automotive brands. This could be a consumer nightmare for purchasers of IoT products. The computer industry has made it easy to network computers and printers. Will the same be a standard for IoT products? The Open Connectivity Foundation is working to set these standards. Members include Microsoft, Intel, LG Electronics, Samsung, and Qualcomm. However, Apple, Amazon, and Google have not joined (*Fortune*, 2016). In a way, their decision not to join the consortium makes sense, since they already have their home hubs on the market (e.g., Google Home, Amazon Echo, Apple is coming soon). For consumers this is troublesome. Will early adaptors have products that will need to be replaced so they can have more products that can connect to their home or office hubs to increase connectivity, or will obsolescence of products cause the consumer to make unwanted additional purchases?

Internet of Things: Applying It to Real Life

Its 5:00 am and a light tune starts to play. The sound is coming from Harper's smart alarm clock. It wakes her up for her daily morning routine. It has determined that she has had an adequate 7.5 hours sleep. She sits up, gets out of bed, and says "alarm off" to silence the music. This command knows from her programmed home control platform to now recite the day's weather report, Harper's sports team's latest scores, and her agenda for the day that she preplanned in her daily calendar.

The weather report helps Harper decide what to wear for her morning run: rainy and cold. Harper grabs her waterproof smart jogging outfit. She straps on her "waterproof" smart watch that will record her heart rate and the distance she will run. Then she laces up her water-resistant smart shoes, embedded with a device that tallies footsteps. After a 45-minute run, she arrives back home. When Harper approaches her front door she puts her thumb onto a smart scanner that allows her entry, meaning it reads her thumbprint and unlocks the door and then locks it behind her. She comes inside and the entryway lights suddenly turn on due to the motion sensor lights she has had installed. These lights turn on when they detect movement and turn off when no one is present. Harper then goes into her room, grabs her smartphone, and looks at her schedule for the day. Pressing an additional smart app, she selects an appropriate outfit from her clothing inventory for her scheduled meetings for the day. It also reminds her that she has a tennis lesson at 5:30 pm and tells her to gather her tennis outfit and equipment. She then hits a phone app to turn on her shower to a preset temperature. While fixing her hair she realizes that she ran out of spray. She then goes into the bathroom closet and locates another container, since her toiletry-supply app spotted the problem, reordered the same brand for her, and delivered it to her home, thus saving her time. Now Harper orders a ride to work using another smartphone app. The day will proceed as "normal" as Harper has started to take full advantage of the "Internet of Things."

Activities

There are many activities that can be incorporated into technology and engineering classes that assist students to better understand the concept of IoT. There are videos that can be downloaded from internet sources to better help one to understand these IoT developments. Some that the authors discovered while researching this resource include:

- https://www.youtube.com/watch?v=QSIPNhOiMoE (How It Works: Internet of Things)
- https://www.youtube.com/watch?v=_AlcRoqS65E (What Is the Internet of Things? And Why Should You Care?)

To develop understanding of emerging IoT products, see:

- www.makeuseof.com/tag/internet-things-10-useful-products-must-try-2016/ (The Internet of Things: 10 Useful Products You Must Try in 2016)

To watch Mary Lee, a great white shark, navigate around the Atlantic Ocean, check out this site:

- http://www.ocearch.org/profile/mary_lee/ (Global Shark Tracker)

To see some applications of Amazon Echo or Google Home, visit:

- http://heavy.com/social/2014/11/amazon-echo-funny-parody-fake-commercial-ad-youtube-video/ (Amazon Echo Commercial)
- https://www.cnet.com/products/google-home/review/ (Google Home Demonstration)

Other class activities could include having students research and present to the class an Internet of Things product. This activity could include an illustrated written paper or an oral presentation including photographs or video clips of the product by each or select students.

A more technical activity could be the design and development of an internet-connected home security system where webcams and window and door sensors could be deployed. Students could employ Intel Edison or Galileo IoT modules to control the system. Giovino (2016) describes these IoT modules in the October issue of *TechDirections*.

Summary

The internet has not only made information searching and instantaneous communications possible, it has also expanded the development of smart products that can be connected and controlled over the internet. Automobile manufacturers have used these devices during the past decade to make cars safer and assist drivers with updated information on vehicle operation. Today many more products can be operated and controlled from a smartphone or computer. Depending on your level of desired internet-connectedness, many home products are coming to the market with IoT connectivity. Much data is being collected and acted upon through databases. These developments should enable machines to further assist us with our daily tasks in the near future.

References

Darrow, Bob. (October 10, 2016). *This mega tech consortium wants to connect all our devices.* Retrieved from Fortune.com: http://fortune.com/2016/10/10/open-connectivity-foundation-wants-to-connect-all-devices/

Engebretson, J. (2016). *Industrial IoT success stories include jet engines, elevators, HVAC.* Retrieved from www.telecompetitors.com/industrial-iot-success-stories-incloude-jet-engines-elevators-hvac/

Giovino, B. (October, 2016). Creating quick connections with IoT development kits. *TechDirections*, 22-24.

Martin, C. (November 2, 2016). IoT connections forecast to top 1 billion in 4 years. *IoT Daily.* Retrieved from www.mediapost.com/publications/article/288102/iot-connections-forecast-to-top-1-billion-in-4-years

Readwrite. (October 22, 2016). *Distributed denial of service (DDoS).* Retrieved from http://readwrite.com/2016/10/22/the-internet-of-things-was-used-in-fridays-ddos-attack-p14/

Transportation Research Board. (May, 2016). *Transformational technologies in transportation* (Number E-C208, Section 3.3). Washington, DC: Author.

John Ritz *is Professor of STEM Education and Professional Studies at Old Dominion University, Norfolk, VA. John can be reached at jritz@odu.edu.*

Zane Knaack *is a sophomore at Norfolk Academy, one of the oldest independent schools in America (founded in 1728), located in Norfolk, VA.*

ITEEA would like to thank John Ritz, DTE for many years of supporting and authoring articles for the Resources in Technology and Engineering resource in* Technology and Engineering Teacher. *This is his final RITE submission, as he will be retiring at the end of the school year. He has enjoyed researching and writing about future technological developments for ITEEA members since 1984, writing 56 of these special resources!