Internet of Things

From Wikipedia, the free encyclopedia

The **Internet of Things** (**IoT**) is the network of physical objects or "things" embedded with electronics, software, sensors, and network connectivity, which enables these objects to collect and exchange data.[1] The Internet of Things allows objects to be sensed and controlled remotely across existing network infrastructure,[2] creating opportunities for more direct integration between the physical world and computer-based systems, and resulting in improved efficiency, accuracy and economic benefit.[3][4][5][6][7][8] Each thing is uniquely identifiable through its embedded computing system but is able to interoperate within the existing Internet infrastructure. Experts estimate that the IoT will consist of almost 50 billion objects by 2020.[9]

British entrepreneur Kevin Ashton first coined the term in 1999 while working at the Auto-ID Labs (originally called Auto-ID centers - referring to a global network of RFID connected objects).[10] Typically, IoT is expected to offer advanced connectivity of devices, systems, and services that goes beyond machine-to-machine communications (M2M) and covers a variety of protocols, domains, and applications.[11] The interconnection of these embedded devices (including smart objects), is expected to usher in automation in nearly all fields, while also enabling advanced applications like a Smart Grid,[12] and expanding to the areas such as smart cities.[13][14]

"Things," in the IoT sense, can refer to a wide variety of devices such as heart monitoring implants, biochip transponders on farm animals, electric clams in coastal waters,[15] automobiles with built-in sensors, or field operation devices that assist firefighters in search and rescue operations.[16] These devices collect useful data with the help of various existing technologies and then autonomously flow the data between other devices.[17][18] Current market examples include smart thermostat systems and washer/dryers that use Wi-Fi for remote monitoring.

Besides the plethora of new application areas for Internet connected automation to expand into, IoT is also expected to generate large amounts of data from diverse locations that is aggregated very quickly, thereby increasing the need to better index, store and process such data.[19][20]

Early history

As of 2014, the vision of the Internet of Things has evolved due to a convergence of multiple technologies, ranging from wireless communication to the Internet and from embedded systems to micro-electromechanical systems (MEMS).[16] This means that the traditional fields of embedded systems, wireless sensor networks, control systems, automation (including home and building automation), and others all contribute to enabling the Internet of Things (IoT).

The concept of a network of smart devices was discussed as early as 1982, with a modified Coke machine at Carnegie Mellon University becoming the first internet-connected appliance,[21] able to report its inventory and whether newly loaded drinks were cold.[22] Mark Weiser's seminal 1991 paper on ubiquitous computing, "The Computer of the 21st Century", as well as academic venues such as UbiComp and PerCom produced the contemporary vision of IoT.[23][24] In 1994 Reza Raji described the concept in *IEEE Spectrum* as "[moving] small packets of data to a large set of nodes, so as to integrate and automate everything from home appliances to entire factories".[25] Between 1993 and 1996 several companies proposed solutions like Microsoft's at Work or Novell's NEST. However, only in 1999 did the field start gathering momentum. Bill Joy envisioned Device to Device (D2D) communication as part of his "Six Webs" framework, presented at the World Economic Forum at Davos in 1999.[26]

The concept of the Internet of Things first became popular in 1999, through the Auto-ID Center at MIT and related market-analysis publications.[27] Radio-frequency identification (RFID) was seen by Kevin Ashton (one of the founders of the original Auto-ID Center) as a prerequisite for the Internet of Things at that point. If all objects and people in daily life were equipped with identifiers, computers could manage and inventory them.[28][29] Besides using RFID, the *tagging* of things may be achieved through such technologies as near field communication, barcodes, QR codes and digital watermarking.[30][31]

In its original interpretation,[*when?*] one of the first consequences of implementing the Internet of Things by equipping all objects in the world with minuscule identifying devices or machine-readable identifiers would be to transform daily life.[32][33] For instance, instant and ceaseless inventory control would become ubiquitous.[33] A person's ability to interact with objects could be altered remotely based on immediate or present needs, in accordance with existing end-user agreements.[28] For example, such technology could grant motion-picture publishers much more control over end-user private devices by remotely enforcing copyright restrictions and digital restrictions management, so the ability of a customer who bought a Blu-ray disc to watch the movie becomes dependent on so-called "copyright holder's" decision, similar to Circuit City's failed DIVX.

The following is a list of countries by IoT devices online per 100 inhabitants as published by the OECD in 2015.[34]

Rank	Country	Devices online	Relative size
1	South Korea	37.9	
2	Denmark	32.7	
3	Switzerland	29.0	
4	United States	24.9	
5	Netherlands	24.7	
6	Germany	22.4	
7	Sweden	21.9	
8	Spain	19.9	
9	France	17.6	
10	Portugal	16.2	
11	Belgium	15.6	
12	United Kingdom	13.0	

Rank	Country	Devices online	Relative size
13	Canada	11.6	
14	Italy	10.2	
15	Brazil	9.2	
16	Japan	8.2	
17	Australia	7.9	
18	Mexico	6.8	
19	Poland	6.3	
20	China	6.2	
21	Colombia	6.1	
22	Russia	4.9	
23	Turkey	2.3	
24	India	0.6	

Applications

According to Gartner, Inc. (a technology research and advisory corporation), there will be nearly 26 billion devices on the Internet of Things by 2020.[35] ABI Research estimates that more than 30 billion devices will be wirelessly connected to the Internet of Things by 2020.[36] As per a recent survey and study done by Pew Research Internet Project, a large majority of the technology experts and engaged Internet users who responded—83 percent—agreed with the notion that the Internet/Cloud of Things, embedded and wearable computing (and the corresponding dynamic systems[37]) will have widespread and beneficial effects by 2025.[38] It is, as such, clear that the IoT will consist of a very large number of devices being connected to the Internet.[39] In an active move to accommodate new and emerging technological innovation, the UK Government, in their 2015 budget, allocated £40,000,000 towards research into the Internet of Things. The British Chancellor of the Exchequer George Osborne, posited that the Internet of Things is the next stage of the information revolution and referenced the inter-connectivity of everything from urban transport to medical devices to household appliances.[40]

Integration with the Internet implies that devices will use an IP address as a unique identifier. However, due to the limited address space of IPv4 (which allows for 4.3 billion unique addresses), objects in the IoT will have to use IPv6 to accommodate the extremely large address space required. [41] [42] [43] [44] [45] Objects in the IoT will not only be devices with sensory capabilities, but also provide actuation capabilities (e.g., bulbs or locks controlled over the Internet).[46] To a large extent, the future of the Internet of Things will not be possible without the support of IPv6; and consequently the global adoption of IPv6 in the coming years will be critical for the successful development of the IoT in the future.[42][43][44][45]

The ability to network embedded devices with limited CPU, memory and power resources means that IoT finds applications in nearly every field.[47] Such systems could be in charge of collecting information in settings ranging from natural ecosystems to buildings and factories,[46] thereby finding applications in fields of environmental sensing and urban planning.[48]
On the other hand, IoT systems could also be responsible for performing actions, not just sensing

things. Intelligent shopping systems, for example, could monitor specific users' purchasing habits in a store by tracking their specific mobile phones. These users could then be provided with special offers on their favorite products, or even location of items that they need, which their fridge has automatically conveyed to the phone.[49][50] Additional examples of sensing and actuating are reflected in applications that deal with heat, electricity and energy management, as well as cruise-assisting transportation systems.[51] Another excellent application that the Internet of Things brings to the picture is home security solutions. Home automation is also a major step forward when it comes to applying IoT. All these advances add to the numerous list of IoT applications. Now with IoT, you can control the electrical devices installed in your house while you are sorting out your files in office. Your water will be warm as soon as you get up in the morning for the shower. All credit goes to smart devices which make up the smart home. Everything connected with the help of Internet.[52]

However, the application of the IoT is not only restricted to these areas. Other specialized use cases of the IoT may also exist. An overview of some of the most prominent application areas is provided here. Based on the application domain, IoT products can be classified broadly into five different categories: smart wearable, smart home, smart city, smart environment, and smart enterprise. The IoT products and solutions in each of these markets have different characteristics.[53]

Media

In order to hone the manner in which the Internet of Things (IoT), the Media and Big Data are interconnected, it is first necessary to provide some context into the mechanism used for media process. It has been suggested by Nick Couldry and Joseph Turow that Practitioners in Media approach Big Data as many actionable points of information about millions of individuals. The industry appears to be moving away from the traditional approach of using specific media environments such as newspapers, magazines, or television shows and instead tap into consumers with technologies that reach targeted people at optimal times in optimal locations. The ultimate aim is of course to serve, or convey, a message or content that is (statistically speaking) in line with the consumer's mindset. For example, publishing environments are increasingly tailoring messages (advertisements) and content (articles) to appeal to consumers that have been exclusively gleaned through various data-mining activities.[54]

The media industries process Big Data in a dual, interconnected manner:

- Targeting of consumers (for advertising by marketers)
- Data-capture

Thus, the internet of things creates an opportunity to measure, collect and analyse an ever-increasing variety of behavioural statistics. Cross-correlation of this data could revolutionise the targeted marketing of products and services.[55] For example, as noted by Danny Meadows-Klue, the combination of analytics for conversion tracking with behavioural targeting has unlocked a new level of precision that enables display advertising to be focused on the devices of people with relevant interests.[56] Big Data and the IoT work in conjunction. From a media perspective, Data is the key derivative of device inter connectivity, whilst being pivotal in allowing clearer accuracy in targeting. The Internet of Things therefore transforms the media industry, companies and even governments, opening up a new era of economic growth and competitiveness. The wealth of data generated by this industry (i.e. Big Data) will allow Practitioners in Advertising and Media to gain an elaborate layer on the present targeting mechanisms used by the industry.

Environmental monitoring

Environmental monitoring applications of the IoT typically use sensors to assist in environmental protection[57] by monitoring air or water quality,[15] atmospheric or soil conditions,[58] and can even include areas like monitoring the movements of wildlife and their habitats.[59] Development of resource[60] constrained devices connected to the Internet also means that other applications like earthquake or tsunami early-warning systems can also be used by emergency services to provide more effective aid. IoT devices in this application typically span a large geographic area and can also be mobile.[46]

Infrastructure management

Monitoring and controlling operations of urban and rural infrastructures like bridges, railway tracks, on- and offshore- wind-farms is a key application of the IoT.[61] The IoT infrastructure can be used for monitoring any events or changes in structural conditions that can compromise safety and increase risk. It can also be used for scheduling repair and maintenance activities in an efficient manner, by coordinating tasks between different service providers and users of these facilities.[46] IoT devices can also be used to control critical infrastructure like bridges to provide access to ships. Usage of IoT devices for monitoring and operating infrastructure is likely to improve incident management and emergency response coordination, and quality of service, up-times and reduce costs of operation in all infrastructure related areas.[62] Even areas such as waste management stand to benefit from automation and optimization that could be brought in by the IoT.[63]

Manufacturing

Network control and management of manufacturing equipment, asset and situation management, or manufacturing process control bring the IoT within the realm on industrial applications and smart manufacturing as well.[64] The IoT intelligent systems enable rapid manufacturing of new products, dynamic response to product demands, and real-time optimization of manufacturing production and supply chain networks, by networking machinery, sensors and control systems together.[46]

Digital control systems to automate process controls, operator tools and service information systems to optimize plant safety and security are within the purview of the IoT.[61] But it also extends itself to asset management via predictive maintenance, statistical evaluation, and measurements to maximize reliability.[65] Smart industrial management systems can also be integrated with the Smart Grid, thereby enabling real-time energy optimization. Measurements, automated controls, plant optimization, health and safety management, and other functions are provided by a large number of networked sensors.[46]

Energy management

Integration of sensing and actuation systems, connected to the Internet, is likely to optimize energy consumption as a whole.[46] It is expected that IoT devices will be integrated into all forms of energy consuming devices (switches, power outlets, bulbs, televisions, etc.) and be able to communicate with the utility supply company in order to effectively balance power generation and energy usage.[66] Such devices would also offer the opportunity for users to remotely control their devices, or centrally manage them via a cloud based interface, and enable advanced functions like scheduling (e.g., remotely powering on or off heating systems, controlling ovens, changing lighting conditions etc.).[46] In fact, a few systems that allow remote control of electric outlets are already available in the market, e.g., Belkin's WeMo,[67] Ambery Remote Power Switch,[68] Budderfly,[69] Telkonet's EcoGuard[70] etc.

Besides home based energy management, the IoT is especially relevant to the Smart Grid since it provides systems to gather and act on energy and power-related information in an automated fashion with the goal to improve the efficiency, reliability, economics, and sustainability of the production and distribution of electricity.[66] Using Advanced Metering Infrastructure (AMI) devices connected to the Internet backbone, electric utilities can not only collect data from end-user connections, but also manage other distribution automation devices like transformers and reclosers.[46]

Medical and healthcare systems

IoT devices can be used to enable remote health monitoring and emergency notification systems. These health monitoring devices can range from blood pressure and heart rate monitors to advanced devices capable of monitoring specialized implants, such as pacemakers or advanced hearing aids.[46] Specialized sensors can also be equipped within living spaces to monitor the health and general well-being of senior citizens, while also ensuring that proper treatment is being administered and assisting people regain lost mobility via therapy as well.[71] Other consumer devices to encourage healthy living, such as, connected scales or wearable heart monitors, are also a possibility with the IoT.[72] More and more end-to-end health monitoring IoT platform are coming up for antenatal and chronic patients, helping one manage health vitals and recurring medication requirements. Distinct advantages over similar products from the US and Europe are cost-effectiveness and personalisation for chronic patients. Doctors can monitor the health of their patients on their smartphones after the patient gets discharged from the hospital.[73]

Building and home automation

IoT devices can be used to monitor and control the mechanical, electrical and electronic systems used in various types of buildings (e.g., public and private, industrial, institutions, or residential).[46] Home automation systems, like other building automation systems, are typically used to control lighting, heating, ventilation, air conditioning, appliances, communication systems, entertainment and home security devices to improve convenience, comfort, energy efficiency, and security.[74]

Transportation

The IoT can assist in integration of communications, control, and information processing across various transportation systems. Application of the IoT extends to all aspects of transportation systems, i.e. the vehicle, the infrastructure, and the driver or user. Dynamic interaction between these components of a transport system enables inter and intra vehicular communication, smart traffic control, smart parking, electronic toll collection systems, logistic and fleet management, vehicle control, and safety and road assistance.[46]

Large scale deployments

There are several planned or ongoing large-scale deployments of the IoT, to enable better management of cities and systems. For example, Songdo, South Korea, the first of its kind fully equipped and wired smart city, is near completion. Nearly everything in this city is planned to be wired, connected and turned into a constant stream of data that would be monitored and analyzed by an array of computers with little, or no human intervention.[*citation needed*]

Another application is a currently undergoing project in Santander, Spain. For this deployment, two approaches have been adopted. This city of 180000 inhabitants, has already seen 18000 city application downloads for their smartphones. This application is connected to 10000 sensors that enable services like parking search, environmental monitoring, digital city agenda among others. City context information is used in this deployment so as to benefit merchants through a spark deals mechanism based on city behavior that aims at maximizing the impact of each notification.[75]

Other examples of large-scale deployments underway include the Sino-Singapore Guangzhou Knowledge City;[76] work on improving air and water quality, reducing noise pollution, and increasing transportation efficiency in San Jose, California;[77] and smart traffic management in western Singapore.[78] French company, Sigfox, commenced building an ultra-narrowband wireless data network in the San Francisco Bay Area in 2014, the first business to achieve such a deployment in the U.S.[79][80] It subsequently announced it would set up a total of 4000 base stations to cover a total of 30 cities in the U.S. by the end of the 2016, making it the largest IoT network coverage provider in the country thus far.[81][82]

Another example of a large deployment is the one completed by New York Waterways in New York City to connect all their vessels and being able to monitor them live 24/7. The network was designed and engineered by Fluidmesh Networks, a Chicago-based company developing wireless networks for critical applications. The NYWW network is currently providing coverage on the Hudson River, East River, and Upper New York Bay. With the wireless network in place, NY Waterway is able to take control of its fleet and passengers in a way that was not previously possible. New applications can include security, energy and fleet management, digital signage, public Wi-Fi, paperless ticketing and others.[83]

Unique addressability of things

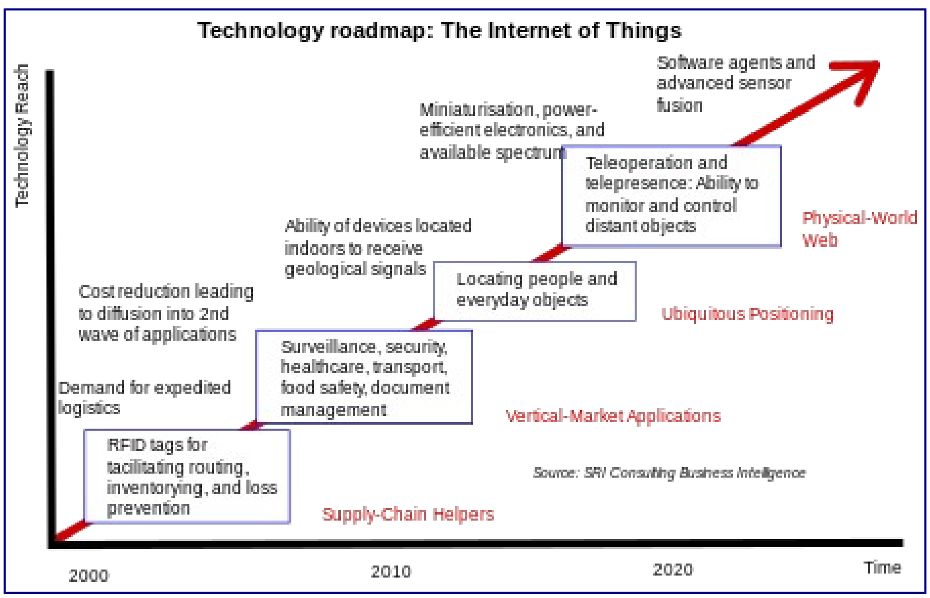
The original idea of the Auto-ID Center is based on RFID-tags and unique identification through the Electronic Product Code however this has evolved into objects having an IP address or URI.

An alternative view, from the world of the Semantic Web[84] focuses instead on making all things (not just those electronic, smart, or RFID-enabled) addressable by the existing naming protocols, such as URI. The objects themselves do not converse, but they may now be referred to by other agents, such as powerful centralized servers acting for their human owners.

The next generation of Internet applications using Internet Protocol Version 6 (IPv6) would be able to communicate with devices attached to virtually all human-made objects because of the extremely large address space of the IPv6 protocol. This system would therefore be able to scale to the large numbers of objects envisaged.[85]

A combination of these ideas can be found in the current GS1/EPCglobal EPC Information Services[86] (EPCIS) specifications. This system is being used to identify objects in industries ranging from aerospace to fast moving consumer products and transportation logistics.[87]

Trends and characteristics



Technology Roadmap: Internet of Things

Intelligence

Ambient intelligence and autonomous control are not part of the original concept of the Internet of Things. Ambient intelligence and autonomous control do not necessarily require Internet structures, either. However, there is a shift in research to integrate the concepts of the Internet of Things and autonomous control, with initial outcomes towards this direction considering objects as the driving force for autonomous IoT.

In the future the Internet of Things may be a non-deterministic and open network in which auto-organized or intelligent entities (Web services, SOA components), virtual objects (avatars) will be interoperable and able to act independently (pursuing their own objectives or shared ones) depending on the context, circumstances or environments. Autonomous behavior through collecting and reasoning context information plays a significant role in IoT. Modern IoT products and solutions in the marketplace use variety of different technologies to support such context-aware automation.

Architecture

The system will likely be an example of event-driven architecture,[88] *bottom-up* made (based on the context of processes and operations, in real-time) and will consider any subsidiary level. Therefore, model driven and functional approaches will coexist with new ones able to treat exceptions and unusual evolution of processes (Multi-agent systems, B-ADSc, etc.).

In an Internet of Things, the meaning of an event will not necessarily be based on a deterministic or syntactic model but would instead be based on the context of the event itself: this will also be a semantic web.[89] Consequently, it will not necessarily need common standards that would not be able to address every context or use: some actors (services, components, avatars) will accordingly be self-referenced and, if ever needed, adaptive to existing common standards (*predicting everything* would be no more than defining a "global finality" for everything that is just not possible with any of the current *top-down* approaches and standardizations). Some researchers argue that sensor networks are the most essential components of the Internet of Things.[90]

Building on top of the Internet of Things, the Web of Things is an architecture for the application layer of the Internet of Things looking at the convergence of data from IoT devices into Web applications to create innovative use-cases. In order to program and control the flow of information in the Internet of Things, a predicted architectural direction is being called BPM Everywhere which is a blending of traditional process management with process mining and special capabilities to automate the control of large numbers of coordinated devices.

Network Architecture[91]

Internet of Things requires huge scalability in the network space to handle the surge of devices. IETF 6LoWPAN would be used to connect devices to IP networks.With billions of devices[35] being added to the internet space, IPv6 will play a major role in handling the network layer scalability. IETF's Constrained Application Protocol, MQTT and ZeroMQ would provide lightweight data transport.

Fog computing is a viable alternative to prevent such large burst of data flow through Internet. The edge devices' computation power can be used to analyse and process data, thus providing easy real time scalability.

Complex system

In semi-open or closed loops (i.e. value chains, whenever a global finality can be settled) it will therefore be considered and studied as a Complex system[92] due to the huge number of different links and interactions between autonomous actors, and its capacity to integrate new actors. At the overall stage (full open loop) it will likely be seen as a chaotic environment (since systems have always finality).

Size considerations

The Internet of objects would encode 50 to 100 trillion objects, and be able to follow the movement of those objects. Human beings in surveyed urban environments are each surrounded by 1000 to 5000 trackable objects.[93]

Space considerations

In an Internet of Things, the precise geographic location of a thing—and also the precise geographic dimensions of a thing—will be critical. Open Geospatial Consortium, "OGC Abstract Specification" Currently, the Internet has been primarily used to manage information processed by people. Therefore, facts about a thing, such as its location in time and space, have been less critical to track because the person processing the information can decide whether or not that information was important to the action being taken, and if so, add the missing information (or decide to not take the action). (Note that some things in the Internet of Things will be sensors, and sensor location is usually important. Mike Botts et al., "OGC Sensor Web Enablement: Overview And High Level Architecture") The GeoWeb and Digital Earth are promising applications that become possible when things can become organized and connected by location. However, challenges that remain include the constraints of variable spatial scales, the need to handle massive amounts of data, and an indexing for fast search and neighbour operations. If in the Internet of Things, things are able to take actions on their own initiative, this human-centric mediation role is eliminated, and the time-space context that we as humans take for granted must be given a central role in this information ecosystem. Just as standards play a key role in the Internet and the Web, geospatial standards will play a key role in the Internet of Things.

Sectors

There are three core sectors of the IoT: enterprise, home, and government, with the Enterprise Internet of Things (EIoT) being the largest of the three. By 2019, the EIoT sector is estimated to account for nearly 40% or 9.1 billion devices.[94]

A Basket of Remotes

According to the CEO of Cisco, the remote control market is expected to be a $USD 19 trillion market.[95] Many IoT devices have a potential to take a piece of this market. Jean-Louis Gassée (Apple initial alumni team, and BeOS co-founder) has addressed this topic in an article on *Monday Note*,[96] where he predicts that the most likely problem will be what he calls the "Basket of remotes" problem, where we'll have hundreds of applications to interface with hundreds of devices that don't share protocols for speaking with one another.

There are multiple approaches to solve this problem, one of them called the "predictive interaction",

[97] where cloud or fog based decision makers [*clarification needed*] will predict the user's next action and trigger some reaction.

For user interaction, new technology leaders are joining forces to create standards for communication between devices. While AllJoyn alliance is composed the top 20 World technology leaders, there are also big companies that promote their own protocol like CCF from Intel.

This problem is also a competitive advantage for some very technical startup companies with fast capabilities.

- AT&T Digital Life provides one solution for the "basket of remotes" problem. This product features home-automation and digital-life experiences. It provides a mobile application to control their closed ecosystem of branded devices;
- Nuve has developed a new technology based on sensors, a cloud-based platform and a mobile application that allows the asset management industry to better protect, control and monitor their property.[98]

Manufacturers are becoming more conscious of this problem, and many companies have begun releasing their devices with open APIs. Many of these APIs are used by smaller companies looking to take advantage of quick integration.[*citation needed*]

Sub systems

Not all elements in an Internet of Things will necessarily run in a global space. Domotics running inside a Smart House, for example, might only run and be available via a local network.

Frameworks

Internet of Things frameworks might help support the interaction between "things" and allow for more complex structures like Distributed computing and the development of Distributed applications. Currently, some Internet of Things frameworks seem to focus on real time data logging solutions like Jasper Technologies, Inc. and Xively (formerly Cosm and before that Pachube): offering some basis to work with many "things" and have them interact. Future developments might lead to specific Software development environments to create the software to work with the hardware used in the Internet of Things. Companies such as Tibbo Systems - AggreGate Platform,[99][100][101] Arrayent,[102][103][104] B-Scada,[105][106] Carriots,[107][108] EVRYTHNG,[109] Exosite,[110][111][112] IoT-Ticket.com, nPhase,[113] Raco Wireless[114][115] and ThingWorx[116][117][118] are developing technology platforms to provide this type of functionality for the Internet of Things.

The XMPP standards foundation XSF is creating such a framework in a fully open standard that isn't tied to any company and not connected to any cloud services. This XMPP initiative is called Chatty Things.[119] XMPP provides a set of needed building blocks and a proven distributed solution that can scale with high security levels. The extensions are published at XMPP/extensions

The independently developed MASH IoT Platform was presented at the 2013 IEEE IoT conference in

Mountain View, CA. MASH's focus is asset management (assets=people/property/information, management=monitoring/control/configuration). Support is provided for design thru deployment with an included IDE, Android client and runtime. Based on a component modeling approach MASH includes support for user defined things and is completely data-driven.[120]

REST is a scalable architecture which allows for things to communicate over Hypertext Transfer Protocol and is easily adopted for IoT applications to provide communication from a thing to a central web server. MQTT is a publish-subscribe architecture on top of TCP/IP which allows for bi-directional communication between a thing and a MQTT broker.

Enabling technologies for the IOT

There are mainly three types of technologies that enable IOT.[121]

1. RFID and near-field communication - In 2000s this was more likely tech. Later on it was modified into many forms. The most likely one among them is the near-field communication (NFC) form. The latest Iphone 6 supports NFC for Apple Pay.
2. Optical tags and quick response codes - This is used for low cost tagging. Phone cameras decodes QR code using image-processing techniques. In reality QR advertisement campaigns gives less turnout as users need to have another application to read QR codes.
3. Bluetooth low energy - This is one of the latest tech. All newly releasing smartphones have BLE hardware in them. Tags based on BLE can signal their presence at a power budget that enables them to operate for up to one year on a lithium coin cell battery.

Simulation

IOT modeling and simulation (and emulation) is typically carried out at the design stage before deployment of the network. Network simulators like OPNET, NetSim and NS2 can be used to simulate IOT networks

Criticism and controversies

While many technologists tout the Internet of Things as a step towards a better world, scholars and social observers have doubts about the promises of the ubiquitous computing revolution.

Privacy, autonomy and control

Peter-Paul Verbeek, a professor of philosophy of technology at the University of Twente, Netherlands, writes that technology already influences our moral decision making, which in turns affects human agency, privacy and autonomy. He cautions against viewing technology merely as a human tool and advocates instead to consider it as an active agent.[122]

Justin Brookman, of the Center for Democracy and Technology, expressed concern regarding the impact of IoT on consumer privacy, saying that "There are some people in the commercial space who say, 'Oh, big data — well, let's collect everything, keep it around forever, we'll pay for somebody to think about security later.’ The question is whether we want to have some sort of policy framework in place to limit that."[123]

Tim O'Reilly believes that the way companies sell the IoT devices on consumers are misplaced, disputing the notion that the IoT is about gaining efficiency from putting all kinds of devices online and postulating that "IoT is really about human augmentation. The applications are profoundly different when you have sensors and data driving the decision-making.".[124]

Editorials at WIRED have also expressed concern, one stating 'What you’re about to lose is your privacy. Actually, it’s worse than that. You aren’t just going to lose your privacy, you’re going to have to watch the very concept of privacy be rewritten under your nose.'[125]

The American Civil Liberties Union (ACLU) expressed concern regarding the ability of IoT to erode people's control over their own lives. The ACLU wrote that "There’s simply no way to forecast how these immense powers -- disproportionately accumulating in the hands of corporations seeking financial advantage and governments craving ever more control -- will be used. Chances are Big Data and the Internet of Things will make it harder for us to control our own lives, as we grow increasingly transparent to powerful corporations and government institutions that are becoming more opaque to us."[126]

Researchers have identified privacy challenges faced by all stakeholders in IoT domain, from the manufacturers and app developers to the consumers themselves, and examined the responsibility of each party in order to ensure user privacy at all times. Problems highlighted by the report[127] include:

- User consent – somehow, the report says, users need to be able to give informed consent to data collection. Users, however, have limited time and technical knowledge.
- Freedom of choice – both privacy protections and underlying standards should promote freedom of choice.
- Anonymity – IoT platforms pay scant attention to user anonymity when transmitting data, the researchers note. Future platforms could, for example, use TOR or similar technologies so that users can't be too deeply profiled based on the behaviors of their "things".

Security

Concerns have been raised that the Internet of Things is being developed rapidly without appropriate consideration of the profound security challenges involved [128] and the regulatory changes that might be necessary.[129] According to the BI (Business Insider) Intelligence Survey conducted in the last quarter of 2014, 39% of the respondents said that security is the biggest concern in adopting Internet of Things technology.[130] In particular, as the Internet of Things spreads widely, cyber attacks are likely to become an increasingly physical (rather than simply virtual) threat.[131] In a January 2014 article in *Forbes*, cybersecurity columnist Joseph Steinberg listed many Internet-connected appliances that can already "spy on people in their own homes" including televisions, kitchen appliances, cameras, and thermostats.[132] Computer-controlled devices in automobiles such as brakes, engine, locks, hood and truck releases, horn, heat, and dashboard have been shown to be vulnerable to attackers who have access to the onboard network. In some cases, vehicle computer systems are internet-connected, allowing them to be exploited remotely.[133]

The U.S. National Intelligence Council in an unclassified report maintains that it would be hard to deny "access to networks of sensors and remotely-controlled objects by enemies of the United States, criminals, and mischief makers… An open market for aggregated sensor data could serve the interests of commerce and security no less than it helps criminals and spies identify vulnerable targets. Thus, massively parallel sensor fusion may undermine social cohesion, if it proves to be fundamentally incompatible with Fourth-Amendment guarantees against unreasonable search."[134] In general, the intelligence community views Internet of Things as a rich source of data.[135]

Children and the Internet of Things

It has been suggested by Sonia Livingstone OBE that young people are the target of a range of policy initiatives designed to realise the benefits of new developments in the internet while minimising the potential risks. These are often developed, of necessity, in the absence of rigorous empirical data, making an informed assessment of access, attitudes, skills and uses essential. The key ideas that reveal the complex dynamic between online opportunities and online risks include:

- Digital in/exclusion
- Learning and literacy
- Peer networking and privacy
- Civic participation
- Risk and harm

This research raises key questions regarding identity, literacy, privacy, participation and risk which are all key issues in relation to IoT developments.[136]

Data capture, or Big Data, is a key starting point whilst considering the effects of the IoT on young people.

Design

Given widespread recognition of the evolving nature of the design and management of the Internet of Things, sustainable and secure deployment of Internet of Things solutions must design for "anarchic scalability."[137] Application of the concept of anarchic scalability can be extended to physical systems (i.e. controlled real-world objects), by virtue of those systems being designed to account for uncertain management futures. This "hard anarchic scalability" thus provides a pathway forward to fully realize the potential of Internet of Things solutions by selectively constraining physical systems to allow for all management regimes without risking physical failure.

Brown University computer scientist Michael Littman has argued that successful execution of the Internet of Things requires consideration of the interface's usability as well as the technology itself. These interfaces need to be not only more user friendly but also better integrated: "If users need to learn different interfaces for their vacuums, their locks, their sprinklers, their lights, and their coffeemakers, it’s tough to say that their lives have been made any easier."[138]

Environmental impact

A concern regarding IoT technologies pertains to the environmental impacts of the manufacture, use, and eventual disposal of all these semiconductor-rich devices. Modern electronics are replete with a wide variety of heavy metals and rare-earth metals, as well as highly toxic synthetic chemicals. This makes them extremely difficult to properly recycle. Electronic components are often simply incinerated or dumped in regular landfills, thereby polluting soil, groundwater, surface water, and air. Such contamination also translates into chronic human-health concerns. Furthermore, the environmental cost of mining the rare-earth metals that are integral to modern electronic components continues to grow. With production of electronic equipment growing globally yet little of the metals (from end-of-life equipment) being recovered for reuse, the environmental impacts can be expected to increase.

Also, because the concept of IoT entails adding electronics to mundane devices (for example, simple light switches), and because the major driver for replacement of electronic components is often technological obsolescence rather than actual failure to function, it is reasonable to expect that items that previously were kept in service for many decades would see an accelerated replacement cycle, if they were part of the IoT. For example, a traditional house built with 30 light switches and 30 electrical outlets might stand for 50 years, with all those components still being original at the end of that period. But a modern house built with the same number of switches and outlets set up for IoT might see each switch and outlet replaced at five-year intervals, in order to keep up-to-date with technological changes. This translates into a ten-fold increase in waste requiring disposal.

See also

- Web of Things
- Algorithmic Regulation
- Bluetooth low energy (BLE)
- Cloud manufacturing
- Data Distribution Service
- Digital Object Memory
- Indoor positioning system
- Open Interconnect Consortium
- Ubiquitous computing

References

1.

- *"Internet of Things Global Standards Initiative". ITU. Retrieved 26 June 2015.*
- https://hbr.org/resources/pdfs/comm/verizon/18980_HBR_Verizon_IoT_Nov_14.pdf
- http://www.internet-of-things-

research.eu/pdf/Converging_Technologies_for_Smart_Environments_and_Integrated_Ecosystems_IERC_Book_Open_Access_2013.pdf

- http://www.cisco.com/web/solutions/trends/iot/introduction_to_IoT_november.pdf
- http://cordis.europa.eu/fp7/ict/enet/documents/publications/iot-between-the-internet-revolution.pdf
- http://www.vs.inf.ethz.ch/publ/papers/Internet-of-things.pdf
- http://www.cognizant.com/InsightsWhitepapers/Reaping-the-Benefits-of-the-Internet-of-Things.pdf
- *"The Supply Chain: Changing at the Speed of Technology". Retrieved 2015-09-18.*
- *Dave Evans (April 2011). "The Internet of Things: How the Next Evolution of the Internet Is Changing Everything" (PDF). Cisco. Retrieved 4 September 2015.*
- *Wood, Alex. "The internet of things is revolutionizing our lives, but standards are a must". theguardian.com. The Guardian. Retrieved 31 March 2015.*
- J. Höller, V. Tsiatsis, C. Mulligan, S. Karnouskos, S. Avesand, D. Boyle: *From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence*. Elsevier, 2014, ISBN 978-0-12-407684-6.
- O. Monnier: *A smarter grid with the Internet of Things*. Texas Instruments, 2013.
- https://www.itu.int/dms_pub/itu-t/oth/0b/15/T0B150000153301PDFE.pdf
- *"IEEE Xplore Full-Text PDF:". Retrieved 26 June 2015.*
- *"Molluscan eye". Retrieved 26 June 2015.*
- I. Wigmore: "Internet of Things (IoT)". TechTarget, June 2014.
- *Farooq, M.U.; Waseem, Muhammad; Khairi, Anjum; Mazhar, Sadia (2015). "A Critical Analysis on the Security Concerns of Internet of Things (IoT)". International Journal of Computer Applications (IJCA)* ***11***. *Retrieved 18 February 2015.*
- *Hendricks, Drew. "The Trouble with the Internet of Things". London Datastore. Greater London Authority. Retrieved 10 August 2015.*
- *Violino, Bob. "The 'Internet of things' will mean really, really big data". InfoWorld. Retrieved 9 July 2014.*
- *Hogan, Michael. "The 'The Internet of Things Database' Data Management Requirements". ScaleDB. Retrieved 15 July 2014.*
- *"The "Only" Coke Machine on the Internet". Carnegie Mellon University. Retrieved 10 November 2014.*
- *"Internet of Things Done Wrong Stifles Innovation". InformationWeek. 7 July 2014. Retrieved 10 November 2014.*
- *Mattern, Friedemann; Christian Floerkemeier (2010). "From the Internet of Computers to the Internet of Things" (PDF). Informatik- Spektrum* ***33*** *(2): 107–121. doi:10.1007/s00287-010-0417-7. Retrieved 3 February 2014.*
- *Weiser, Mark (1991). "The Computer for the 21st Century" (PDF). Scientific American* ***265*** *(3): 94–104. doi:10.1038/scientificamerican0991-94. Retrieved 5 November 2014.*

- *Raji, RS (June 1994). "Smart networks for control". IEEE Spectrum.*
- Jason Pontin: ETC: Bill Joy's Six Webs. In: *MIT Technology Review*, 29 September 2005. Retrieved 17 November 2013.
- Analyst Anish Gaddam interviewed by Sue Bushell in *Computerworld*, on 24 July 2000 ("M-commerce key to ubiquitous internet")
- P. Magrassi, T. Berg, *A World of Smart Objects*, Gartner research report R-17-2243, 12 August 2002 [1]
- *Commission of the European Communities (18 June 2009). "Internet of Things — An action plan for Europe" (PDF). COM(2009) 278 final.*
- Techvibes *From M2M to The Internet of Things: Viewpoints From Europe* 7 July 2011
- Dr. Lara Sristava, European Commission Internet of Things Conference in Budapest, 16 May 2011 *The Internet of Things - Back to the Future (Presentation)*
- P. Magrassi, A. Panarella, N. Deighton, G. Johnson, *Computers to Acquire Control of the Physical World*, Gartner research report T-14-0301, 28 September 2001[*need quotation to verify*]
- Casaleggio Associati *The Evolution of Internet of Things* February 2011[*need quotation to verify*]
- http://dx.doi.org/10.1787/888933225312
- *"Gartner Says the Internet of Things Installed Base Will Grow to 26 Billion Units By 2020". Gartner. 12 December 2013. Retrieved 2 January 2014.*
- More Than 30 Billion Devices Will Wirelessly Connect to the Internet of Everything in 2020, ABI Research
- *Fickas, S.; Kortuem, G.; Segall, Z. (13–14 Oct 1997). "Software organization for dynamic and adaptable wearable systems". International Symposium on Wearable Computers: 56–63. doi:10.1109/ISWC.1997.629920.*
- *"Main Report: An In-depth Look at Expert Responses". Pew Research Center: Internet, Science & Tech. 14 May 2014. Retrieved 26 June 2015.*
- *"Behind The Numbers: Growth in the Internet of Things". platform. Retrieved 26 June 2015.*
- *"Budget 2015: some of the things we've announced". gov.uk. GOV.UK. Retrieved 31 March 2015.*
- *Kushalnagar, N; Montenegro, G; Schumacher, C (August 2007). "IPv6 over Low-Power Wireless Personal Area Networks (6LoWPANs): Overview, Assumptions, Problem Statement, and Goals". IETF RFC 4919.*
- *Sun, Charles C. (1 May 2014). "Stop using Internet Protocol Version 4!". Computerworld.*
- *Sun, Charles C. (2014-05-01). "Stop Using Internet Protocol Version 4!". CIO. Retrieved 2015-01-28.*
- *Sun, Charles C. (2 May 2014). "Stop using Internet Protocol Version 4!". InfoWorld.*
- *Sun, Charles C. (1 May 2014). "Stop using Internet Protocol Version 4!". IDG News India.*
- *Ersue, M; Romascanu, D; Schoenwaelder, J; Sehgal, A (4 July 2014). "Management of*

Networks with Constrained Devices: Use Cases". IETF Internet Draft < draft-ietf-opsawg-coman-use-cases>.

- *Vongsingthong, S.; Smanchat, S. (2014). "Internet of Things: A review of applications & technologies" (PDF). Suranaree Journal of Science and Technology.*
- *Mitchell, Shane; Villa, Nicola; Stewart-Weeks, Martin; Lange, Anne. "The Internet of Everything for Cities: Connecting People, Process, Data, and Things To Improve the 'Livability' of Cities and Communities" (PDF). Cisco Systems. Retrieved 10 July 2014.*
- *Narayanan, Ajit. "Impact of Internet of Things on the Retail Industry". PCQuest. Cyber Media Ltd. Retrieved 20 May 2014.*
- *CasCard; Gemalto; Ericsson. "Smart Shopping: spark deals" (PDF). EU FP7 BUTLER Project.*
- *Kyriazis, D.; Varvarigou, T.; Rossi, A.; White, D.; Cooper, J. (4–7 June 2013). "Sustainable smart city IoT applications: Heat and electricity management & Eco-conscious cruise control for public transportation". IEEE International Symposium and Workshops on a World of Wireless, Mobile and Multimedia Networks (WoWMoM). doi:10.1109/WoWMoM.2013.6583500.*
- *"Making your home 'smart', the Indian way". The Times of India. Retrieved 26 June 2015.*
- *Perera, Charith; Liu, Harold; Jayawardena, Srimal. "The Emerging Internet of Things Marketplace From an Industrial Perspective: A Survey". Emerging Topics in Computing, IEEE Transactions on. PrePrint. doi:10.1109/TETC.2015.2390034. Retrieved 1 February 2015.*
- *Couldry, Nick; Turow, Joseph (2014). "Advertising, Big Data, and the Clearance of the Public Realm: Marketers' New Approaches to the Content Subsidy". International Journal of Communication **8**: 1710–1726.*
- *Moss, Jamie. "The internet of things: unlocking the marketing potential". theguardian.com. The Guardian. Retrieved 31 March 2015.*
- *Meadows-Klue, Danny. "A new era of personal data unlocked in an "Internet of Things"". http://www.digitalstrategyconsulting.com. Digital Strategy Consulting. Retrieved 26 January 2015.*
- *"How the Internet of Things will enable 'smart buildings'".* `|first1=` missing `|last1=` in Authors list (help)
- *Li, Shixing; Wang, Hong; Xu, Tao; Zhou, Guiping (2011). "Application Study on Internet of Things in Environment Protection Field". Lecture Notes in Electrical Engineering Volume **133**: 99–106. doi:10.1007/978-3-642-25992-0_13.*
- *FIT French Project. "Use case: Sensitive wildlife monitoring". Retrieved 10 July 2014.*
- Resource
- *Gubbi, Jayavardhana; Buyya, Rajkumar; Marusic, Slaven; Palaniswami, Marimuthu (24 February 2013). "Internet of Things (IoT): A vision, architectural elements, and future directions". Future Generation Computer Systems **29** (7): 1645–1660. doi:10.1016/j.future.2013.01.010.*
- *Chui, Michael; Löffler, Markus; Roberts, Roger. "The Internet of Things". McKinsey Quarterly.*

McKinsey & Company. Retrieved 10 July 2014.

- *Postscapes. "Smart Trash". Retrieved 10 July 2014.*
- *Severi, S.; Abreu, G.; Sottile, F.; Pastrone, C.; Spirito, M.; Berens, F. (23–26 June 2014). "M2M Technologies: Enablers for a Pervasive Internet of Things". The European Conference on Networks and Communications (EUCNC2014).*
- *Tan, Lu; Wang, Neng (20–22 August 2010). "Future Internet: The Internet of Things". 3rd International Conference on Advanced Computer Theory and Engineering (ICACTE) **5**: 376–380. doi:10.1109/ICACTE.2010.5579543.*
- *Parello, J.; Claise, B.; Schoening, B.; Quittek, J. (28 April 2014). "Energy Management Framework". IETF Internet Draft <draft-ietf-eman-framework-19>.*
- *"Why Wemo?". Belkin. Retrieved 30 January 2015.*
- *"Professional 4-Port Remote Power Switch - Phone Control + Web Control". Ambery.*
- *"Budderfly - The Power to Manage ALL YOUR ENERGY".*
- *"EcoSmart - Where Energy Matters".*
- *Istepanian, R.; Hu, S.; Philip, N.; Sungoor, A. (30 August – 3 September 2011). "The potential of Internet of m-health Things "m-IoT" for non-invasive glucose level sensing". Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC). doi:10.1109/IEMBS.2011.6091302.*
- *Swan, Melanie (8 November 2012). "Sensor Mania! The Internet of Things, Wearable Computing, Objective Metrics, and the Quantified Self 2.0". Sensor and Actuator Networks **1** (3): 217–253. doi:10.3390/jsan1030217.*
- *Kamalanathan, Nitya Ahilandam; Eardley, Alan; Chibelushi, Caroline; Collins, Tim (2013). "Improving the Patient Discharge Planning Process through Knowledge Management by Using the Internet of Things". Advances in Internet of Things **03** (02): 16–26. doi:10.4236/ait.2013.32A003. ISSN 2161-6817.*
- http://asia.nikkei.com/print/article/77022
- *Rico, Juan (22–24 April 2014). "Going beyond monitoring and actuating in large scale smart cities". NFC & Proximity Solutions - WIMA Monaco.*
- *"Sino-Singapore Guangzhou Knowledge City: A vision for a city today, a city of vision tomorrow". Retrieved 11 July 2014.*
- *"San Jose Implements Intel Technology for a Smarter City". Retrieved 11 July 2014.*
- *Coconuts Singapore. "Western Singapore becomes test-bed for smart city solutions". Retrieved 11 July 2014.*
- *Lipsky, Jessica. "IoT Clash Over 900 MHz Options". EETimes. EETimes. Retrieved 15 May 2015.*
- *Alleven, Monica. "Sigfox launches IoT network in 10 UK cities". Fierce Wireless Tech. Fierce Wireless Tech. Retrieved 13 May 2015.*
- *Merritt, Rick. "13 Views of IoT World". EETimes. EETimes. Retrieved 15 May 2015.*
- *Fitchard, Kevin. "Sigfox brings its internet of things network to San Francisco". Gigaom.*

Gigaom. Retrieved 15 May 2015.

- *"STE Security Innovation Awards Honorable Mention: The End of the Disconnect". Retrieved 12 August 2015.*
- Dan Brickley et al., c. 2001
- *Waldner, Jean-Baptiste (2008). Nanocomputers and Swarm Intelligence. London: ISTE. pp. 227–231. ISBN 1-84704-002-0.*
- *"EPCIS - EPC Information Services Standard". GS1. Retrieved 2 January 2014.*
- *Miles, Stephen B. (2011). RFID Technology and Applications. London: Cambridge University Press. pp. 6–8. ISBN 978-0-521-16961-5.*
- Philippe Gautier, « RFID et acquisition de données évènementielles : retours d'expérience chez Bénédicta », pages 94 à 96, Systèmes d'Information et Management - revue trimestrielle N°2 Vol. 12, 2007, ISSN 1260-4984 / ISBN 978-2-7472-1290-8, éditions ESKA. [2]
- *Philippe GAUTIER (17 April 2010). "3 questions to Philippe GAUTIER, by David Fayon (from the original interview by David Fayon, in French : http://david.fayon.free.fr/interview/philippe-gautier.htm) - I-O-T : INTERNET Of THINGS / Internet des Objets". Retrieved 26 June 2015.*
- *Charith Perera; Arkady Zaslavsky; Peter Christen & Dimitrios Georgakopoulos (2013). "Context Aware Computing for The Internet of Things: A Survey". Communications Surveys Tutorials, IEEE **PP** (n/a): 1–44. doi:10.1109/SURV.2013.042313.00197.*
- *Pal, Arpan. "Internet of Things Making the Hype a Reality" (PDF). IEEE Computer Society.*
- *Gautier, Philippe; Gonzalez, Laurent (2011). L'Internet des Objets... Internet, mais en mieux (PDF). foreword by Gérald Santucci (European commission), postword by Daniel Kaplan (FING) and Michel Volle. Paris: AFNOR editions. ISBN 978-2-12-465316-4.*
- *Waldner, Jean-Baptiste (2007). Nanoinformatique et intelligence ambiante. Inventer l'Ordinateur du XXIeme Siècle. London: Hermes Science. p. 254. ISBN 2-7462-1516-0.*
- *"The Enterprise Internet of Things Market - Business Insider". Business Insider. 25 February 2015. Retrieved 26 June 2015.*
- *Olga Kharif (8 January 2014). "Cisco CEO Pegs Internet of Things as $19 Trillion Market". Bloomberg.com. Retrieved 26 June 2015.*
- *"Internet of Things: The "Basket of Remotes" Problem". Monday Note. Retrieved 26 June 2015.*
- *"Better Business Decisions with Advanced Predictive Analytics". Intel. Retrieved 26 June 2015.*
- *"Nuve - Asset Management and Fraud Prevention". Nuve - Asset Management and Fraud Prevention. Retrieved 26 June 2015.*
- *"Tibbo now is a member of the Internet of Things Council".*
- *"Tibbo Systems has become an official member of StarNet Alliance". Retrieved 23 July 2015.*
- *"A list of IoT and M2M platforms".*
- *Maxine Bingham (10 January 2015). "IoT startups (A-F)". IoT Perspectives. Retrieved 30 March 2015.*
- *"Number One Consumer Brands are Selecting the Arrayent Connect(TM) Platform to Power Their Connected Product Initiatives". Market Watch. 19 December 2012. Retrieved 30 March*

2015.

- *"Arrayent Brings the Internet of Things to Life with New Products at CES 2014". Business Wire. 2 January 2014. Retrieved 30 March 2015.*
- *Boccamazzo, Allison (28 January 2015). "B-Scada Launches New IoT Initiative at ITEXPO 2015". TMCnet.*
- *"B-Scada Takes SCADA to the Cloud". Automation.com. Retrieved 13 February 2015.*
- *"What is Carriots". Carriots official site. Retrieved 10 October 2013.*
- *Higginbotham, Stacey. "Carriots is building a PaaS for the Internet of Things". GigaOM. Retrieved 26 April 2013.*
- *"IoT Startup EVRYTHNG Secures $7M Series A From Atomico, BHLP, Cisco And Dawn". Techcrunch.*
- *Katharine Greyson (22 October 2013). "Is Minn.'s next big thing the Internet of Things?". Minneapolis-Saint Paul Business Journal.*
- *"Exosite: Extending Big Data to Next Generation Of Cloud Solutions". CIOReview.*
- *Bill Wong (1 May 2014). "Dev Kits Light Up The Internet Of Things". Electronic Design.*
- *Bowen, Suzanne. "Interview with nPhase (Qualcomm - Verizon) Steve Pazol on M2M". DIDX Audio Podcast Newspaper. Retrieved 9 April 2013.*
- *Bowen, Suzanne. "Raco Wireless John Horn on the Connected World and M2M". DIDX Audio Podcast Newspaper. Retrieved 9 April 2013.*
- *Fitchard, Kevin (26 February 2013). "T-Mobile's M2M provider Raco goes international with Sprint, Telefónica deals". GigaOm.*
- *Rizzo, Tony (12 March 2013). "ThingWorx Drives M2M and IoT Developer Efficiency with New Platform Release". TMCnet.*
- *Bowen, Suzanne. "ThingWorx CEO Russell Fadel on M2M and the Connected World". DIDX Audio Podcast Newspaper. Retrieved 9 April 2013.*
- *"ThingWorx".*
- *"Tech pages/IoT systems". Retrieved 26 June 2015.*
- http://www.youtube.com/user/MASHPlatform "YouTube channel"
- *Want, Roy; Bill N. Schilit, Scott Jenson (2015). "Enabling the Internet of Things" **1**. Sponsored by IEEE Computer Society. IEEE. pp. 28 – 35.*
- Verbeek, Peter-Paul. "Moralizing Technology: Understanding and Designing the Morality of Things." Chicago: *The University of Chicago Press*, 2011.
- Diane Cardwell, At Newark Airport, the Lights Are On, and They're Watching You, *The New York Times*, 2014.02.17
- *Hardy, Quentin (4 February 2015). "Tim O'Reilly Explains the Internet of Things". The New York Times Bits (The New York Times). Retrieved 18 May 2015.*
- *Webb, Geoff (5 February 2015). "Say Goodbye to Privacy". WIRED. Retrieved 15 February 2015.*
- Catherine Crump and Matthew Harwood, The Net Closes Around Us, *TomDispatch*, 25 March

2014

- *Perera, Charith; Ranjan, Rajiv; Wang, Lizhe; Khan, Samee; Zomaya, Albert (2015). "Privacy of Big Data in the Internet of Things Era". IEEE IT Professional Magazine. PrePrint (Internet of Anything). Retrieved 1 February 2015.*
- *Singh, Jatinder; Pasquier, Thomas; Bacon, Jean; Ko, Hajoon; Eyers, David (2015). "Twenty Cloud Security Considerations for Supporting the Internet of Things". IEEE Internet of Things Journal: 1–1. doi:10.1109/JIOT.2015.2460333.*
- *Chris Clearfield. "Why The FTC Can't Regulate The Internet Of Things". Forbes. Retrieved 26 June 2015.*
- *"We Asked Executives About The Internet Of Things And Their Answers Reveal That Security Remains A Huge Concern". Business Insider. Retrieved 26 June 2015.*
- Christopher Clearfield "Rethinking Security for the Internet of Things" Harvard Business Review Blog, 26 June 2013/
- *Joseph Steinberg (27 January 2014). "These Devices May Be Spying On You (Even In Your Own Home)". Forbes. Retrieved 27 May 2014.*
- *Andy Greenberg (21 July 2015). "Hackers Remotely Kill a Jeep on the Highway—With Me in It". Wired. Retrieved 21 July 2015.*
- Disruptive Technologies Global Trends 2025. National Intelligence Council (NIC), April 2008, P. 27.
- *Ackerman, Spencer (15 March 2012). "CIA Chief: We'll Spy on You Through Your Dishwasher". WIRED. Retrieved 26 June 2015.*
- *Livingstone, Sonia (2009). Children and the Internet (1st ed.). London: Polity. ISBN 978-0-7456-3194-3.*
- Roy Thomas Fielding, Architectural Styles and the Design of Network-based Software Architectures (2000), Dissertation - Doctor of Philosophy in Information and Computer Science

138.*Littman, Michael and Samuel Kortchmar. "The Path To A Programmable World". Footnote. Retrieved 14 June 2014.*

Further reading

- *Zanella, Andrea; Bui, Nicola; Castellani, Angelo; Vangelista, Lorenzo & Zorzi, Michele. "Internet of Things for Smart Cities". IEEE Internet of Things Journal, VOL. 1, NO. 1, FEBRUARY 2014.*
- *Guinard, Dominique; Vlad, Trifa (2015). Building the Web of Things. Manning. ISBN 9781617292682.*
- *Atzori, Luigi; Iera, Antonio & Morabito, Giacomo. "The internet of things: A survey" (PDF). Computer Networks, Elsevier, The Netherlands, 2010.*
- *Carsten, Paul (2015). "Lenovo to stop pre-installing controversial software". Reuters.*
- Chaouchi, Hakima. The Internet of Things. London: Wiley-ISTE, 2010.

- Chabanne, Herve, Pascal Urien, and Jean-Ferdinand Susini. RFID and the Internet of Things. London: ISTE, 2011.
- *"Disruptive Technologies Global Trends 2025" (PDF). U.S. National Intelligence Council (NIC).*
- *Fahrion, Mike (2015). "Internet of Things for the Modern M2M".*
- *Fell, Mark (2014). "Roadmap for the Emerging Internet of Things - Its Impact, Architecture and Future Governance" (PDF). Carré & Strauss, United Kingdom.*
- *Fell, Mark (2013). "Manifesto for Smarter Intervention in Complex Systems" (PDF). Carré & Strauss, United Kingdom.*
- *Jayavardhana Gubbi; Rajkumar Buyya; Slaven Marusic; Marimuthu Palaniswami (September 2013). "Internet of Things (IoT): A Vision, Architectural Elements, and Future Directions" (PDF). Future Generation Computer Systems, Elsevier, The Netherlands.*
- Hersent, Olivier, David Boswarthick and Omar Elloumi. The Internet of Things: Key Applications and Protocols. Chichester, West Sussex: Wiley, 2012.
- *Howard, Philip. "Pax Technica: Will The Internet of Things Lock Us Up or Set Us Free?". Yale University Press, New Haven CT, 2015.*
- *"Internet of Things in 2020: A Roadmap for the future" (PDF). EPoSS.*
- *Ishaq, Isam; Carels, David; Teklemariam ,Girum K.; Hoebeke, Jeroen; Van den Abeele, Floris; De Poorter, Eli; Moerman, Ingrid & Demeester, Piet (2013). "IETF Standardization in the Field of the Internet of Things (IoT): A Survey". Journal of Sensor and Actuator Networks, Multidisciplinary Digital Publishing Institute.*
- IERC - European Research Cluster on the Internet of Things: Documents and Publications
- Michahelles, Florian, et al. Proceedings of 2012 International Conference on the Internet of Things (IOT) : 24–26 October 2012 : Wuxi, China. Piscataway, N.J.: IEEE, 2012.
- *"What is the Internet of Things? An Economic Perspective" (PDF). Auto-ID Labs.*
- Pfister, Cuno. Getting Started with the Internet of Things. Sebastapool, Calif: O'Reilly Media, Inc., 2011.
- Uckelmann, Dieter, Mark Harrison and Florian Michahelles. Architecting the Internet of Things. Berlin: Springer, 2011.
- Weber, Rolf H., and Romana Weber. Internet of Things: Legal Perspectives. Berlin: Springer, 2010.
- Zhou, Honbo. The Internet of Things in the Cloud: A Middleware Perspective. Boca Raton: CRC Press, Taylor & Francis Group, 2013.
- *Singh, Jatinder; Pasquier, Thomas; Bacon, Jean; Ko, Hajoon; Eyers, David (2015). "Twenty Cloud Security Considerations for Supporting the Internet of Things". IEEE Internet of Things Journal: 1–1. doi:10.1109/JIOT.2015.2460333.*

External links

- *"A New Economic Vision for Addressing Climate Change (Internet of things - part II)"*. *Huffington Post. 2 June 2014.* (2014-06-02) and *"Monopoly Capitalism vs. Collaborative Commons (Internet of things - part I)"*. *Huffington Post. 7 April 2014.* (2014-04-07)
- Pew Internet canvas of experts, prognosticating on the nature, application, and impact of the Internet of Things in 2025
- *"The Creepy New Wave of the Internet (Internet of things)"*. (2014-11-02), *New York Review of Books*
- The IoT Council
- Internet of Things and People research center at Malmö University, Sweden
- Internet of Things could get big with battery free Devices powered by Wi-Fi signals. (PoWi-Fi).
- IoT and Last Mile Navigation