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National Telecommunications and Information Administration
U.S. Department of Commerce
1401 Constitution Avenue NW
Room 4725
Attn: IOT RFC 2016
Washington, DC 20230

Re. **Request for Comment (RFC) on the Benefits, Challenges, and Potential Roles for the Government in Fostering the Advancement of the Internet of Things - Docket Number: 160331306-6306-01**

Commenter: Alain Louchez

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Question numbers refer to order of questions in RFC.

Q2. Internet of Things Definition

The expression "Internet of Things" (IoT), for which there is no lack of definitional efforts [2], is a catchphrase somewhat similar to a "meme" [3] that has been adopted around the world to describe something inherently disruptive, i.e., the immersion of almost anything and everything (previously "out of scope") into the communications space thanks to the timely convergence of scientific, technological, and societal advances and trends.

"Machines, everyday objects and virtual elements (such as digital pictures) now have the possibility to be identified in the same way as individuals on the Internet of people. As a result, things can be integrated into a vast web of interrelations where they can communicate with each other or with people. Essentially, in the world of the Internet of Things, things are now on par with people" [4].

(*) The commenter is indebted to Professors Jason Borenstein and Haesun Park at Georgia Tech for their insightful review. Errors and omissions remain entirely his own.

Through embedded intelligence, the Internet of Things will transform the dimensions of the economy and society on a scale not experienced before. Nothing will be forever fixed. Inert will become active; delayed, instantaneous; offline, online; and static, dynamic. The Internet of Things will give rise to what could rightfully be called *a pulsating world*.

This "pulsation", emerging from things sending and receiving data, is central to the concept. Not only will the end points capture data about the physical world (through sensors) but they will also act upon it (through actuators/effectors).

Therefore, of all the many facets of the Internet of Things as it is understood today, the one single groundbreaking element is not the connectivity, albeit not an inconsequential issue, but, perhaps more accurately, the smartness of things. As argued by Sir Harold Evans: "to truly find meaning, we must look beyond the current novel phase for connected devices to the transformative experience of the near future, what pioneers call the Intelligence of Things. In this new age, smart connected devices don't just hand over data to their human users, who then must engage more software or analysis to make decisions. Intelligent things direct human action and interaction" [5].

Since the interconnection (within the Internet, but also to and from the Internet [6]) of smart devices carries with it its own momentous challenges, the all-inclusive term "Interconnection of Intelligent Things" may grasp well the actual geography of the so-called "Internet of Things" and its related challenges [7]. This is not an attempt to replace a catchy phrase by another one, but a suggestion to direct the attention to core constituents of the Internet of Things.

While sensors and actuators are currently, by and large, added onto the "thing" (car, house appliance, etc.), we can expect that in the future they will become integral to the material [8], and the power needed for the device interfacing with the physical world will increasingly be generated through energy harvesting, wireless power delivery, or advanced energy storage technologies [9]. Requirements for low-level processing and decreasing power has prompted researchers to explore the infinitesimal edge of the IoT and led Professor Ian Akyildiz to conclude: "the inevitable end point is the internet of *nano*things" [10].

IoT is a truly innovative concept not because it relates to technologies fostering automated and integrated production and consumption. This is an aspect of IoT that was already (and continues to be) explored in various research communities such as the ones focused on "flexible automation" and "intelligent manufacturing".

Rather, it is a fundamentally novel framework because in an IoT-based society, as a matter of course, "things" will be born digital with congenital addressable intelligence capabilities. The IoT-centered production process will then evolve from a strong emphasis on "smart manufacturing" (i.e., automated production) to a more balanced approach including the all-important "manufacturing smart" end purpose (i.e., inserting intelligence capabilities) [11]. Embedding computation within everyday objects and connecting them to cloud computing via wireless sensing transforms these objects into "smart goods":

“The emergence of smart goods represents a seismic shift in the way IT will be designed, produced, distributed and marketed. Computers are increasingly being sold as a subsystem within an existing product rather than as a stand-alone processor driving new requirements for form factors and component integration across sensing, computing and communication platforms. Further, mobile smart goods are driving new requirements for power management and energy harvesting, challenging conventional wisdom associated with semiconductor device design and integration. Like the IT revolution of the last 50 years, the IoT revolution of the next 50 years will be enabled in part by the development of manufacturing platforms capable of delivering higher performance at lower cost. In this way, these manufacturing platforms form part of the economic foundation necessary for advancing many significant IoT industries of the future including personalized medicine, precision agriculture, smart grid and the industrial internet among many others” [12].

A useful distinction between the two structuring components of the Internet of Things needs to be underlined between the “consumer Internet of Things” and the “industrial Internet of Things” [13]; while obviously related, they are intrinsically different. Even if associated technologies may be converging, dissimilarities will persist regarding target markets, marketing approaches and regulatory requirements.

Within these two subsets, there is a further distinction that remains to be made, i.e., communications that require little or no human interaction (most of the time, but not always, supporting industrial IoT solutions) and the rest where human intervention is a requisite (most of the time, but not always, supporting consumer IoT solutions). The former is known as Machine-to-Machine communications or M2M [14], while the latter is mostly concerned with human-centric applications where interaction means “interfaces which allow people to either monitor or configure IoT devices” [15].

Q1. Challenges and opportunities arising from IoT

Like many existing technologies, IoT is both a source of opportunity and a reason for concern.

Among many other possibilities, as it is now widely anticipated, IoT will contribute more and more to simplifying manufacturing and integrating logistics processes [16]; improving the quality of the food supply chain [17]; preventing, detecting and curing diseases [18]; managing personal fitness and health [19]; improving care for adults with special needs [20]; constructing smart homes and smart buildings [21]; measuring and ensuring the integrity of a wide variety of structures [22]; managing the environment [23]; optimizing transportation [24]; saving energy through smart grids [25]; transforming education [26]; creating smart cities [27]; and more generally, promoting global sustainable development [28].

The pervasive availability of embedded intelligence will allow the birth and growth of new ecosystems and services to maintain, upgrade and leverage the related capabilities.

This will not, however, happen overnight; the Internet of Things is a transformational journey, which has only just begun and is fraught with many puzzles to solve and challenges to overcome.

History does not repeat itself; at best, it stutters. But, be that as it may, its study can uncover useful beacons that may guide today's actions. The history of residential electricity is such a relevant guide for the IoT space.

When Thomas Edison exhibited his electric lighting in 1879, residential electrification, which Edison's invention ignited, did not spread immediately: "it is hard to imagine that new houses were generally not built to accept a wide range of electrical appliances until the 1930s; many houses were wired for lighting only. Even with the new homes constructed during the boom years of the 1920s, homes lacked adequate electrical systems capable of handling the variety of new electrical appliances available. To make homes safe for motorized appliances, the National Electrical Code, established in 1897, was revised in 1923 with requirements for new types of wiring and distribution circuits. In 1922, 80 percent of the dwellings in the country had either no electricity or substandard wiring. About two-thirds of the nation's dwellings were not technologically able to be modernized by the installation of basic wiring for lights and appliances in the 1920s, but by the end of the 1930s, two-thirds of homes had this capability and could be modernized with appliances" [29]. Yet, it is only after World War II that residential air conditioning, the highest share of U.S residential electricity consumption in 2014 ahead of lighting [30], really took off. The comparison with the IoT expansion is straightforward: 1) universal IoT capability (i.e. pervasive embedded intelligence as a matter of course) will take time, and 2) there is an antiphonal relationship between the availability of the energy source (electricity on the one hand, and smartness of the things on the other) and the applications, i.e., they feed off each other.

Policy will have to ease the transition from the current IoT landscape consisting of a patchwork of isolated silos, where systems and solutions are still dominated by proprietary protocols and the lack of a commonly-accepted and deployed architecture, to a more orderly and interconnected Internet of Things.

The challenges are both technological and non-technological.

Technological IoT Challenges

A report based on a March 2015 workshop supported by the National Science Foundation (NSF) and sponsored by the Semiconductor Industry Association (SIA) and Semiconductor Research Corporation (SRC), *Rebooting the IT Revolution: A Call to Action* [31], which was released on September 1, 2015, "identifies fundamental research needs for advancing the burgeoning Internet of Things and catalyzing cutting-edge innovations that will support future U.S. technology leadership and economic competitiveness" (NSF Website [32]). Among the critical research needs are energy-efficient sensing and computing; cyber-physical systems (CPS) optimal design; intelligent storage (memory technologies and management systems); real-time communication ecosystem; multi-level and scalable security; new paradigm for semiconductor manufacturing, insight computing and IoT test platform.

The latter point (test platform) deserves to be expanded as we might find reasons here to argue for a strong coordination among government and industry partners: "due to the bourgeoning complexity of the IoT, there is a significant requirement for infrastructure to test new technologies. Today there is no representative test platform or system demonstrator to stand in for the anticipated IoT of the future. Without such a test platform, solution verification and benchmarking is not possible. Definition and support of such a system demonstrator will be required for rapid and meaningful progress. Such a platform should be accessible to researchers from academia, industry, and government" [33].

In this regard, Professor Sanjay Sarma has also proposed [34] that in order to create a "secure order" in the IoT space, the U.S. government has a key role to play when it comes to testing: "the world needs a test bed in which all these best practices can be incubated and perfected. While the first two activities *[i.e., architecture and open standards]* are best handled by industry, the test bed is best created by the government — and this is a huge opportunity. The modern Internet would not have existed without the leadership of ARPA (now called DARPA) in incubating the network with a number of academic institutions, labs and companies. For example, what if the government created an Internet of Things test bed in national parks with different standards at work to manipulate sensors and actuators for maintenance? Perhaps companies could cooperate to control electronic signage, watering systems, cameras and so on — with an agency or an industrial committee chosen by the government monitoring emerging issues such as security, privacy, emerging practices and standards. Only the government has the breadth to make something like this happen." The comparison with the modern Internet offers a helpful point of departure to evaluate a possible leadership role in IoT testing for the government (supported by industry and academia).

IoT security is unequivocally and universally viewed as an overwhelming challenge on the road to pervasive IoT.

The U.S. President's National Security Telecommunications Advisory Committee (NSTAC) cannot be any clearer about the risks and the urgency to minimize them: "the NSTAC found that IoT adoption will increase in both speed and scope, and that it will impact virtually all sectors of our society. The Nation's challenge is ensuring that the IoT's adoption does not create undue risk. Additionally, the NSTAC determined that there is a small —and rapidly closing — window to ensure that IoT is adopted in a way that maximizes security and minimizes risk. If the country fails to do so, it will be coping with the consequences for generations /…/ it [NSTAC] also found that the IoT has several security factors that Government and industry should consider, including an exponential expansion in attack surfaces, a changing threat landscape, privacy concerns, an increased potential for kinetic-focused cyber attacks, and changes to the hardware lifecycle" [35]. Recent initiatives in the U.S. Senate, e.g., introduction in March 2016 of the bill short-titled the Developing Innovation and Growing the Internet of Things Act, or DIGIT for short (S. 2607) [36] or in the U.S. House of Representatives, e.g., creation in May 2016 of a bipartisan working group to examine the Internet of Things (IoT) [37] also put "privacy and security" at the top of their concerns.

Incidentally, the consequences on prospects for international order of "the rate of change of computing power and the expansion of information technology into every sphere of existence" were not lost on Dr. Henry Kissinger in in his latest book on *World Order*. When reflecting on the "looming" Internet of Things, he observed, implicitly highlighting the paramount criticality of IoT security, that "the revolution [in computing]'s effects extend to every level of human organization /…/ A solitary actor with enough computing power is able to access the cyber domain to disable and potentially destroy critical infrastructure from a position of near complete anonymity. Electric grids could be surged and power plants disabled through actions undertaken exclusively outside a nation's physical territory (or at least its territory as traditionally conceived) /…/ The road to a world order may be long and uncertain, but no meaningful progress can be made if one of the most pervasive elements of international life is excluded from serious dialogue" [38].

The security risk is better addressed not in isolation but in a broader context, which the Cyber-Physical Systems Public Working Group (CPS PWG), established at the National Institute of Standards and Technology (NIST) calls "trustworthiness management" with the top-level trustworthiness management properties being cybersecurity (or security); privacy; safety; reliability; and resilience [39].

Additional technological challenges are availability and use of frequencies (licensed vs. unlicensed spectrum) and reduction of the increasing IoT-generated radio-frequency noise [40], seamless integration of legacy systems to an IoT-centered environment [41], convergence of operational technology (OT) and informational technology (IT) [42], and data science as well as modelling and simulation adapted to the Internet of Things.

Non-Technological IoT Challenges

While the technological hurdles to the pervasive dissemination of IoT technologies are non-trivial, the non-technological challenges are as formidable and urgent.

First and foremost, the real or perceived lack of privacy, especially in consumer IoT, must be addressed in order to ensure that IoT adoption occurs in a responsible way; see for example concerns reposted on the ACLU website: "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" [43].

Note however that upholding privacy might be difficult as Dr. Vint Cerf wondered during the November 2013 FTC Workshop on "Internet of Things - Privacy and Security in a Connected World: "it will be increasingly difficult for us to achieve privacy. I want you to think for just a minute that privacy may actually be an anomaly" [44].

Related to the overall trustworthiness of IoT in general, and privacy in particular, is ethics, which in this context refers to the moral dimensions of the services provided, i.e., "we can, but should we?" Take for example the case of assistance services provided to aging populations through sensors and actuators. Individuals with a loss of cognitive abilities might agree to the collection and use of personal information that they might have been reluctant to share otherwise. There might be a need, for example, for ethical standards that would prohibit data misuse and uphold human dignity. Creating an environment where the public's well-being is protected is a challenging undertaking; yet the government might help serve as a catalytic agent.

As proposed by Professor Jeroen van den Hoven [45]: "A key element *[among others]* in achieving several of the aforementioned *[ethics-related]* objectives is the openness of IoT technology vendors about the functioning of their products." This "openness", or more precisely transparency, might be guided by regulation. Regarding the promotion of ethical behavior, we should not, of course, underestimate the complexity of the task at hand; philosophers have debated the nature of rightness and wrongness throughout the ages, and yet moral disputes continue, according to Professor Alex Rosenberg, "to seem intractable — more intractable than other disputes" [46].

The IoT value chain is long and complex. It relies on a myriad of disciplines, which need to be harnessed and combined to deliver new applications and solutions. The education of the future workforce as well as the training of the current one is critical to a successful deployment of the Internet of Things.

At the same time, IoT-tailored education, K-12 [47] and beyond, in a future hopefully not too distant should facilitate a better grasp of the related benefits and promote IoT-aware consumption by educated citizens. Incidentally, "the necessity to raise awareness and to educate citizens/users in their relationships with IoT – a recommendation highlighted and shared by most documents on the Internet of Things," [48] is widely seen as a way to tackle ethics in IoT.

Education and training should also address systemic issues such as the transformation of business models [49], the necessary convergence of information technology (IT) and operations technology (OT), as well as the complete overhaul of marketing and customer service. The relevance of a new legal framework for product liability must be explored [50].

All of the above technological (e.g., standards) and non-technological challenges (e.g., privacy and liability) will require international cooperation at the government level.

One of the most pressing challenges that has both technological and non-technological dimensions is the impact of the Internet of Things on the future of jobs.

The impact on jobs

In recent years, there has been a plethora of academic and industry projections regarding machines performing work-related tasks instead of humans, which have been reported in the press worldwide, see, for example, Dr. Frey and Professor Osborne's [51], and the World Economic Forum's [52].

Frey and Osborne's extensively quoted study, while not explicitly referring to the Internet of Things, use IoT cognates such as "sensing technology" and "monitoring applications" as examples of automating technologies. According to their estimate, "47 percent of total US employment is in the high risk category, meaning that associated occupations are potentially automatable over some unspecified number of years, perhaps a decade or two" [53]. The World Economic Forum, which, overlapping technologies notwithstanding, lists the Internet of Things as the fourth technological driver of change (behind mobile internet and cloud technology; advances in computing power and Big Data; and new energy supplies and technologies) and concludes that "current trends could lead to a net employment impact of more than 5.1 million jobs lost to disruptive labor market changes over the period 2015–2020, with a total loss of 7.1 million jobs — two thirds of which are concentrated in the Office and Administrative job family—and a total gain of 2 million jobs, in several smaller job families" [54].

This automation pessimism echoes John Maynard Keynes's views on "technological unemployment", which are getting renewed interest of late, defined as "unemployment due to our discovery of means of economizing the use of labour outrunning the pace at which we can find new uses for labour" [55].

Professor David Autor offers an insightful counterpoint in a recent essay on the future of workplace automation. While not directly mentioning the Internet of Things, he addresses the resurgence of anxiety as a result of the increasing substitution of technology for labor (which certainly is one of the consequences of the use of IoT technologies), and asserts that "journalists and even expert commentators tend to overstate the extent of machine substitution for human labor and ignore the strong complementarities between automation and labor that increase productivity, raise earnings, and augment demand for labor" [56].

Another parallel perspective is proposed by Professors Joel Mokyr, Chris Vickers and Nicolas L. Ziebarth in a recent essay that looks at the history of work in a world of continuing innovation:

"In the end, it is important to acknowledge the limits of our imaginations. Technophobic predictions about the future of the labor market sometimes suggest that computers and robots will have an absolute and comparative advantage over humans in all activities, which is nonsensical. The future will surely bring new products that are currently barely imagined, but will be viewed as necessities by the citizens of 2050 or 2080. These product innovations will combine with new occupations and services that are currently not even imagined. Discussions of how technology may affect labor demand are often focused on existing jobs, which can offer insights about which occupations may suffer the greatest dislocation, but offer much less insight about the emergence of as-yet-nonexistent occupations of the future. If someone as brilliant as David Ricardo could be so terribly wrong in how machinery would reduce the overall demand for labor, modern economists should be cautious in making pronouncements about the end of work" [57].

Following these comments and observations, which admittedly only consist of a sample of relevant views on the issue, we can propose three recommendations regarding related government policy:

1. *The consequences on employment should not be ignored*

As discussed above, the injection of IoT technologies in consumption and production cycles will have both positive and negative impacts on employment. New jobs are created, e.g., design and implementation of new services, while old jobs are being wiped out, e.g., monitoring and surveillance of physical assets. However, workers that are displaced are not necessarily able to fill the new positions created by IoT.

As a result, beyond the need to accurately assess the net-net impact at all levels, there are both geographic (new jobs may be somewhere else) and expertise (inadequacy of experience and training) challenges that must be addressed through policy at the federal and state levels.

When reporting that "new middle jobs" might in fact be growing rapidly, Professor Autor adds a useful nuance in this regard: "this prediction has one obvious catch: the ability of the US education and job training system (both public and private) to produce the kinds of workers who will thrive in these middle-skill jobs of the future can be called into question. In this and other ways, the issue is not that middle-class workers are doomed by automation and technology, but instead that human capital investment must be at the heart of any long-term strategy for producing skills that are complemented by rather than substituted for by technological change” [58].

2. Demographic trends do matter

Any study on the human impact of IoT must be made within a dynamic demographic context and integrate that the population will (dramatically) change. The United States, while not as rapidly as other countries, is an aging country - see below age pyramids from the U.S. Census Bureau [59].

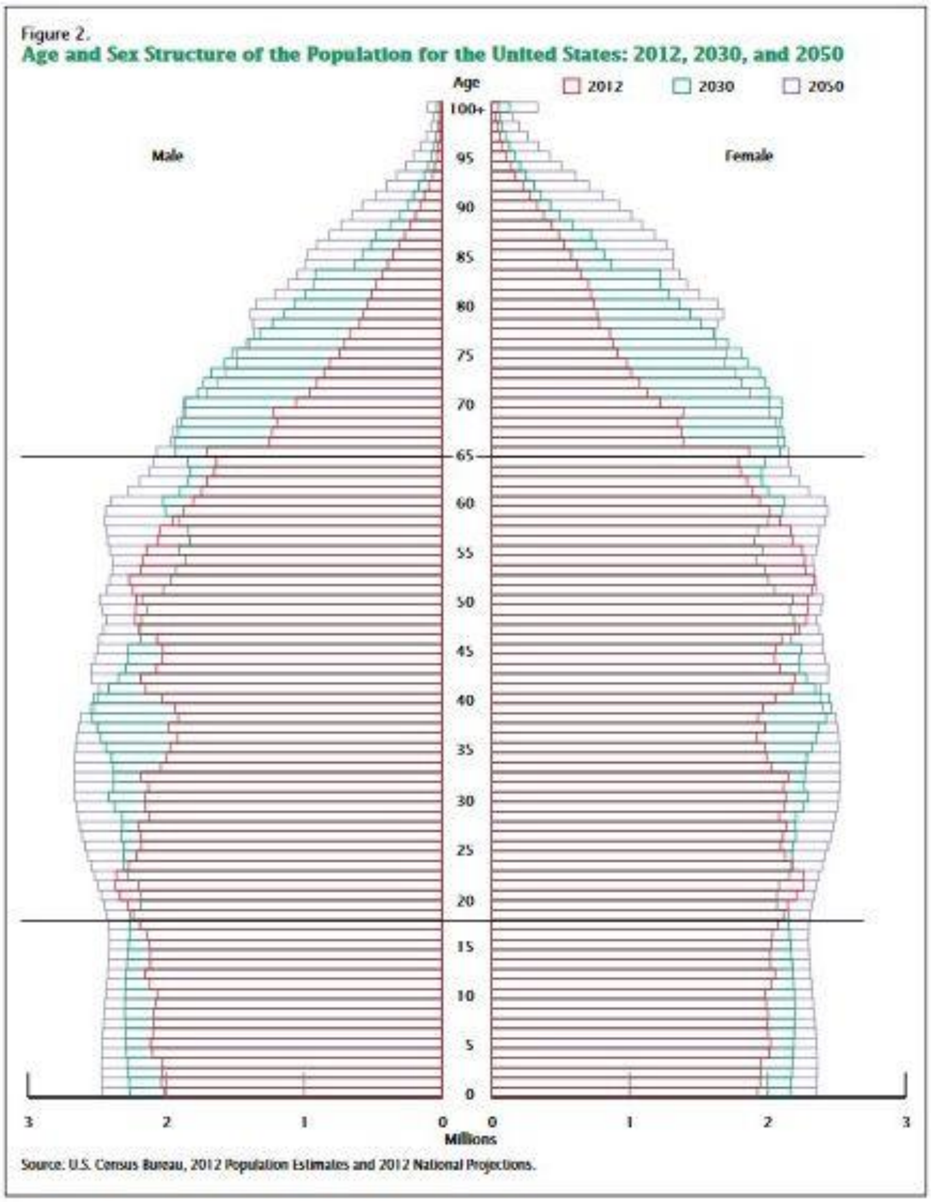


Figure 2.
Age and Sex Structure of the Population for the United States: 2012, 2030, and 2050
Source: U.S. Census Bureau, 2012 Population Estimates and 2012 National Projections.

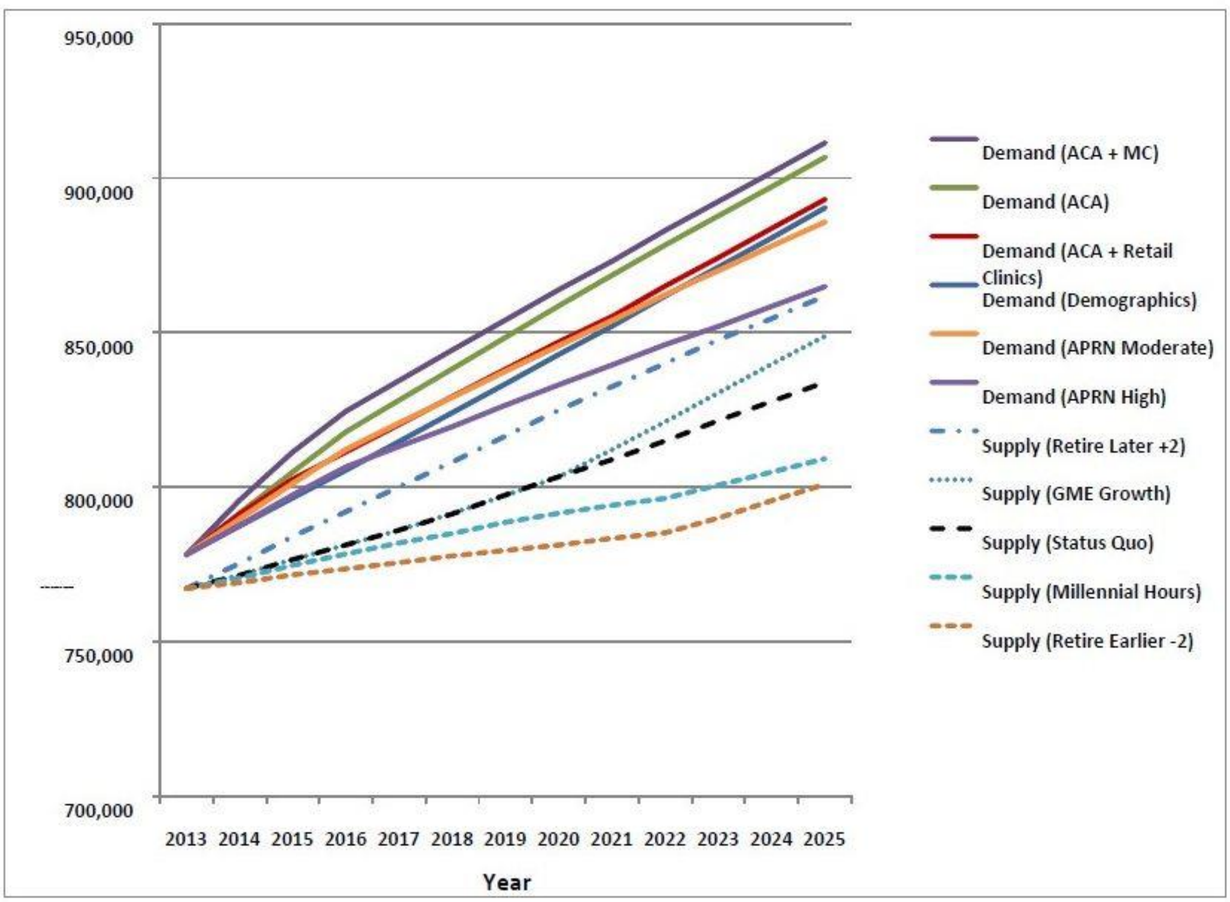
“The projected growth of the older population in the United States will present challenges to policy makers and programs, such as Social Security and Medicare. It will also affect families, businesses, and health care providers” [60].

Employers are confronted with a growing new set of challenges, i.e., replacing baby boomers who are retiring and accommodating older workers, e.g., in regard to physical job demands and skills needed. IoT technologies might be arriving at the right time. It is not a coincidence if throughout the world, there is a strong correlation between the use of industrial robots and shrinking population [61].

On the consumer side, the growingly large aging population might also be helped by the introduction of household robots and IoT services (e.g., medical alert services such as Personal Emergency Response Systems or PERS).

The projected imbalance between healthcare workers and the demand for healthcare services in the United States is widely documented, see for instance: “Demand for physicians continues to grow faster than supply, leading to a projected shortfall of between 46,100 and 90,400 physicians by 2025. Although physician supply is projected to increase modestly between 2013 and 2025, demand will grow more steeply (Exhibit ES-1). Across scenarios modeled, total physician demand is projected to grow by 86,700 to 133,200 (11-17%), with population growth and aging accounting for 112,100 (14%) in growth. By comparison, physician supply will likely increase by 66,700 (9%) if labor force participation patterns remain unchanged. with a range of 33,700 to 94,600 (4-12%), reflecting uncertainty regarding future retirement and hours-worked patterns” [62].

Exhibit ES-1: Projected Total Supply and Demand for Physicians, 2013-2025



ACA: Affordable Care Act; MC: Managed Care; APRN: Advanced Practice Nurses

As a result, telehealth and telemedicine, which are prototypical IoT services, might increasingly be welcome as they should help bridge the gap between supply and demand. However, note that in addition to public acceptance, "successful adoption of telehealth will require a number of regulatory and policy changes" [63].

3. It may be time to look also into training consumers and nurturing a new kind of consumption

In 1900, 41 percent of the U.S. workforce was employed in agriculture, and by 2000, the share had tumbled down to 1.9% [64] while in the meantime the total population grew from 76 million to over 281 million [65].

Likewise, huge gains of productivity and displacement of workers as a result of technological innovation and improvements could perhaps be observed over time for the IoT-fueled economy as a whole.

If this were to happen, and, in the process, render a large swath of the population idle, at least not directly engaged in production, giving rise to what Professor Yuval Noah Harari has called "the useless class" [64], the chief economic problem, as emphasized by Professor Autor [67], would be "one of distribution".

Distribution of collective wealth is a hot economic and political issue where taxation is brought sooner or later in the controversy and consensus is hard to find (see propositions concerning "basic income guarantee" and "revamping the Earned Income Tax Credit (EIC)" [68]).

In order to address this quandary, there might be a long-term solution, decidedly best handled at the government level (and therefore is a matter of public policy), i.e., fostering the consumption of services based on human and social interaction that are difficult to automate and, consequently, could use the potential surplus of workers.

Without neglecting science, technology, engineering and mathematics (STEM) education (which would be self-defeating), the time may have come to pay special attention to an educational curriculum that could in time lead to a consumption of services enhanced (but not substituted) by technology. Of course, Liberal Arts, defended vigorously by the likes of Mr. Fareed Zacharia [69] and Professor Danielle Allen [70] for example, come to mind as "shapers" of this new demand. Providing the foundations for the development of a modern-day "Artisan Economy", which could create "new jobs to replace those mass production and middle management jobs lost to outsourcing or new technology" as described by Professor Lawrence Katz [71] falls within the realm of public policy.

We are not only advocating a renewed commitment to Liberal Arts. The suggestion goes a bit farther. The idea is, from an early age, to instill the appreciation and taste for a wide range of interests (some of them might not be quite apparent yet), which will require interpersonal and social skills. We might find some inspiration in ancient Greece and more specifically "the open-minded cultural experimentation (free-enterprise) of Athenian liberalism, home to the arts and free expression, and to all kinds of intellectual exploration" (description is from Professor Mark Griffith [72]), which contrasted with the rigid, blindly conformist Spartan educational system or the later pragmatic and functional views of the ancient Roman education [73].

Conclusion on the impact on jobs

Central to public policy is the identification of challenges and problems that affect citizens as a whole tightly coupled with the formulation and implementation of effective responses by government bodies and their representatives.

However, as observed by Professor James Anderson, "the goals of a policy may be somewhat loosely stated and cloudy in content, thus providing general direction rather than precise targets for its implementation" [74].

The ideas submitted herein to alleviate the dislocation to employment caused by the Internet of Things undoubtedly belong to this category. They aim at offering a starting point for a policy debate, which should be rooted in education.

This debate has to focus not only on how to best meet through technical education the IoT-induced high demand for skilled workers [75] but also, peering into the long-term horizon, apprehend the whole educational system as a foundry of enlightened consumption; a daunting task, without a doubt, but worthy of exploration.

References

[1] CDAIT (pronounced "sedate")'s purpose is to expand and promote the Internet of Things (IoT)'s huge potential and transformational capabilities through research, education and industry outreach. *See* http://www.cdait.gatech.edu/.

[2] *See* in particular the work from the Institute of Electrical and Electronics Engineers (IEEE) on establishing a "baseline definition of IoT in the context of applications that range from small, localized systems constrained to a specific location, to a large global system that is geographically distributed and composed of complex sub-systems," *Towards a Definition of the Internet of Things (IoT)*, May 27, 2015, *available at* http://iot.ieee.org/images/files/pdf/IEEE_IoT_Towards_Definition_Internet_of_Things_Revision1_27MAY15.pdf. The expression "ubiquitous computing", which captures a domain that is arguably the intellectual crucible of the present-day "Internet of Things", is perhaps a better descriptor of what IoT is about. A brief paper by ubiquitous computing pioneers, published before the term "Internet of Things" came in existence, foreshadowed today's IoT, as it is clearly evidenced here: "The confluence of technological advances in wireless technology, mobile computing, novel displays, and sensors in addition to the decreasing cost of computing power provides the opportunity for utilizing computational capabilities in an increasing number of specialized, yet networked devices." *See* Roy Want, Mark Weiser and Elizabeth Mynatt, *Activating Everyday Objects*, 1998 DARPA/NIST Smart Spaces Workshop, (Gaithersburg, Maryland, 1998), 7-140 to 143 *available at* http://citeseerx.ist.psu.edu/viewdoc/download;jsessionid=1FC170B10A3AC8EE93C90FEA42708AE7?doi=10.1.1.43.130&rep=rep1&type=pdf

[3] *See* James Gleick, *What Defines a Meme?* SMITHONIAN MAGAZINE, May 2011, *available at* http://www.smithsonianmag.com/arts-culture/what-defines-a-meme-1904778/?all

[4] *See* Alain Louchez, *The Internet of things — Machines, businesses, people, everything*, ITU NEWS, No 3, 2013, *available at* https://itunews.itu.int/En/4291-The-Internet-of-things-Machines-businesses-people-everything-.note.aspx

[5] *See* Sir Harold Evans, *The Age of Intelligent Things*, INTELLIGENCE (quarterly print and digital magazine published by Flex – the expression "the Intelligence of Things" is trademarked by Flex), issue one, January 2015, *available at* https://www.theintelligenceofthings.com/article/the-age-of-intelligent-things/.

[6] *See* Cristina Alcaraz, Rodrigo Roman, Pablo Najera, and Javier Lopez, *Security of Industrial Sensor Network based Remote Substations in the context of the Internet of Things*, AD HOC NETWORKS, vol. 11, pp. 1091-1104, 2013, *available at* https://www.nics.uma.es/pub/papers/1752_0.pdf

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[8] *See* Eric Vogel and Alain Louchez, *The Invisible Edge of the Internet of Things*, AUTOMATION WORLD, November 18, 2014 *available at* http://www.automationworld.com/industrial-internet-things/invisible-edge-internet-things

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[67] *See* David Autor, *Why Are There Still So Many Jobs?* p. 28.

[68] *See* Darrell M. West, *What happens if robots take the jobs? The impact of emerging technologies on employment and public policy*, Center for Technology Innovation at Brookings, THE BROOKINGS INSTITUTION, pp. 12-1, *available at* http://www.brookings.edu/~/media/research/files/papers/2015/10/26-robots-emerging-technologies-public-policy-west/robotwork.pdf

[69] *See* Fareed Zacharia, *In Defense of a Liberal Education*, New York: Simon and Schuster, 2015.

[70] *See* Danielle Allen, *What is Education For?* BOSTON REVIEW, May 9, 2016, *available at* http://bostonreview.net/forum/what-education/clint-smith-clint-smith-responds-danielle-allen Professor Allen while acknowledging the "riches of liberal arts" in general, focuses on their role for political equality and distributive justice: "In the final analysis, the reliance on an exclusively vocational paradigm as the sole guide to education policy-making is a failure to meet the legal standard for securing a basic right. Precisely those parts of the K–12 curriculum most vulnerable during a recession—humanities, social studies, arts, and extracurricular activities such as debate and model UN—deserve rights-based legal protection. What is more, defending the right to civic education, and the kind of curriculum that delivers it, would benefit not only individual students but also society as a whole, advancing both political equality and distributive justice. This is an untapped source of advocacy around educational rights and on behalf of an egalitarian America."

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[73] *See* "Roman education was citizen training. In adapting the Greek system, the Romans exclude numerous elements in the process of adoption and do not hesitate to justify those choices. For example, Cicero argues that Rome's inferiority to Greece in literature, art and music should be attributed not to inferior talent but to Roman unwillingness to support such endeavors unduly. He provides as an example geometry, which, he maintains, was to be studied not as an abstract science but only for its utility in measurement and calculation. In fact, those skills attendant upon mathematical training for which the Romans are best remembered, such as engineering and architecture, were not formally taught in this period. Instead the knowledge necessary was passed on within the trades by direct example or through manuals. To study the arts of music, dance, and gymnastics was discouraged among the elites; in this case numerous sources from the period testify that such activities can lead only to moral corruption," Anthony Corbeill, *Education in the Roman Republic: Creating traditions,* in *Education in Greek and Roman antiquity.* Ed. Yun Lee Too, Leiden: Brill, 2001, pp. 266-267.

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