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Emerging synergies between Internet of Things and social technologies

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ABSTRACT
This essay discusses the phenomena of amalgamation of two prominent technologies: Internet of Things (IoT) and Social technologies. IoT devices are primarily used for connectivity between physical objects while Social technologies are responsible for collaboration and social interaction. The domain of Social Internet of Things (SIoTs) points toward social interactions of IoT devices. This phenomenon will further enhance the collaboration capabilities of IoTs to deliver huge amounts of human–computer interactions with very limited interventions from humans. Thus, high degrees of human–computer interfaces can be created among physical objects by enabling them with human-like capabilities and social interactions. In this context, we discuss relevant research developments, contextually analyze the drivers and challenges of SIoTs, and describe some interesting business use cases along with suitable recommendations going forward.

KEYWORDS
Social Internet of Things; technology convergence; cyber-physical-social systems

Introduction

In recent times, we have been witnessing rapid growth in the adoption of Internet of Things (IoT) and Social media technologies. Traditionally, IoT aims to foster ubiquitous connectivity amongst industrial equipment as well as everyday objects, thereby allowing businesses to explore new ways of creating and delivering value (Atzori, Iera, & Morabito, 2010). On the other hand, Social technologies help increase collaboration between people, permitting organizations to explore innovative ways to engage with their stakeholders. Though apparently from different domains, in this era of technology convergence, there appear to be growing synergies between IoT and Social technologies (Atzori, Iera, & Morabito, 2014; Atzori, Iera, Morabito, & Nitti, 2012).

The emanating overlap between IoT and Social technologies has been pointed out in recent literature, with researchers (e.g., Zhang, Jin, & El Baz, 2015) predicting such integration will help evolve innovative sensing and computing capabilities. The extension of social relationships to share contextual data that permit better coordination between humans and smart devices (Ortiz, Hussein, Park, Han, & Crespi, 2014) shapes the development of Social IoT, a form of cyber–physical social system (Ali, 2015; Ning et al., 2016). While some researchers are addressing the complexities (e.g., Asl, Iera, Atzori, & Morabito, 2013) to realize such technology integration, others are analyzing challenges likely to arise thereof (e.g., STOA, 2016). In the early phases of any promising initiative, sense-making efforts are required to delineate hype from reality. In this article, we trace the relevant historical background to identify drivers of growing synergies between IoT and Social technologies, analyze state-of-the-art developments, outline the potential, summarize challenges, and propose a way forward. We also highlight use cases that could be of direct relevance to industry.

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Historical background

The basic IoT concept envisages connectivity between everyday objects, leading to collective wisdom that enables paradigmatic upheaval of user experience. Prior to the evolution of IoT, multiple attempts were made over the years in different contexts to integrate systems or machines through the existing connectivity mechanisms that leveraged specific protocols. Given the proprietary nature of their inter-connections, such endeavors were plagued with drawbacks entailing inherent incompatibilities, significant configuration and maintenance efforts, escalating costs, and lack of scalability. To overcome such limitations, IoT now promulgates standards-based connectivity that envisages Intranet of Things, growing to Extranet of Things, IoT, and Internet of Everything (Uckelmann, Harrison, & Michahelles, 2011).

Kevin Ashton coined the term "Internet of Things" (Frost, 2015); and Cisco (2008–2009) declared that since IoT was born, the number of "things" have exceeded the number of people on Internet – reaching the Gartner's "Peak of Inflated Expectations" in 2014. Most industry analysts predict between 25 and 50 billion IoT devices by 2020. The strategic importance of IoT has hardly gone unnoticed by researchers, organizations, regulators, and governments. The affordances of new sensing, analyzing, and responding capabilities promised by IoT technologies have led to widespread anticipation of blurring traditional industry demarcations. Such considerations are based on the objectification of actors leveraging social and network connections, leading to intermediation through changing roles of value ecosystem players, thereby leading to the evolution of new business models. This obviously raises various possibilities across functional areas (Atzori et al., 2010), including operations, manufacturing, health–safety–environment, service provision, product support, sales, marketing, etc. from the point of view of providers, while allowing customers to optimize their utilization and expenses (e.g., Smart Metering) and leverage the technology for delivering next levels for human benefits (e.g., ambience assisted living).

From an architectural perspective, IoT is at the intersection of semantic-oriented, internet-oriented, and things-oriented visions (Atzori et al., 2010; Kortuem, Kawsar, Sundramoorthy, & Fitton, 2010), and comprises of four broad layers – devices, connectivity, data analysis, and applications, each with unique challenges and opportunities. Some researchers draw parallels from compounding acceleration curves in the adoption of Internet, starting with early usage limited to the scientific community, followed by select businesses and then widespread general-purpose usage as social collaboration capabilities are enhanced. In a similar vein, it is expected that the adoption of IoT in a true-sense will proliferate as it encompasses collaboration capabilities across devices and humans. Just like Web 1.0 with static content had limited appeal, till interactive content and social networking services blew the lid off the Internet; growing connection of smart devices, through social capabilities closely related to semantic web technologies, can help accelerate adoption and fulfillment of the potential of IoT.

State-of-the-art

Though what constitutes IoT seems to be generally known, wider consensus on what precisely defines IoT and demarcates it from technologies that provide similarly enhanced capabilities seems to be still evolutionary. The IoT device layer typically comprises of sensors, actuators or "things", which with enhanced analytical computing capabilities, "cyber-enable" the physical or "real-world" object they interact with. Traditionally, such elements leverage specialized local network capabilities to route their data through a gateway device, which in turn interfaces with other networks of elements or computing devices (Frost, 2015).

With increasing technology affordances, the abilities of elements that interface physical objects with the cyber-world seem to be growing. Some of these elements connect to specialized cloud networks or the internet. The more advanced ones, i.e., "smart objects", promise context-awareness (of activities, processes, and policies), support representations (based on functions, rules, and workflows), and can collaborate with other similar smart objects (Kortuem et al., 2010).

Recent research envisages provisioning enhanced capabilities in such smart objects, so that resulting "social objects" can initiate collaborations, evolve, and manage their relationships without requiring human interventions. Literature points to propositions that permit social objects to dynamically build their networks, while also leveraging and participating in human social networks (Atzori et al., 2012). For example, Kranz, Holleis, and Schmidt (2010) and Atzori et al. (2012) have investigated the integration-potential of IoT with humans and their social network building blocks (like identity, conversations, sharing, presence, relations, reputations, and groups). Kietzmann, Silvestre, McCarthy, and Pitt (2012) described it as the next level of ubiquitous computing, to bridge gaps between real and virtual worlds, through closed loop sensing–cognition–actuation.

Atzori et al. (2012, 2014) introduced the concept of "Social Internet of Things (SIoT)" considering three-staged maturity evolution: (i) "Res sapiens" objects, which push information about their state, to drive interoperability and communication with human social networks, e.g., Web of Things (WoT) based on Device Profile for Web Services (DPWS), Representational State Transfer (RESTful) application programming interfaces (APIs), Thing-REST, etc., (ii) "Res agens" objects, which communicate at the application layer with each other and humans displaying environmental awareness and pseudo-social behavior, e.g., Blog-jects, and (iii) "Res socialis" objects, which showcase social collaboration amongst themselves and self-build social networks. Such relationships among objects can be based on various criteria, e.g., based on same manufacturer – "Parental object relationship" (POR), owner – "Co-location object relationship" (C-LOR), proximity/relation – "Co-work object relationship" (C-WOR), "Ownership object relationship (OOR), "Social object relationship" (SOR), etc. (Atzori et al., 2012; Atzori et al., 2014).

Researchers, like Pticek, Podobnik, and Jezic (2016), considered such social networking of machines, as a separate but somewhat overlapping concept to IoT. In a parallel stream of thought, while IoT focuses on device communication without human involvement, the Human Agent Collectives (Jennings et al., 2014), a class of socio-technical systems, consider human involvement even in data acquisition and processing; with increased co-operation between humans and systems. Such environments are typically considered part of the emerging cyber–physical–social ecosystems.

Advances across research areas like semiconductors, nanotechnologies, mobile computing, artificial intelligence, analytics, etc. allow conceptualization of innovative value propositions, bridging hereto unrelated developments. This permits researchers to propose several variants, extensions, integrations, and adaptations of technologies, evangelizing benefits in appropriate contexts.

Potential

In this section, we discuss few interesting use cases across industries with respect to SIoT. Given significant mobile penetration, a smart IoT device (e.g., a smart phone) is a clear choice of use for the socially active generation. This in itself showcases the emerging proximity of IoT and Social technologies. Multimedia-enabled sensing capabilities coupled with social networks allow sharing of text, images, audios, and videos in near real time, as never before. A wide range of available connectivity options ensures that devices can discover and network with each other, albeit primarily driven at this stage through human intervention. We are witnessing the emergence of more automatic information sharing through a plethora of applications like those uploading health and fitness data to cloud networks, some leveraging such generic mobiles, while others rely on IoT wearables.

With social networking applications releasing versions for business use and the growing use of social networks by businesses for a wide spectrum of functions – it would not be out of order to expect the growing use of some forms of fusion between IoT and social technologies. An example is social recommenders, which leverage similarity or connectedness between friend profiles to make contextually relevant offers based on locational intelligence. Furthermore, the increased linkages of transactional capabilities with financial services options, and growing ecosystems of a variety of intermediaries, compound the possibilities.

Similarly, recommendations may emerge from in-built IoT intelligence in Consumer Packaged Goods for after-sales service, based on self-analysis of condition and statistical predictions, while also leveraging comparative information from similar devices. The literature abounds with Social IoT enabled home-automation use cases aimed to provide higher quality of living, some of which can be especially relevant for the elderly and people with different disabilities. In another context, such capabilities could be beneficial for industrial equipment as well, e.g., machines that self-learn leveraging or enhancing "others' experience" to optimize maintenance costs and drive higher productivity.

In public spaces like airports, malls, etc., we are witnessing growing interest in IoT devices, coupled with social analytics, to personalize offerings for patrons. For example, some airports seem keen to explore the potential of IoT and cognitive analytics technologies for weaving constellations of values to enhance customer experience during departures and arrivals, in conjunction with social networked mobile technologies apparently leveraged for both formal communication as well as promotional intent. Illustrative use cases include – IoT devices like cameras coupled with video analytics automatically take stock of the number of passengers in various sections of the airport, communicate with similar devices, trigger notifications to management and providers to augment facilities in required sections, as well as inform passengers, based on their needs or preferences, to reconsider usage of such sections; leading to optimal service delivery, e.g., security checks, baggage management, etc. Some researchers have proposed Social Internet of Vehicles. In a larger e-Governance/Smart Cities context, multiple social objects across the city could collaborate with each other to exchange and analyze information, ensuring appropriate proactive response to a wide range of scenarios ranging from traffic congestions, accidents, to law and order situations, as well as environmental and emergency response systems (Raj & Raman, 2017).

Thus, the synergies between social and IoT devices unleash significant potential starting with the use cases that could be of relevance to industry in the near future, to those promising esoteric benefits in the form of fairly advanced cyber–physical–social intelligence.

Challenges and way forward

While we have discussed several benefits of Social IoTs with respect to connectivity and collaboration, there exist multiple catalysts that can potentially accelerate the synthesis of social and IoT technologies. There are many issues to be addressed, to ensure seamless integration and collaboration. Probably, the foremost challenges are currently technical in nature, starting with the necessity for universal adoption of open standards to bear seamless interfaces. Multiple methods have been proposed to help social objects automatically identify potential partners, initiate and establish connectivity, and manage relationships. Though standards are emerging across the layers, currently integration still tends to rely on vendor or application specific methods. Part of the problem, is that the core technologies are nascent in nature, aspiring to deliver innovative capabilities that span diverse realms like power consumption, sensory capabilities, social, contextual, man-machine interfaces, etc.

Another crucial aspect that merits due consideration is the enormity of security concerns, especially with visions that encompass everything connected to everything. Closely associated privacy capabilities are needed to permit individuals or machines to exert the desired degree of control over data they choose to share.

The growing capabilities of Cyber–Physical Social Systems and Artificial Intelligence technologies (STOA, 2016) is another frontier, especially in the context of the expected nature of their potential relationships with and impact on humans. There appears to be some time before futuristic technology advances can provision such social machines with adequate capabilities that may rival human potential, in areas like automated transportation, production, medical care, agriculture, emergency response services, etc. The more imminent questions relate to whether unabated investments in such research are likely to continue, despite fluid economics with uncertainty in technology cycles similar to the case of Artificial Intelligence triggering a phenomenon called "AI Winter" (decrease in funding and interest in Artificial Intelligence for some time, followed by renewed interest). In the context of Social IoTs, understanding of business use cases, benefits and business models may require more detailed research to define the tangible outcomes of future investments.

Global implications

Given that both IoT and Social technologies aim to deliver global consequences, the growing synergies between these technologies can be expected to be part of the larger global information technology phenomena, being experienced at individual, organizational and societal levels. Across the world, firms are keenly pursuing digital business strategies heralding transformational initiatives that tend to enhance digital options for creating and capturing higher value with their ecosystem stakeholders. Similarly, governments across countries are exploring digitalization in line with their socio-economic strategies ranging from poverty elimination to enhanced citizen experiences. Social and IoT technology convergence can buttress such initiatives through promises of enhanced "globally seamless connectedness", enabling cascaded benefits in terms of enhanced efficiencies that facilitate contextual communication, collaboration and learning.

Such requirements pose several ramifications from the global information technology research perspective. These include evolution of the next generation storage, computing and communication structures that integrate traditional IT systems, cyber-enabled hitherto physical systems as well as humans. It may transform the existing ecosystem of prevalent technologies such as ERP, CRM, and supply chain management solutions. Entirely new definitions and frameworks for information security and privacy may also be required in the future.

There will be a need for the coalescence of diverse technology capabilities, to ensure required levels of autonomy and control. Besides enhancements in traditional IT architectural and design representation techniques to cover such diverse elements; the current development, data management and analytics, and testing methods will need to be augmented, especially in the context of the evolving criticality of applications that are likely to demand such integration.

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