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The Road Map Form Wireless Sensor Networks to Internet of Things to the Social Internet of Things

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Abstract: The Internet world comprises of billions of electronic gadgets connected along with people. This has changed the way we live. Life has become smarter through these objects. This paper explores Social Internet of Things a new paradigm that integrates Internet of Things (IoT) and Social Networking. IoT has emerged as a leading technology providing worldwide networked collaboration of things. Social networking is a revolution beyond IoT where tremendous collaborations exists between people and things to achieve desired targets. Social Internet of things combines these two giant technologies leading to interconnected objects not only smarter but also socially conscious. With no doubt the SIoT will, in the future make the world smartest and a better place to live. This paper presents the roadmap from Wireless Sensor Networks to Internet of Things to Social Internet of Things. We present the evolution of Internet of Things from Wireless Sensor Networks, the applications of Internet of Things and the need to integrate social networking concepts into Internet of Things. We also present the evolution of Social Internet of Things from IoT, the relationship between social objects, the recent research contributions in SIoT and the future challenges.

Key words: Wireless Sensor Networks (WSN) · Internet of Things (IoT) · Social Internet of Things (SioT) · Social Networks · Smart objects

INTRODUCTION

We are living in an era where our electronic gadgets do most of our work and simplify our lives. Our gadgets are becoming part of our fabric. Today's Internet not only supports human to human communication but also human to thing communication. Recently a new type of collaboration is seen in the Internet i.e., thing – thing communication. The use of sensors, actuators, RFIDs and other electrical electronic components have increased their intelligence through the notion of pervasive computing. Decade ago, Wireless Sensor networks was a promising technology which extracted specific content from things(objects) but was not able to collaborate among heterogeneous technologies. The Internet of Things, the many vision one paradigm technology proved to be promising to achieve collaboration between large scale heterogeneous intranets. [29] defines the Internet of Things as anytime, anywhere, anything access. Simultaneous to IoT evolved the notion of Social Networking, the technology that upraised the world through voluminous collaborations and interconnections. Out of the many visions of IoT, one was to socialize the objects. Then came the notion of Social Internet of Things (SIoT), a collection of socially aware intelligent objects interconnected with each other ready to render services. According to [11], the Social Internet of Things is defined as Internet of Things where objects are capable of establishing social relationship with other objects autonomously via owners. As a result social network of objects are created. The main objective of Social Internet of Things is to allow objects to create their own social networks, protect privacy of people by imposing their own rules and ease the role of humans by accessingonly the result of the object interaction. Novel applications and networking solutions are possible through Social Internet of Things. The paper uses the following acronyms here forth. Wireless Sensor Networks (WSN), Internet of Things (IoT), Social Internet of Things (SIoT). Figure 1 shows the simple layout of WSN, IoT and SioT.

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Fig. 1: Wireless Sensor Networks, Internet of Things and Social Internet of Things

The Evolutionary Perspective: From WSN to IoT: WSN was a pioneer technology during the last century. WSNs resource constrained nature motivated many researchers and resulted in newer architectures, protocols, design solutions and models. The authors in [30] presents the research challenges, deployment pattern, applications, protocols and architecture of WSN. The main components of a WSN include a base station, central node and gateway or sink which is responsible to gather information from all nodes. They are deployed in tens to few thousands in number. These nodes drain out energy very quickly and are less suited for heterogeneous connectivity. Few applications of WSN include Environmental monitoring - Flood detection, Precision agriculture, Forest fire detection and tracking, Military target tracking, General surveillance, Health monitoring - Patient tracking, Drug administration, Construction and automation, Security, Vehicular applications, Warehouse management. WSN are also an important part of Body Area Networks, VANETS, Domotics and Smart cities. A major pitfall that WSN community faces is the availability of data ie, how and who should access and control the data.The deployment of WSN was proprietary and the data is private. No standard communication approaches were practised throughout. All these led to the IoT revolution. The Internet of Things is perceived as a worldwide network of interconnected objects uniquely addressable based on standard communication protocols.

The Internet of Things Evolution: The concept of IoT became very popular in the late 1990s through the Auto ID centre at MIT.IoT is not the result of a single technology instead several complementary technologies were used to provide capabilities to bridge the gap between the physical and the virtual world. These capabilities include addressability, communication, cooperation, identification, sensing, actuation, information processing, localization and user interfaces. To keep it simple we define IoT formally as a network of networks which enables to identify digital entities and physical objects. The key enabling technologies that led to successful IoT are RFID, Sensors, Smart technologies and Nano Technologies.IoT leads to a new space for innovative services i.e., from anytime, anyplace connectivity for any one, we will now have connectivity for anything. Key reasons for the actual want of IoT are its event driven nature, ambient technologies, flexible structures, complex access technologies and semantic sharing. With no doubt that life will change better in the IoT era. Application of IoT includes Smart city and smart buildings, Environmental monitoring, Transport, eHealth, Security, Smart Grids, etc.The figure3 shows the layered architecture of IoT. The perception layer is also called the sensing layer which is responsible for information gathering and generation, the network layer is responsible for information transmission, the middle ware layer is the management layer which is responsible for information processing and providing interfaces to things, the application layer is responsible for information application. Business layers are used by stakeholders. Table 1 shows the enabling technologies used at each layer by the IoT architectural model.

The Need to Integrate Social Networking Principles into IoT: Social networking have changed the way people work and live. Collaboration among people, objects and other physical entities have improved tremendously with the Social network revolution. People share, publish ideas and services with each other. A community of interest is thus formed as a result of social networking. A Community of Interest (COI) refers to collection of entities (humans / things) engaged in communication to achieve a desired goal. The COI thus formed may be good or bad. Social relationship and contextual data shared within an online community render cooperation between humans, objects for mutual benefits. It is assumed that likeminded people often are cooperative.

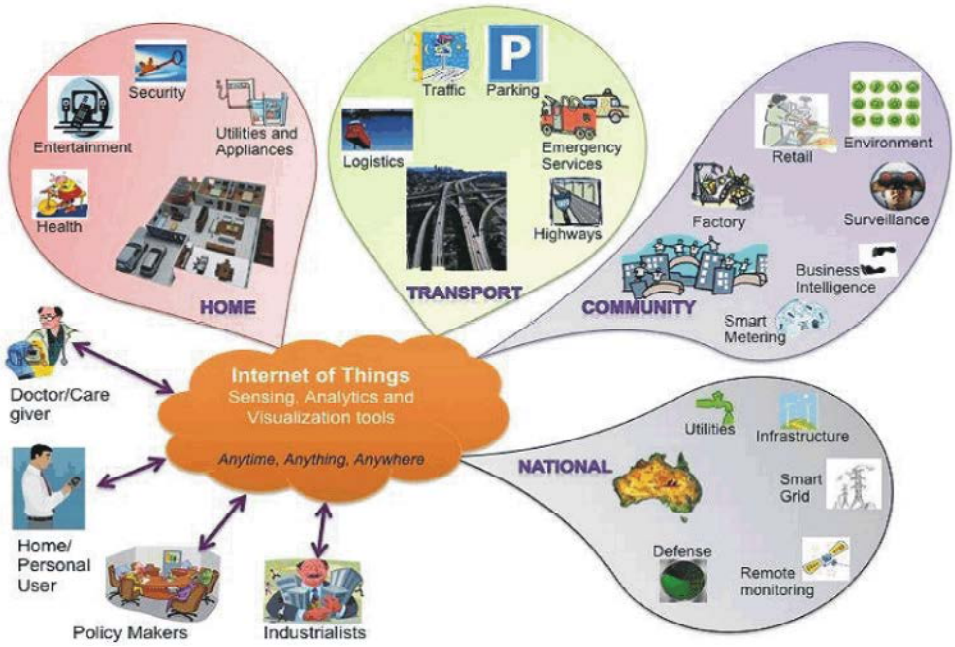

Fig. 2: Applications of IoT

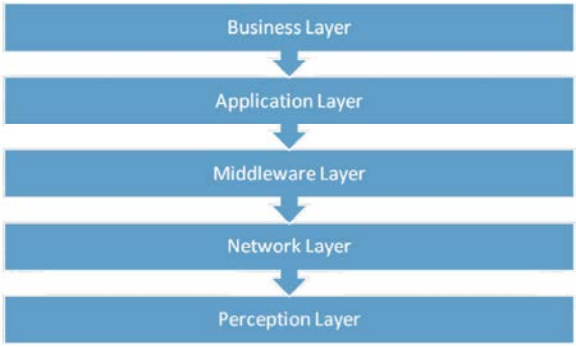

Fig. 3: The Layers of IoT

Table 1: Technologies used by the IoT layers

What IoT layers do	Applies to
Integrated Application	Smart logistics, Smart grids, green building, smart transport, environmental monitoring
Information Processing	Data centre, search engine, smart devices, data mining
Network Construction	WPAN, WLAN, WWAN, WMAN, Internet
Sensing and Identification	GPS, Smart device, RFID, Sensors, Actuators.

From the reality perspective, for humans to establish relationships with each other, things should be socialized. Not only physical connections between humans and things are needed, a logical connection is very important for defining social communities involving humans and things. The logical connection can be established through social networks where people exhibit different feature sets including profiling system, recommendations and set of mash up services. A new socially driven community can be inherited from traditional social networks which is called the Social Internet of Things (SIoT). This new ecosystem resulted out by clustering social networks and IoT.

The Evolution of SIoT from IoT: Future pervasive world will want smart services and applications to tackle many sophisticated real world challenges. IoT still talks only about communications to the physical world through sensing and actuating. Whereas SIoT explains why and how to use services and applications effectively. The three main causes that led to the SIoT revolution are:

- Improved pervasiveness
- Increased social interactions
- Increased smart objects

Smart and Social Objects: SIoT is still young and is in early stage of investigation. Today objects are not only smarter but also socially conscious. [1] derives and analyses the transformation of smart objects into socially conscious smart objects. Smart objects are considered as the building blocks of Internet of Things [2] and are classified according to their awareness, representation and interaction. Three main categories were identified:

- Activity aware smart objects: maintain logs of information about work activities of its own and others
- Policy aware smart objects: understand events and activities with respect to predefined policies.
- Process aware smart objects: understand inbuilt processes and provides context aware guidelines.

Recent smart objects also exhibit pseudo social behaviour. The distinction between a "Thing" that is simply connected to an internet and a "Thing" that plays an active role in the network has to be clearly defined. An acting object is an object that is able to translate the awareness of casual relationships into actions. An active object has the ability to stimulate action and participate in social web, having a self-confident role within the social web. [3-6] lists smart objects namely Smart-Its, Blog-jects, Embodied Micro blogging, spontaneous and their activities. Many unanswered questions exist like: what really objects talk about? Are these conversations useful? Do they promote developments for human society? Should objects need a separate social network that of humans? Recent studies [7-10] discuss how smart objects are given social awareness and address many issues in social network of objects.

The Social Internet of Things: SIoT is defined as a "social network of intelligence objects" based on the notion of social relationships among objects [11]. The idea of integrating social networking into IoT is to allow objects to autonomously establish social relationships. The distributed objects can be used for selection, discovery and composition of services. Within the resulting objects social network, complex services and applications can be implemented by navigating friend of social objects rather than relying on internet discover tools. A SioT community can be build based on the type of social object interactions. Objects establish social relationships with each other autonomously [12]. [13, 14] have studied SIoT environment and has proved that the network is navigable. [15] has studied social virtual objects and their properties in the cloud.

Social Object Relationships: Five kinds of object relationships are identified [11]

- Parental object relationship
- Co-location object relationship
- Co work object relationship
- Social object relationship
- Owner object relationship

Parental object relationships are defined among similar objects build by the same manufacturer. Co-location object relationship is determined whenever objects reside constantly at same place. Co work object relationship is defined as the relationship between objects when they come into contact at their owner's work place. Social object relationship is established when objects come into contact periodically or continuously for purely reasons related to relations among owners. Ownership object relationship is established when objects owned by the same user come into contact.

Social Relations: A widely accepted classification of social relations is proposed by [16] through his relation model theory. Four basic relational frames or structures are sources for generating social actions. These are derived from four elementary models of [16]. The relational frames are;

- Community sharing
- Equality matching
- Authority ranking
- Market pricing

Communal sharing relationships can be associated with behaviours of objects which are not relevant individually but have a collective relevance. Communal sharing objects are associated to whole group. Equality matching relationship may represent all forms of information exchange between objects that operate as equals and that request and provide information amongst them in view of providing IoT services to users while maintaining individuality. These objects associate to a service that it advertises. Authority ranking relationship is asymmetrical based on precedence, hierarchy, status, command and difference. They are established between objects of different kinds of complexity and hierarchal

levels. The service advertised is associated to the whole group of objects or to the object of highest rank. Market pricing relationships are based on proportionality with interactions organized with reference to a common scale of ratio values. These can be associated with interactions that objects have whenever they find themselves having to work together in the view of achieving mutual benefit. Cooperation among smart objects is crucial in many SIoT applications.

Building the SioT: The SIoT community is not easy and simple to build. The objects need to possess some key functionality to become a part of the SIoT community. The functionalities include Socialized devices, Everything as a service, intelligence of objects and social role. Socialized devices are possible since social networking is integrated with IoT, objects are smarter and socially conscious and can play a social role via owners. Intelligence is required to monitor the relationship between objects, Everything as a service is made possible by turning Social networks and smart objects into services and enable them t o be easily discovered. Figure 5 shows the layered architecture of SIoT. The IoT layers were modified to suit SIoT components. Table 2 lists the research contributions to the SIoT community. Few contributions to security and privacy, Energy management were not really meant for SIoT but can be accommodated in the umbrella of SIoT. These contributions include service discovery and mash up,

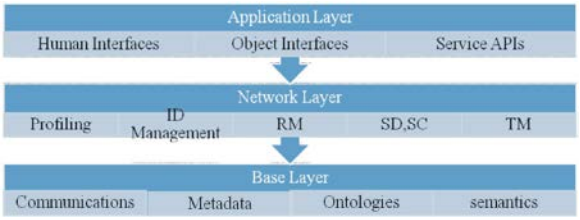

Fig. 5: The Layers of SIoT

location awareness of objects, social intelligence of objects, social network analysis, security and privacy, trust management, energy management, Context awareness. Table 3 lists some of the prototype examples in the field of SIoT. Many industries have shifted to this cutting edge technology. Few have started to develop their products and services that wold in the near future drive the innovation wave of SIoT. Low power sensors to complex embedded system are used to gather data and collaborate these datum through the Social Network via Internet. People and things are able to respond to the communicated problem, deliver solutions and service.

The base layer is responsible for storage and management of data, ontologies engine, semantics engine and communications. The Network layer hosts tools for profiling, ID management, Resource Management (RM), Service Discovery (SD), Service Composition (SC) and Trust Management (TM). The application layer provides the required service APIs, human and object interfaces.

Table 2: Research Contribution to SioT

Contributions	Service discovery	Location Awareness	Social Intelligence	Social Network Analysis	Trust Management	Security and Privacy	Energy management.	Context awareness
[1, 11, 13, 14]	*		*					
[11, 13]			*					
[17, 18]				*				
[19, 20, 21]		*						
[22, 23]					*			
[24, 25}						*		
[26]							*	
[27, 28]								*

Table 3: SIoT prototype domains

Research Contributions	Gastronomy	Smart Home	Smart City	Smart Shopping	Smart Classroom	Smart Robots
[31]	*					
[32]				*		
[33]			*			
[34]		*				
[1]					*	
[35]						*

Table 4: Future research perspectives

Future Research	Mechanisms to be developed	Resulting SioT
Completely Self-Driven SIoT	Self-management, self-healing, self-operations, self-organization, self-protection capabilities of objects in SIoT	Autonomous SIoT
Completely automatic network management	Automatic data analysis	Efficient service discovery and service provisioning
Heterogeneity	Different technologies like smartphones, tablets, RFIDs, sensors, need to be interoperable.	Improved pervasiveness
Business models	Develop non conflicting business models, recognize customer experience	Successful deployment
Stakeholders	Increase customer participation	Successful deployment
Interfaces	Human centric user friendly interfaces	Increased connectivity
Fault tolerance	Identify trusty platforms	Increased reliability

Table 4 lists the unexplored research perspectives that have to be dealt in the future. As a future work and an extension study researchers might explore the following challenges listed in Table 4.

CONCLUSION

Social Internet of Things is a novel paradigm that integrates two giant technologies namely IoT and Social Networking. This paper provides a roadmap from WSN to IoT to SIoT. The paper begins by highlighting the WSN technology and its drawbacks. We present themotive for the jump and craze towards Internet of Things. The importance of IoT, its architecture and applications are discussed. The reason to integrate social networking principles into IoT were clearly acknowledged. The paper discusses the need and importance of SIoT, the nature of smart social objects and their relationships. Technical research contributions in the field of SIoT were surveyed and the future research directions were identified. With no doubt, SIoT will be the pioneer technology in the future.

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