A review of human-to-machine and machine-to-machine approaches for internet of things

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***Abstract*—The complicated circumstance of the Internet of Things (IoT) context rises the difficulty of the interactions between IoT services and human or among IoT devices. This paper focuses on the approaches related to Web technology that intends to improve interaction efficiency of IoT. Those approaches provide outstanding ability in locating, exploring and service integrity for IoT through Web technology services. This research paper will review several research studies and compare these approaches in form of a descriptive and tabular analysis, and compared them with several parameter like innovation, costs reduction, Flexibility etc. This study has clearly determined that a well-designed IoT architecture should include precise data exchange, comprehensive and optimized structure as well as advanced algorithms.**

***Index Terms*—Internet of Things (IoT), Web service, Application, Human-To-Machine, Machine-To-Machine, Web-Socket**

I. Introduction

This research aims to review those approaches that intend to improve interactions in web-based search, discovery and service composition in IoT environment. Internet of Thing (IoT) intends to form our environment to be smarter by embedding abilities of sense, execution and communication to the ordinary items [1]. Similarly, from the benefit of those extended abilities, IOT can be more centralized control and increased responsiveness. In addition, the interactions between the IoT could provide infinite imagine to the potential of their capacities. Especially, the development of IoT has significantly increased in recent years, which is supplied by Internet as the globally intelligent fundamental. Great benefit makes IoT plays an essential character in the life of people from industry environment to smart home [2] Although IoT is evolved from many mature technologies, efficient management to those numerous amounts of IoT devices and their data is apparently a major challenge. In nowadays, IoT devices and services mostly runs on Internet, a wide area network based on Web. However, most web protocols are designed for communications between human and services on the network, but IoT focuses more on interactions between machine to machine, machine to service and machine to human instead of only fulfil human and services. Therefore, it is necessary that Web service on IoT requires a variety of improvement and development for new demands and challenges. IoT as a distributed architecture provides the advanced interactive operations for human-to-machine (H2M) and machine-to-machine (M2M). In addition, without the comprehensive standards for communication and interacting, an enormous amount of IoT devices will face the situation with lack of observation, less supervision and low facilitation [3]. Moreover, the web protocols that run on the application level, that includes MQTT, AMQP, CoAP, Restful Services, Web-Socket, XMPP, DDS, SMQTT. Study mentions that while IoT is established on several existing technologies, there are still many challenges from security, reliability, limited resources and network capability [4]. In [13], authors proposed a mechanism that can discover the physical topology with low-cost and accuracy using Vehicles joint UAVs Topology Discovery (VUTD). Their results show that the proposed scheme (which is called VUTD scheme) provides better performance than both the Vehicles Topology Discovery (VTD) scheme (in terms of localization ratio, mean localization error) and UAVs Topology Discovery (UTD) scheme (in terms of the cost of location discovery

Consequently, these approaches that discussed in this report will be grouped into two categories: Human-to-Machine (H2M) and Machine-to-Machine (M2M)

II. Literature Review

Most articles reviewed in relation to IoT all show that the mechanisms that can improve efficiency of interactions in IoT:

LISA [T1] - A lightweight context-aware IoT service architecture called LISA. They state that this system can supply push-based web services in IoT context in a cost-effective form by diminishing uncritical data for target users. In their article, the authors additionally described that they deployed the LISA approach that positions into a tourist guide system in IoT environment as evaluation. The findings of their results show that LISA provides quite high accuracy in filtering information that forward to users, which can considerably decrease the overwhelming information that bombards to end nodes [5].

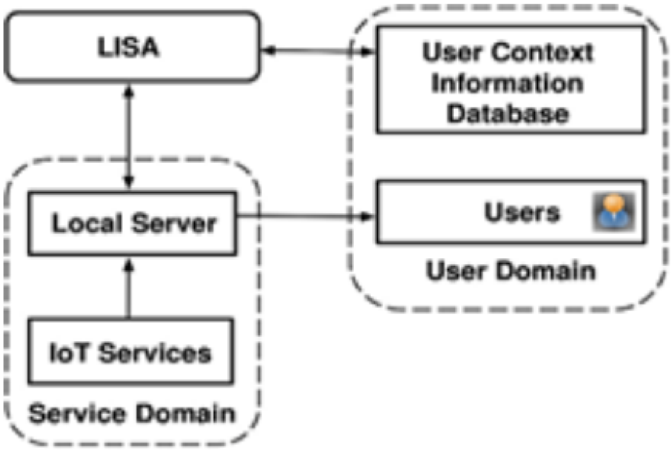

Fig. 1. Role of LISA in IoT environment.

An approach as an On-ramp for IoT [T2] – A solution that can offer users a gateway of interaction with IoT by combining IoT and Web technology. This method is through an embed web portal with RF protocol, that advances approach would allow people to operate IoT devices in short distance nevertheless not requiring any installed application. Moreover, a smartphone can receive the URLs from the nearby IoT devices. After produced that information, the smartphone can create a page-ranked list for those IoT devices [6].

E2C2 Mechanism [T3] - This study developed a mechanism called E2C2 that can reduce large amounts of data exchange throughout providing the minimized number and of combined IoT services. This algorithm intends to decrease the energy produced while IoT devices exchange data by integrating web services as the service pool [2].

Accessors Mode [T4] - They described a new scheme called accessors, which is like web pages or services on Internet, offering the interactive ability to the things in IoT environment. This architecture includes the following features:

- The ports of input and output for interval events stream.
- As a web proxy service for local or remote service
- The input ports and parameters are used to submit data, output ports are used to draw page as well.
- Supports script language as if HTML and JavaScript in Web.

Decentralized Composition of Service Mashups [T5] – This proposed a new approach that can provide both of flexibility and responsiveness to limited-energy IoT devices, which employs a middle ground mechanism on WoT (Web of Things) that introduces agents with ability of self-discovery and interactivity [7].

WoT Store [T6] – This study emphasized that the Web of Things (WoT) infrastructure could be a future method that can manage issues of interaction among the diverse IoT nodes and system through semantic procedures and interoperability schemas. This protocol is designed to supply the interactions amidst IoT devices that beyond many different network protocols, by without regard to the detail of those protocols due to addresses the description of the interfaces of the IoT devices [8].

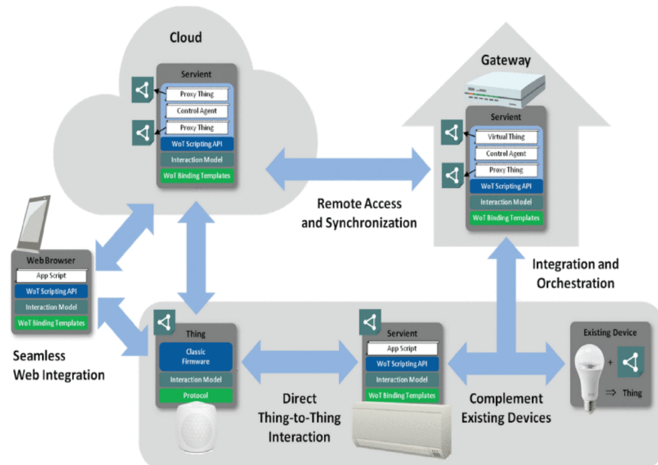

Fig. 2. Architecture of W3C WoT .

Semantic-based IoT service discovery mechanism [T7] – This study intend to propose an approach that can improve the efficiency of locating IoT services in IoT. In this mechanism, the whole IoT context is represented as an architecture that many intelligent spaces are organized into the tree structure. In each space, semantic web service as a gateway that embeds a routing table is responsible for management of all requests from IoT service as well as their information [9].

Resource Discovery in IoT [T8] – They Developed a new framework shown in figure-3 based on a searching system, which provides the capacity of discovering resources efficiently and automatically. This framework includes a search engine, which offers the ability to finding an IoT object in local or remote range through RESTful web service [10]

An adaptive meta-heuristic search [T9] – This study claims a mechanism that can organize those IoT sensors with similar context information in the form of Sensor Semantic Overlay Networks (SSONs) and group them into a cluster. This system is inspired by ant clustering algorithm and designed to perform search in the large amount number of shared data that dynamically generated by millions of IoT devices all the time [11].

An efficient indexing and query mechanism [T10] – A new method that can support indexing for discovery of the IoT-WSs Services (IoTs based Web Services), which can overcome the spatial and temporal limit of IoT-WSs Services. In particular, this approach group IoT-WSs into functionality cluster, spatial index and temporal index based on their purposes, specific durations and limited locations. In addition, an efficient query method aims to reduce the costs of computation is embedded in this mechanism [12].

TABLE I
ANALYSIS OF DIFFERENT IOT TECHNIQUES

Techniques	Context	Purpose	Description	Findings
T1	H2M	Composition	Decreasing uncritical data that pushing to users in a push-based web service by understanding and filtering the data	1. Reducing overwhelming information to target point. 2. Accuracy ratio is 0.3, recalling ratio is 0.8 3. Optimization with particular configuration for users
T2	H2M	Search	Deploying a web portal into IoT device, which can access through RF protocol.	1. Allowing people to use IoT devices without App on smartphone 2. A smartphone can receive URL from IoT devices nearby. 3. Can be as the reflection of the physical world.
T3	M2M	Composition	Integrating web services as the service pool, in order to manage IoT devices in efficiency.	1. Decreasing a numerous of data exchange. 2. Reducing produced energy from interactions of IoT devices. 3. In evaluation, E2C2 has the shortest process time compared to the other algorithms.
T4	M2M	Composition	Similar to web service in traditional, which provide capacity of interaction to IoT.	1. Designing for communications among devices. 2. Compatible to work model of web page with input/output port and parameter. 3. Supports script languages.
T5	M2M	Composition	A decentralized mashup that can benefit both of flexibility and responsiveness to limited-energy IoT devices.	1. An open-source platform that can supply the applications. 2. Agents with self-management run on WoT (Web of Things). 3. Costs of the mashup only increases with the number of agents in linear.
T6	M2M	Discovery	Web of Things (WoT) infrastructure controls communications among IoT nodes and system through semantic procedures and interoperability schemas.	1. Above on many Internet protocols. 2. Regardless of the details of the protocols. 3. WoT Store provides authority to the distribution of the applications.
T7	M2M	Discovery	Many spaces comprise of IoT context by tree structure, each the space with a gateway.	1. Semantic web service as the gateway that embeds a routing table. 2. A flexible algorithm can reduce costs of search. 3. The update rate of the father node is less than 1% which means high level gateway is less affected by the changes that happened in low level nodes..
T8	M2M	Search	A new search system with high efficiency and automatic discovery of resource.	1. Includes a search engine, which locate IoT objects in local or remote through RESTful web service. 2. Three layers: Proxy Layer, Discover Layer and Service enablement layer. 3. A registration central: for register or unregister of IoT devices or services..
T9	M2M	Search	Organization of IoT sensors with similar context information as a Sensor Semantic Overlay Networks (SSONs).	1. Search in the numerous numbers of data that produced by IoT devices. 2. Classification of IoT sensors to SSONs.. 3. Group all IoT sensors by AntClust algorithm. 4. Decreases costs of locating a sensor.
T10	M2M	Search	A method for Indexing for discovery of IoT-WSs Services..	1. Overcome the spatial and temporal limit of IoT-WSs Services.. 2. Grouping IoT-WSs into functionality cluster, spatial index and temporal index. 3. Only impacted by the number of IoT-WSs.

III. RESEARCH DATA COLLECTION AND METHODOLOGY

A. Techniques Summary

In this section study will compare the above approaches in Table1 in the interactivity methods of Human-to-Machines (H2M) or Machines-to-Machines (M2M). only two techniques are providing the context of H2M while rest of them are related to M2M. so there is a lack of technique for H2M techniques. In this context the techniques based on web services are reducing the overwhelming information and smartphone can receive webservices from IoT devices.

Reducing energy consumption and data exchange are main issues in M2M context. Web of things infrastructure controls communications among IoT nodes used the RESTful web services. The use of sensor semantic overlay networks decreases the cost of locating the sensor. Moreover, our findings demonstrate the factors that can improve the interactions in IoT in each method.

B. Comparative Metrics of techniques in IoT

To measure the effectiveness of these approaches, the following parameters are compared in the metrics: According to the mentioned metrics, the existing techniques have been analyzed in TABLE 2

- ***Innovation*** determines existing creative or enhanced aspects in the approach.
- ***Costs Reduction*** the approach decreases the costs of interaction on IoT context.
- ***Scalability*** is any combination of additional or indirect computation time, communication, or other resources required to perform a particular task.
- ***Ease of Use*** the technology is developed or operated in the approach that can be managed easily for users.
- ***Security*** the technology includes security measurements to reduce the risks from internal or external threat.

TABLE II
METRICS CONSIDERED BY EXISTING TECHNIQUES IN IOT

Techniques	Innovation	Costs Reduction	Scalability	Ease of Use	Security	EF
T1	✓	✓	✓	×	×	×
T2	✓	✓	✓	✓	×	×
T3	✓	✓	✓	×	×	×
T4	✓	✓	✓	✓	✓	×
T5	✓	✓	✓	✓	✓	×
T6	✓	✓	✓	✓	✓	×
T7	✓	✓	✓	×	×	×
T8	✓	✓	✓	✓	✓	×
T9	✓	✓	✓	×	×	×
T10	✓	✓	✓	✓	×	×

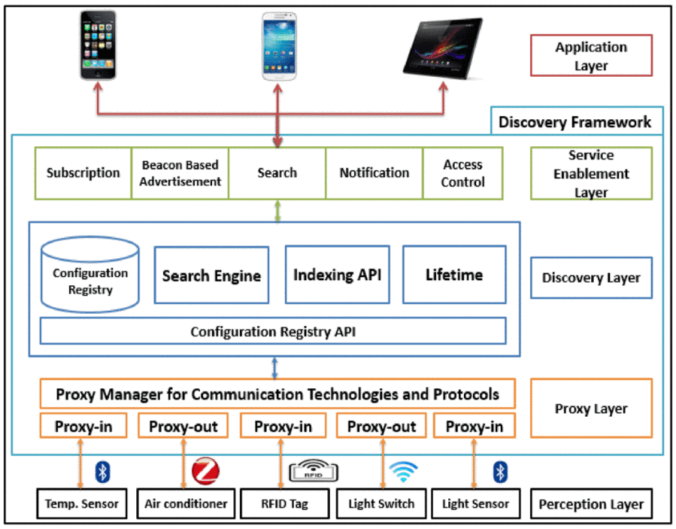

Fig. 3. The Layers of the framework.

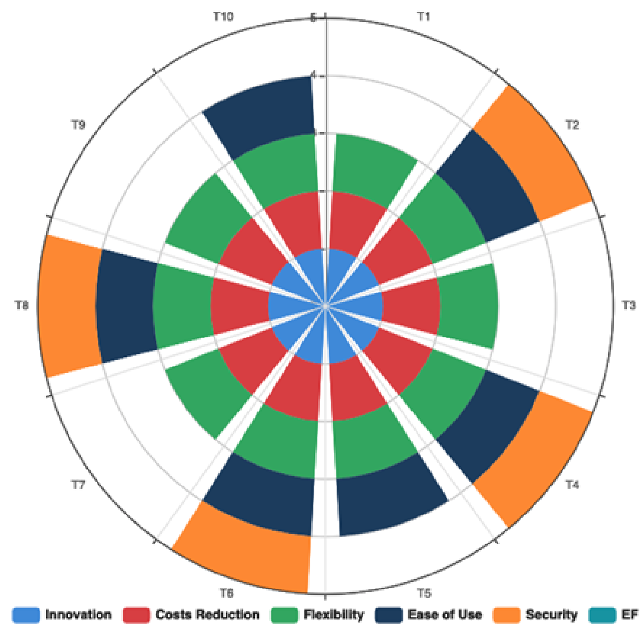

Fig. 4. The percentage of techniques that affects different metrics.

C. Comparison of technique capabilities

In figure 4 paper divides these technologies into the percentage of techniques that affects different matric, these techniques only consider improving overall performance. Only few techniques are in the context of H2M communication. From 2015 to 2019, only 20 % of techniques are able to communicate between H2M while 80 % capable of M2M.

IV. CONCLUSION

IoT is the most important information technology in the future, which progresses rapidly based on the traditional Web technologies. However, this trend might be impeded by efficiency of communications and operations between IoT nodes or human. This challenge drives people to develop these enhanced architectures and approaches to reduce unnecessary data exchanges, to increase productivity of search and to create advanced algorithms. To conclude, Web technologies are still essential to IoT, and the future of IoT needs more efficient capacity of interactions of services based on Web. Thus, this requirement could lead to the evolution of Web technology and change the whole protocol stack as well, which means IoT can have its exclusive protocol stack that works on high efficiency, low energy consumption and wide extension

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