# Efficient Internet of Things Virtualization Framework that Uses Peer to Peer Networking and Processing to Save Power

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**ABSTRACT—** In this paper, an energy efficient IoT virtualization framework with P2P networking and edge computing is proposed. The proposed network encompasses IoT objects and relay devices. In this network, the IoT task processing requests are served by peers. The peers in our work are represented by IoT objects and relays that host virtual machines (VMs). We have considered three scenarios to investigate the saving in power consumption and the system capabilities in terms of task processing. The first scenario is the relays only scenario, where the task requests are processed using relays only. The second scenario is the objects only scenario, where the task requests are processed using the IoT objects only. The last scenario is a hybrid scenario, where the task requests are processed using both IoT objects and VMs. We have developed a mixed integer linear programming (MILP) model to maximize the number of processing tasks served by the system and minimize the total power consumed by the IoT network. We investigated our framework under the impact of VMs placement constraints, fairness constraints between the objects, tasks number limitations, uplink and downlink limited capacities, and processing capability limitations. Based on the MILP model principles, we developed an energy efficient virtualized IoT P2P networks heuristic (EEVIPN). The heuristic results were comparable to those of the MILP in terms of energy efficiency and tasks processing. Our results show that the hybrid scenario serves up to 77% (57% on average) processing task requests, but with higher energy consumption compared to the other scenarios. The relays only scenario can serve 74% (57% on average) of the processing

task requests with 8% saving in power consumption compared to the hybrid scenario. In contrast, 28% (22% on average) of task requests can be successfully handled by applying the objects only scenario with up to 62% power saving compared to the hybrid scenario. The results also revealed the low percentage of addressed task requests in the objects only scenario resulting from the capacity limits of the IoT objects' processors. In addition, the small difference between the serving percentage of hybrid scenario and relays only scenario resulted from the allowed internal processing of objects in the hybrid scenario

## INTRODUCTION

THe dramatic recent developments in IoT were mainly driven by the tremendous need and benefits that can be gained from connecting our physical world to the Internet. It is expected that there will be 50 billion (and by some estimates, more) IoT interconnected devices in the coming years [1]. This growth in the number of connected devices opens the doors to new applications, for example in agriculture, transportation, manufacturing, smart homes, smart healthcare, and M2M communications [2], [3]. Many challenges such as energy efficiency, reliability, security, interoperability and scalability have to be overcome before the planned growth in the number and functionalities of IoT can be realized [4]. Given the expected number of devices, one of the most important challenges is energy efficiency and hence greening the associated networks, which grabbed attention in both the academic and industrial domains. Cloud computing is investigated as one of the solutions to the energy efficiency challenge in networks and data centers [5]-[8]. However, with the large data generated by the connected IoT objects (expected to generate 2.3 trillion gigabytes of data every day by year 2020) [2], emerging cloud computing with IoT poses new challenges which have to be addressed. Among these challenges is the hunger for more processing capabilities, high communication bandwidth, security, and latency requirements [9]. A number of solutions were suggested to address these issues. The work started with distributed content placement, thus bringing content closer to users [10], distributed data centers, thus bringing the processing capabilities closer to users and IoT devices [11] and distributed processing of big data, where processing the huge data generated by IoT devices near the source can extract knowledge from the data and hence transmit the small volume 'extracted knowledge' messages, thus saving network and processing resources and hence energy [12]. However, a different and potentially more efficient solution, advocated here, is to process the IoT data by the IoT objects themselves or by the devices in the nearest layer to these objects. According to Allied Business Intelligence (ABI), it is expected that 90% of the data created by the endpoints will be processed and stored locally rather than being handled by the conventional clouds [10]. Since some complicated data processing tasks cannot be done by most of the IoT devices and sensors because of their limited capabilities, edge computing is proposed to provide more resources to serve such tasks in efficient and fast ways. One of the suggested ways to do this is the dynamic installation of virtual machines (VMs) in the edge cloud to process the raw data generated by the tasks requested by the IoT objects. The processed results are then sent back to the objects [2]. In [13], we considered a single IoT network consisting of IoT network elements (relays, coordinators and gateways). In [13], data processing and traffic aggregation were done by VMs hosted in cloudlets, where these mini clouds are distributed over the IoT network elements. The work was extended in [14] where two separated IoT networks were considered with the deployment of a Passive Optical Access Network (PON). The main goal of our previous work was to investigate the potential energy efficiency gains that can be made if use is made of distributed cloudlets at the edge of the network compared to centralized cloudlets at highest layer of the implemented model. There is a recent trend in research toward proposing IoT platforms based on local computing close to the objects such as fog and edge computing. Such platforms have many common characteristics with our proposed architecture. In [15], a combination of fog computing and microgrid is proposed in order to reduce the energy consumed by IoT applications. A set of measurements and experiments were implemented considering different processing and traffic requirements. In [15], dynamic decisions can be made by the proposed IoT gateway to minimize the consumed energy by choosing the most efficient location for processing a task in the fog or in the cloud. This decision is affected by the type of deployed IoT application, weather forecasting and the availability of renewable sources. An edge computation platform is presented in [16] where the design of an IoT gateway virtualized environment for IoT applications is proposed using lightweight virtualization technologies. In this work [16], IoT data processing can be achieved by making use of container-based virtualization technologies such as Docker containers. IoT devices can make use of P2P communication capabilities and architectures [17]. A number of advantages could be reaized by using P2P communication systems compared to conventional communication systems such as energy efficiency, traffic reduction [17] and reliability. Based on the potential energy efficiency advantage, we introduce our energy efficient IoT network considering a combination of P2P communication between the IoT objects and edge computing while installing VMs in the relays. Computing tasks and the communication between the peers in our network is achieved through two stages, in the first stage, objects send the requests for tasks to be served by other peers (represented by IoT objects and relays hosting VMs) through the directly connected relays in the network. In the second stage the results of the processed tasks are received. We assume the traffic generated by task requests is reduced after processing by different percentages depending on the complexity of the requested tasks

## RELATED WORK

### ‘‘A practical evaluation of information processing and abstraction techniques for the Internet of Things,”

The term Internet of Things (IoT) refers to the interaction and communication between billions of devices that produce and exchange data related to real-world objects (i.e. things). Extracting higher level information from the raw sensory data captured by the devices and representing this data as machine-interpretable or human-understandable information has several interesting applications. Deriving raw data into higher level information representations demands mechanisms to find, extract, and characterize meaningful abstractions from the raw data. This meaningful abstractions then have to be presented in a human and/or machine-understandable representation. However, the heterogeneity of the data originated from different sensor devices and application scenarios such as e-health, environmental monitoring, and smart home applications, and the dynamic nature of sensor data make it difficult to apply only one particular information processing technique to the underlying data. A considerable amount of methods from machine-learning, the semantic web, as well as pattern and data mining have been used to abstract from sensor observations to information representations. This paper provides a survey of the requirements and solutions and describes challenges in the area of information abstraction and presents an efficient workflow to extract meaningful information from raw sensor data based on the current state-of-the-art in this area. This paper also identifies research directions at the edge of information abstraction for sensor data. To ease the understanding of the abstraction workflow process, we introduce a software toolkit that implements the introduced techniques and motivates to apply them on various data sets.

**‘‘Future edge cloud and edge computing for Internet of Things applications,’’**

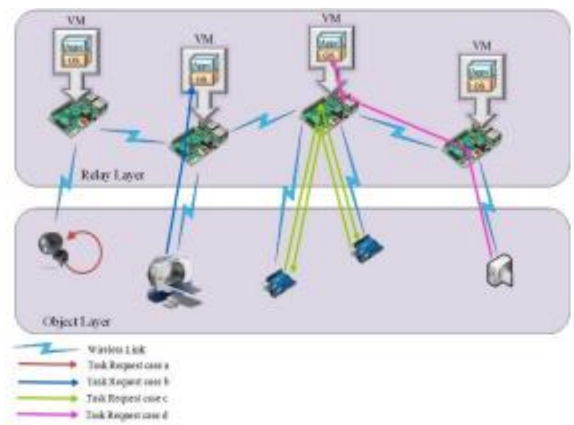
The Internet is evolving rapidly toward the future Internet of Things (IoT) which will potentially connect billions or even trillions of edge devices which could generate huge amount of data at a very high speed and some of the applications may require very low latency. The traditional cloud infrastructure will run into a series of difficulties due to centralized computation, storage, and networking in a small number of datacenters, and due to the relative long distance between the edge devices and the remote datacenters. To tackle this challenge, edge cloud and edge computing seem to be a promising possibility which provides resources closer to the resource-poor edge IoT devices and potentially can nurture a new IoT innovation ecosystem. Such prospect is enabled by a series of emerging technologies, including network function virtualization and software defined networking. In this survey paper, we investigate the key rationale, the state-of-the-art efforts, the key enabling technologies and research topics, and typical IoT applications benefiting from edge cloud. We aim to draw an overall picture of both ongoing research efforts and future possible research directions through comprehensive discussions.

**‘‘Internet of Things: A survey on enabling technologies, protocols, and applications,”**

This paper provides an overview of the Internet of Things (IoT) with emphasis on enabling technologies, protocols, and application issues. The IoT is enabled by the latest developments in RFID, smart sensors, communication technologies, and Internet protocols. The basic premise is to have smart sensors collaborate directly without human involvement to deliver a new class of applications. The current revolution in Internet, mobile, and machine-to-machine (M2M) technologies can be seen as the first phase of the IoT. In the coming years, the IoT is expected to bridge diverse technologies to enable new applications by connecting physical objects together in support of intelligent decision making. This paper starts by providing a horizontal overview of the IoT. Then, we give an overview of some technical details that pertain to the IoT enabling technologies, protocols, and applications. Compared to other survey papers in the field, our objective is to provide a more thorough summary of the most relevant protocols and application issues to enable researchers and application developers to get up to speed quickly on how the different protocols fit together to deliver desired functionalities without having to go through RFCs and the standards specifications. We also provide an overview of some of the key IoT challenges presented in the recent literature and provide a summary of related research work. Moreover, we explore the relation between the IoT and other emerging technologies including big data analytics and cloud and fog computing. We also present the need for better horizontal integration among IoT services. Finally, we present detailed service use-cases to illustrate how the different protocols presented in the paper fit together to deliver desired IoT services.

## METHODOLOGY

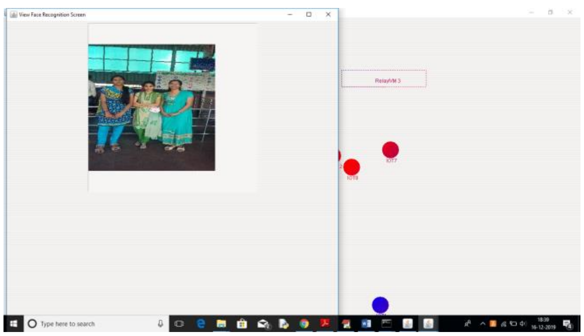
The MILP model developed considers the architecture shown in Fig. 1. The proposed architecture is constructed of two layers. The first layer represents the IoT objects. The upper layer consists of the relay devices that realize traffic transportation between peers. In our framework, each object is capable of processing three types of tasks that are required by other objects. The task processing capabilities and task requirements for the IoT objects are specified by the MILP model parameters. Each relay node has the ability to host VMs in order to process the tasks requested by IoT objects. The number of relays that can handle all task types is limited to a subset of total number of relays. For example, in the results section we consider a scenario in which 10 out of 25 relays host VMs that can handle all tasks types. Fig. 1 illustrates all the processing cases we have considered in our P2P platform. Internal processing is shown in case (a), where the object has the ability to process its own request. Consequently, the network power consumption associated with sending the task request to another object or relay or receiving a task result from them will be eliminated. One application of this case might be in smart lights. In case (b), the object sends its task request to the object's neighbor (the directly connected relay device) to be processed by the hosted VM, for example a healthcare device. Some of the objects in our model have the ability to process task requests generated by other objects but considering fairness constraint limitations. The fairness constraint states that each object should reciprocate equally to other objects choosing it to process its requested task. Object to object communication such as two Arduino devices with different capabilities is illustrated in case (c). The last task processing case is case (d). In this case, none of the objects themselves or the other objects or even the VM hosted by its directly connected relay have the ability to process the requested tasks. In spite of that, relays can process all types of tasks, but the capacity of each relay-processor is limited to a specific maximum workload. So, in order to process this task, the relay sends the task request to other relays to be processed by the nearest possible relay hosting VM (keep in mind that not all the relays host VMs) such as a smart camera sending small size images to be processed.



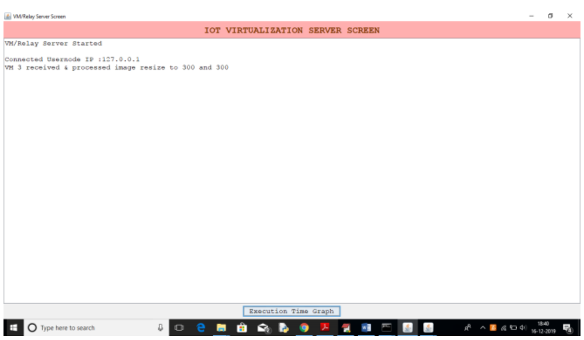

**RESULT AND DISCUSSION**

In this project author describing concept to minimize energy consumption and maximize task request process in IoT Virtualization Framework. IoT/Peer (examples CCTV camera, mobile phones or body sensors which sense data and the send to centralized server using Internet Connection) means small devices which are connected to internet and exchange data with cloud/servers using that internet connections. This small IoT devices will run on battery and if execute heavy logic then they will lose battery faster and to prevent that IoT devices will offload task to VM/Relay/Edge Servers. VM/Relay node runs on cloud with high resources and they accept request from IoT devices and execute request and send response back to IoT devices.

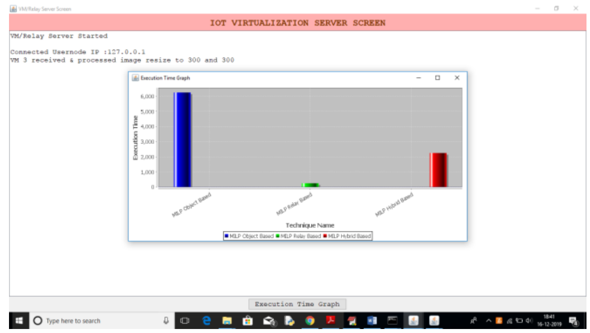
screen a line between IOT device and VM server indicates data is transferring between them and we get new resize image



you can select any IOT device and then upload image and resize to any size and test




we can see message that VM 3 received request to resize image for 300 and 300.




x-axis represents technique name and y-axis represents execution time and we can see MILP Relay technique took less execution time and its energy consumption will be less

## CONCLUSION

In this paper, we have investigated the energy efficiency of an IoT virtualization framework with P2P network and edge computing. This investigation has been carried out by considering three different scenarios. A MILP was developed to maximize the number of processing tasks served by peers and minimize the total power consumption of the network. Our results show that the hybrid scenario serves up to 77% (57% on average) processed task requests, but with higher energy consumption compared with other scenarios. The relays only scenario can serve 74% (57% on average) of the processing task requests with 8% of power saving and 28% (22% on average) of task requests can be successfully handled by applying the objects only scenario with 62% power saving. The results also revealed the low percentage of addressed task requests in the objects only scenario resulting from the capacity limit of the IoT objects' processors. In addition, the small difference between the serving percentage of hybrid scenario and relays only scenario resulted from the allowed internal processing of objects in the hybrid scenario. For real time implementation, we have developed the EEVIPN heuristic based on the MILP model concepts. The heuristic achieved a comparable power efficiency and comparable number of executed tasks to the MILP model. The hybrid Scenario in the heuristic executes up to 74% of the total tasks (MILP 77%), up to 74% of tasks by the relays only scenario (MILP 74%) while the objects only scenario executes up to 21% of the tasks (MILP 28%).

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