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# Hierarchical Clustering for Dynamic and Heterogeneous Internet of Things

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**Abstract**

Internet of Things has gained significant attention over the last decade in academia and in industry because it offers a wide range of applications. Imagining that the devices in the world are going to perform tasks together, the non-trivial issue is the energy efficient connectivity and communication. In this context, we propose a Hierarchical Clustering algorithm for Dynamic and Heterogeneous Internet of Things. The proposed clustering algorithm is evaluated on actual IoT platform. The parameters like network coverage, communication cost and power consumption analysis are carried out by conducting experiments on IoT based simulator.
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*Keywords:* Internet of Things; Dynamic Clustering; Hierarchical architecture; Cooja simulator.

## 1. Introduction

IoT enables innovative services[1] for common citizens, business in industries and government bodies involving the use of technologies such as Nano Technology (NT), Bio Technology (BT) and Content Technology (CT), thereby granting the provision of services that go beyond traditional IT services and telecommunication. These innovative services, in terms of availability of all sorts of objects as well as service capabilities and networking including interdisciplinary services were necessitated. Interoperability among heterogeneous scalability and sensing systems are, thus, very important challenges to seamlessly interconnect objects and people[1].

Smart objects having different communication protocols, information and processing capabilities with battery-operated, power consumption is a critical aspect[1]. The consolidation of content and connectivity with computing, collaboration, context, communications and cognition for transmitting information, developing each and every day in an effective manner is a challenging task. Hence, IoT is a global network of discovering and identification of objects that are interconnected and enabling the semantic data processing via content, connectivity, computing, context, cognition, collaboration, anytime, any service, anywhere, any object, any network and any human as shown in Fig 1.

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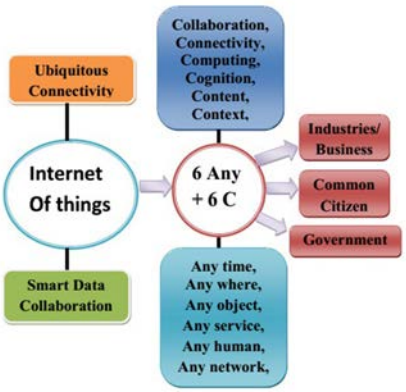


Fig. 1. Vision of Internet of Things

In 2011, the number of devices interconnected on the earth overtook the actual number of people. It is expected to reach 24 billion devices by 2020 because currently, there are 9 billion interconnected devices[2]. In this regard, clustering assures to have efficient communication and effective connectivity with such a huge number of devices. Although in the past decades, lot of algorithms have been proposed on clustering[3], the novelty of our proposed algorithm, performs hierarchical clustering using heterogeneous devices or sensors that works in hierarchical fashion by considering the dynamic environment. The applications that are suitable for this scenario are event detection and monitoring, traffic surveillance and task based monitoring etc, because our algorithm assures these huge number of devices to communicate in an energy efficient way, which are detailed and discussed further in the section II and III.

The proposed hierarchical clustering algorithm is evaluated on the platform which works on IoT features supported environment and corresponding simulator. For this purpose, we have explored cooja simulator which is IoT based simulator and that works on the Contiki2.7 Operating system[4]. As far the knowledge of authors, there is no specific work reported in the literature on hierarchical clustering concept in IoT and with actual simulation using IoT based operating system and simulator to demonstrate the approach. So, it is difficult to compare with existing methods. But, our proposed hierarchical clustering is evaluated thoroughly using standard parameters in IoT environment, which is detailed in the following sections.

Rest of the paper is organized as follows: System model of hierarchical clustering algorithm for dynamic and heterogeneous Internet of Things is detailed in Section 2. Section 3 explains the algorithm and its corresponding details. Simulation results are given in section 4. Section 5 concludes the paper with references at the end.

## 2. System Model

In this section, we describe clustering as important aspect that makes IoT possible to have efficient connectivity and communication. Assuming all things or devices that takes part in the scenario as nodes, clustering promises to reduce the communication overhead by allowing only the nodes that are necessary to take part in communication by choosing cluster head (CH)[5]. It also promises to have a load balanced system, fault tolerance, increased connectivity and reduced delay, minimal energy, maximal network longevity and completely a scalable solution which are the realistic expectations of IoT[6].

Few aspect are taken into consideration for the system model. First, nodes are heterogeneous in nature. By definition, IoT assumes that any device should be capable of communicating with any other. This implies, in the real world the devices attain heterogeneity[7,8] and our proposed algorithm is deployed with different kinds of devices in the network and they can able to communicate and collaborate with each other to accomplish a given task.

In dynamic cluster, CH and cluster formation are changed with the rounds or time but in static, once the clusters are created, they remain same throughout network lifetime. Another most realistic feature of IoT is mobility[6,7], that can be achieved only in dynamic environment. This implies frequent changing of the cluster formation and their respective

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