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Resource Consumption in a Distributed Internet of Things

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It is predicted that the Internet will be populated by billions of devices in the near future. These new devices will mainly be new types of things that have not previously been connected. This newfound connectivity is a threshold for a paradigm shift in computer science and how intelligent devices are perceived by the public. The intelligence that a computer may exhibit today will be a seamless integral part of all things tomorrow, where devices show an intelligent behavior based on their current context. Before this can happen, there are several challenges that must be overcome.

With several billions of devices, it is clear that a clever way of selecting with whom to communicate that reduces the resource demand as much as possible must be developed. Current solutions have been optimized for static data in static locations, as that is how the Internet of today has been designed. But in order for devices that are worn by people or that are otherwise mobile in nature to exhibit an awareness of their surroundings, their purpose, and the context they occupy, there is a demand for near ubiquitous sensing. In order for a device to exhibit intelligence it must ba able to select which other devices it should maintain connections with and when to exchange information. This selection process must use as few resources as possible while supporting fast and efficient communication of large quantities of data as well as distributed decision capabilities.

This thesis will deal with enabling techniques for context aware networking between mobile devices on a global scale and their resource consumption. The focus will be on two important and related problems. The first problem is how to enable efficient communication between mobile endpoints to reduce the demands on network infrastructure. The second problem is how to localize and initiate communication with a previously unknown device. These problems are fundamental in order to enable context aware intelligent devices. The proposed solution is to use a distributed overlay network to enable fast relocations. The advantage is that multiple endpoints can relocate simultaneously using less communication. This is done by separating device identity from location using a second overlay network on top of the first. To address the second problem a multidimensional range query based index is used to reduce signaling. This enables relevant information to be acquired without exhaustive or delay inducing queries. A solution to both problems serve as a foundation for context based communication and automated creation of groups based on context.

This thesis describes a way to integrate a fully distributed approach to acquire and exchange information with a semantic web, providing access to continuously changing information with short delays and low overhead. In addition, it shows how legacy devices can participate without extensive modifications. The approach is evaluated based on the energy consumption incurred by end devices and intermediate networking equipment due to signaling and processing. It is shown that signaling workload may be reduced by up to fifty percent for an Internet of Things scenario using the distributed approach when compared to a centralized approach.

For future work, the overlay network can be modified to reduce lookup delays at the cost of increased network consumption; the challenge would be to minimize lookup delays bounded by device communication capacity. Another interesting topic for future work is to investigate proactive link acquisitions based on predicted the context of the device.

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