CIS-490H Edge Computing

With Dr. Zheng Song

Paper Review: Week 10

"Ad-hoc Edge Cloud: A framework for dynamic creation of Edge computing infrastructures"

Student: Demetrius Johnson

22 March 2023

1. Summary.

(1) Motivation

The primary motivation for the Ad-hoc Edge framework is to take advantage of the number of IoT devices in existence and predicted to be in existence in the near and long term future. This advantage involves utilizing the conglomerate computational power present and aiming to reduce latency by processing data closer to the edge and reducing bandwidth consumption in the network core (i.e. the cloud).

(2) Contribution

The researchers provide the framework to use in order to overcome the challenges that the Ad-hoc Edge presents. They test the system and show that it can work, but that they need to better understand resource management as performance of the convergence of the ad hoc network was substantially reduced as the number of nodes in the network increased.

(3) Methodology and/or argument

For their implementation, they used a physical setup, including two sets of four raspberry pies with different hardware availability in order to factor into their experiment the heterogeneity of devices. Then, they implemented a larger scale version of their experiment in the cloud using Amazon AWS.

(4) Conclusion

Overall, proved to be effective, however the churn problem (when nodes appear and suddenly leave the network) needs to be better addressed through node management (i.e. resources, admission, etc.) when the number of nodes in the network increases, even to just 100 you see significant performance reduction in the Ad hoc Edge network. They still prove there is some scalability but prove that node churn is a key factor to overcome in order to improve and make more realistically usable an ad hoc edge.

2. Critique.

It must be pointed out that the estimation used for the predicted connectivity and existence of IoT devices fails to recognize that as new devices are created, many devices are going offline due to lifespan or becoming obsolete. Also, the definition of computational capacity when it comes to edge devices needs to be better defined. Since IoT devices usually do not explicitly exist to assist other nodes in the network with computation, we need to understand that the available computational capacity is limited by some portion that has a significant impact on the computational capability of an ad hoc edge network. It was mentioned that managing an ad hoc edge network poses a challenge due to the shear number of IoT devices that exist and are expected to join and contribute to the network, but also create a lot of overhead due to the shear amount of communications that would need to take place among so many devices. However, the solution of this paper does not sufficiently address this challenge. Also, the issue of heterogeneity of devices and node churn seems to be an impossible problem to solve without using some hierarchical, centralization structure. Although it can be done, it perhaps will never reach the capacity necessary for more practical use than can a centralized control node that is fixed and reliable.

3. Synthesis.

Sometimes, while reading so many academic papers on edge computing, I wonder what the difference is between IoT ten years ago versus today, including the fact that IoT devices have always been doing lots of computation on their own already; for example, smart watches that can be used to track exercise metrics including GPS distance, heartrate, steps, etc. have already been a widely used IoT device that does not rely on edge computing in the cloud sense, and also has already served as the edge device itself that does a lot of the computation on the fly (such as current pace, average heart rate, etc.).

It seems already true that as IoT devices gain computational power and battery life capabilities, application developers are already taking advantage of it to make the device do more computation and serve more purposes with less reliance on external computational devices including cloud services. I think the paper did hit at the heart of edge computing when it comes to computation on the IoT devices themselves: AI algorithms require significant computational power and is heavily transforming technology as a whole; thus, I agree that to take advantage of such advances we need to develop better edge infrastructure as a whole such as edge server devices and ad hoc edge networks that can collaborate with cloud servers to overall increase computational output and efficiency, including optimizing bandwidth usage in the network core and edge as a whole.

I also want to point out that although more IoT devices are coming online, we seem to forget that at the same time there are many that are going offline as they become obsolete as they can become replaced by other, better devices or devices that can serve the purpose of several IoT devices all in one device. So estimations of network core strain due to increasingly connectivity needs to keep in mind that we are becoming more efficient with our connectivity and IoT devices naturally do more edge computing as they become more powerful, and that there are also so many sectors and IoT devices that go offline as well.

Finally, although the paper did briefly mention battery consumption, I want to remind myself and others that when an edge device is idle, it uses much less energy. This is especially important for IoT devices which rely on battery power; it is not really "a waste" of compute resources when an edge device is idle and there is reducing power consumption (and extending battery life for battery-powered devices). There is a better case for calling devices do not rely on battery power as a waste of computational resources if they go underutilized computationally speaking. Even still, less computation means less energy consumption. This leads me to, yet again, a conclusion that I always end up reaching for one reason or another when it comes to the most realistic use case for edge computing, particularly ad hoc versions of it: the most important aspect is the personal, private use of an edge device, such as a home router serving as an edge device or personal car or even a private drone. Such an application would allow for the edge-server based approach and for the ad hoc based approach where a person's personal devices can establish a network and fully optimize the network acting as one, very efficient distributed computing system (because in some sense, this is already the reality of any network, and it is only a matter of how much computational coordination through the communication that takes place that defines the level of sophistication and efficiency of the distributed network/system).