**Graduate Research Plan Statement**

**Highlight:** The focus of my proposed research is to capture, analyze, and make sense of heterogeneous sensors to make driving safer. The method uses different sensors, mobile phones, car mounted sensors, and smart road sensors to captureweather sensor data and processes it on the edge (real-time) using a *BesoEdge* *network*: a network that uses equivalent functions to optimize QoS between heterogeneous nodes in an edge network)[1]. The goal is to make driving safer by advancing edge-based standardized middleware that can be applicable to vehicular networks and weather applications by providing the necessary quality of service (QoS) in a dynamic, opportunistic resource environment.

**Background:** Microclimates suffer a serious impact on driving. This includes snow and heavy rain that create rapidly changing road conditions as the weather is very dynamic. Also, autonomous vehicles may lose efficiency in their functions because of the weather; for example, a drone may have limited wind vector data that is not real-time (high latency) and thus waste energy in its route planning algorithm. The need for sensor data to detect and perform offline (not relying solely on internet) sharing is a big roadblock for the autonomous vehicle industry. A best-effort Edge Computing standard can provide the peer-to-peer (P2P) infrastructure necessary in vehicle networks to enhance responsiveness in delay-sensitive applications (like autonomous driving)[2].

**Problem:** Current vehicle networks include nodes that consume a lot of network resources that do not provide enough QoS or allow for flexibility (heterogeneous nodes)[2]. Consequently, services such as weather applications are not being leveraged to their full potential. There is a need to develop *BesoEdge networks* that can load-balance between network utilization and edge computation resources (for data analysis) to maximize throughput and provide the level of QoS required for such applications[1, 3].

**Research Questions:**

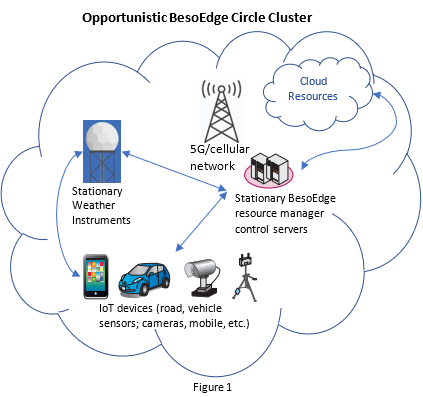
1. How to use different sensor/data processing methods to adapt to dissimilar environments; how can we translate all heterogeneous inputs into a homogeneity to guarantee the basic functionality for the BesoEdge system?
2. How to provide the software architecture/standard to enable application developers to leverage this information/infrastructure to build their software (how to build this middleware service)?.

**Approach and Methods:**

Objectives:

1. Build a test-bed that can collect weather sensor data from multiple edge network sources: Dr. Zheng Son, a researcher and professor of Edge Computing at The University of Michigan-Dearborn is currently conducting research in this exact application and has the resources to develop a test bed and experience center for BesoEdge networks [1].
2. Design equivalent functions that can fuse the data provided by heterogeneous sensors: Starting off with simple scenarios, for example only two sources of heterogeneous data, equivalent functions can be computed and tested. Gradually, we can add more heterogeneous nodes and continue to develop equivalent functions that accommodate any number of heterogeneous nodes.
3. Use the weather sensor data to create a novel application for improving driving safety: use step 2’s results to put a weather analysis tool that uses the BesoEdge network into practice.

Figure 1 demonstrates how a BesEdge network can leverage sensor data to provide real-time, fine-grain weather analysis. Vehicular networks no longer have to rely *solely* on homogenous data or less scalable and less adaptive cloud resources [3]. The system can potentially increase throughput and thus improve QoS of weather analysis by 40%, as shown in previous research [1], allowing drivers and autonomous vehicles to be more aware and alert to rapidly changing road conditions in real-time.

**Logistics and Support:** 

1) Myself: Edge computing research.

2)LiveRoadAnalytics sensors.

3)Ford/automotive companies

4)State of the Art CIS and Engineering research

facilities at the University of Michigan-Dearborn:

* Engineering Lab Building (2022).
  + Multiple CIS labs.
* Institute for Advanced Vehicle Systems.
* Edge Computing researchers
  + Dr. Zheng Song, IEEE best paper[1]

**Intellectual Merit**

For decades, the IoT has not reached its true potential for one simple reason: We have not leveraged heterogeneous data provided from all devices using a connecting (equivalent) function. Mathematically, it is very complex as it is an NP-Hard problem; however, we need to work towards the solution of creating homogeneity among the diversity of devices and data. This will also help to incorporate and advance the field of Artificial Intelligence, as equivalent functions could rely on data analysis. Ultimately, we need to develop a widely standardized protocol (much like IP protocol) that can adapt to dissimilar environments and leverage different sensor data to complete the same tasks (such as weather applications) with QoS guarantee in improvements.

**Broader Impacts**

Research in edge computing in vehicle networks with weather sensor data can specifically keep drivers safe and advance the development of autonomous vehicles. This project involves the IoT, which all groups from all walks of life rely on. As such, there is no way such an undertaking can be done effectively without involving students and everyday users from all backgrounds. In the future, imagine a world where there is essentially always internet connectivity for all users - a world where there are so many devices that are all securely connected in a web that does not only rely on the internet core, but where every device (buildings, cameras, cell phones, smart watches, satellites, etc.) is always contributing and making so many applications possible. That is the vision for edge computing. As long as enough people are nearby, connectivity is practically guaranteed.

**References**

[1] Z. Song and E. Tilevich. “A programming model for reliable and efficient edge-based execution under resource variability”. In 2019 IEEE International Conference on Edge Computing (EDGE), pages 64–

71. IEEE, 2019.

[2] R. Soua, I. Turcanu, F. Adamsky, D. Führer and T. Engel. “Multi-Access Edge Computing for Vehicular Networks: A Position Paper”. 2018 IEEE Globecom Workshops (GC Wkshps), 2018, pp. 1-6, doi: 10.1109/GLOCOMW.2018.8644392.

[3] Srivastava, Kavita & Sharma, Sudhir. (2020). “Enabling Edge Computing in an IoT-Based Weather Monitoring Application”. 10.1007/978-981-15-2329-8\_18.