Wireless Sensor Network Based Advisory System for Apple Scab Prevention – M.Tech. Thesis by Kriti Bhargava

It's interesting to see WSN's be able to predict something like Apple Scab disease based off environmental conditions. Though the sheer magnitude of the project was within expectation, it's interesting to see something that seemed so theoretical a few years ago have a real-world application.

MANY different factors are required to go from a theoretical model to a working real-world model, and it's not something that can be done with just some thinking. On-site work is needed to assess:

- Environment factors and potential hazards; where to avoid?
- Methodology of node communication, where should the nodes go and why?
- Possible disruptions, whether it be weather or other environmental factors; Animals? People? Weather?

Even with just these factors, there's also the method of optimization:

- Number of nodes
- Required battery and energy consumption
- Amount of communication and calculation
- On-site resources (people)

Initially, when working with sensor modules, I always considered them to be dumbed-down variations of smart home devices, like temperature nodes that control the heating in the house and what-not. This was a good introduction to seeing how these nodes can work together to create an intelligent system.

Teaching Using Virtualized IoT Devices

The paper emphasizes the shift from physical IoT devices to virtual environments for teaching IoT concepts. This approach can be applied to Arduino Nano BLE Sense, where virtual simulations could replace physical experimentation in certain educational scenarios, especially when in-person access is limited. This felt pretty relevant as a second paper to explore as it deals much more with the virtual sense rather than on-site applications, because I have always been wondering what exactly is the backbone of these projects. I read up on IoT devices before, but never in relation to WSN and mostly to smart devices, this is my first time realizing that smart devices and the networks they run on are similar to WSN.

Once again, there were the introduced challenges for this which I empathized a lot with having gone through high school during COVID. Despite the absence of physical interaction, the paper highlights the potential for virtual environments to still offer kinesthetic learning experiences. Virtualized environments offer the opportunity to experiment with a wide range of software and emulated hardware without the cost and logistical constraints of physical devices, but this sort of highlights how different the theoretical virtual models of WSN can differ from the real-world applicable models.

Nonetheless, very interesting

Edge Mining the Internet of Things – Elena I. Gaura, James Brusey, Michael Allen, Ross Wilkins, Dan Goldsmith, and Ramona Rednic

A very important concept of Edge Mining is introduced in this paper. This is the process of data mining at the edge of the network, specifically on wireless, battery-powered smart sensing devices. For Arduino Nano BLE Sense, this means the device can process data locally, reducing the need to send raw data to a central server. The paper discusses algorithms like Linear Spanish Inquisition Protocol (L-SIP), ClassAct, and Bare Necessities (BN), which can drastically reduce data transmission. For instance, L-SIP can reduce packet transmission by about 95%, which is crucial for battery-powered devices like Arduino Nano BLE Sense.

By reducing data transmission, these edge mining algorithms can extend battery life, a critical aspect for IoT devices which are often deployed in remote or inaccessible locations. These algorithms were likely used in the Apple Scab model.

The algorithms operate on real-time data streams and do not impose significant processing requirements. This can make edge nodes very good for supporting working personalized central networks, while handling a large amount of the data communication. ClassAct, for example, is used for human posture recognition through wearable sensors. By processing data locally, these algorithms can also reduce privacy risks, as less raw data is transmitted over the network.

The concepts and algorithms discussed are applicable to a wide range of IoT scenarios, including smart cities, health monitoring, and environmental sensing, all of which can be explored in a smaller scale with Arduino Nano BLE Sense.

A Context-Aware Edge Computing Framework for Smart Internet of Things

This paper introduced a framework called CONTESS, which is designed to improve the efficiency of smart IoT networks through context-aware selective sensing. This framework is particularly relevant to applications in smart cities, like parking space management systems. There's a few points that can be made to relate these to edge sensor nodes:

- **Context-Aware Edge Computing** can optimize data processing, which is very useful for the Arduino node we have that can gather environmental data. When processed in a context-aware manner, this can efficiently analyze the data gained by the node and increase the overall efficacy of the network
- **Selective Sensing** has the nodes process only relevant data, which reduces the communication and the storage overhead. Only pertinent sensor data on the Arduino noose will be processed and transmitted, which enhances battery life.
- CONTESS supports scalable and real-time data processing, which is essential for IoT networks. Arduino Nano BLE Sense, known for its compact size and BLE capabilities, can fit well into such scalable systems, providing real-time data with low energy consumption.

The paper discusses the use of linked data, semantic web technologies, and ontologies, indicating a high level of integration with modern IoT paradigms. I'm not exactly sure how to properly integrate these things into a WSN that doesn't have that central-processing heavy architecture, but they seem interesting to look into for sake of concept. The idea of a smart city is interesting, and WSN seem to be the backbone of implementing these smart network concepts in places where it's difficult to establish (third world countries, places very rural, etc)

A Fog Computing Approach for Localization in WSN – Kriti Bhargava, Stepan Ivanov

This really steps away from the idea of a centralized computing/processing model to focusing a lot more on the nodes themselves. The word fog computing itself is basically leveraging the intimacy between the nodes and the "cloud," which in this case is fog because of how closely related it is to the edge. This model condenses the information generated by edge nodes to reduce the amount of communication necessary. The idea of having the computation done by sensors instead of a centralized unit is interesting, because I was wondering if this is a possibility. After all, the computations themselves do not have to be intense.

One thing I know about algorithms is that applying the direct mathematical formula is more efficient than relying on iterative or recursive implementations. For example, applying a formula can have a function done in **constant** time whereas an iterative or recursive may require **linear** time. Increasing the efficiency of the programs the nodes run on can make for useful computations with what little programming power the nodes have, and if possible, it can reduce the burden of communicating all these results between the nodes and the cloud. The Edge Mining algorithms from earlier will definitely prove useful here.

This is also one of the turning points for me, because understanding the performance of these networks had always been a bit confusing for me. The graphics made it pretty intuitive.

Leveraging Fog Analytics for Context-Aware Sensing in Cooperative Wireless Sensor Networks – Kriti Bhargava, Stepan Ivanov, Diarmuid McSweeney and William Donnelly

Classification problems regarding the activity of cows. We talked about this during one of our meetings, but this feels like a very general overview of what we have been doing. A lot of the time I spent researching linear regression, I was actually thinking of classification because it seems like a much more intuitive approach--to me at least.

Essentially, there are classifications made based on the data sent to the model. Sensors communicate amongst themselves and create their own personal profile, which helps enhance the quality of the classifications. The edge nodes are assigned weights to determine how relevant the data provided by them is to the classifications, establishing which nodes are the important and significant ones. The downside to this is it requires more battery power, but optimizing systems to have a proper trade-off between efficiency and power is what makes a good WSN.

Decision Tree Models are used commonly, but with classification they are used pretty differently. In the paper, the accelerometer axes were the ones used for data analysis to determine which measurements are the most useful for determining the states. Weights of concurrent AND previous measurements are used to compare, and something called an epsilon trade-off is done where a lower epsilon yields more sensitivity but a risk of incorrectly sensing a change in state. Optimizing this epsilon value is key.

Miscellaneous Github Research

https://github.com/intel/wireless-network-ready-intelligent-traffic-management

https://github.com/stack-labs/stack

https://github.com/CrickWu/GCMC

https://github.com/benedekrozemberczki/walklets

https://github.com/lady-bluecopper/ReSuM