SC23 Network Research Exhibition: Demonstration Abstract

5G on the Showfloor

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Abstract

In this research proposal, we aim to build a self-driving 5G network using multiple research experiences - engineering, hardware and field scientists. Leveraging open source solutions for tackling the 5G stack, our solution monitors and manages fronthaul to backhaul for a complete edge-to-core solution

Wireless technologies and network advances with 5G and even beyond-5G, are ushering in a new era for Internet of Things (IoT), with intelligent sensors bringing complex temporal and spatial challenges to the way we do science across multiple DOE-related activities. While bringing many advantages, such as connectivity in urban non-wired areas, mmWave technologies, new upload/download speeds with less latency, it also brings unprecedented data demands, new hardware and desire to seamlessly connect across multiple network domains. DOE networking researchers have anticipated this impact as *networks of the future science*, particularly impact of powerful hardware, advanced sensors or programmable edge devices (e.g. Smart NICs), that may cause performance bottlenecks and new security challenges for science.

Goals

1. Working 5G prototype from end device to Core
2. Demonstrate the 5G Base station in action
3. Communicate data from sensors on the floor to the cloud.

Resources

- We need a booth for demonstration. The demo will be done on a laptop and would need a large monitor to display to a wider audience. The capability of machine learning will be shown through our easy to use GUI and real traffic simulation in topology.
- We will need a network connection to set up our network circuits and access monitoring database with a PCE controller (linked to ESnet prototype lab and the wide area internet through the show floor).

AWS collaboration: We will show the data pipeline being created on AWS to connect the data from the sensors and to be processed on the cloud.

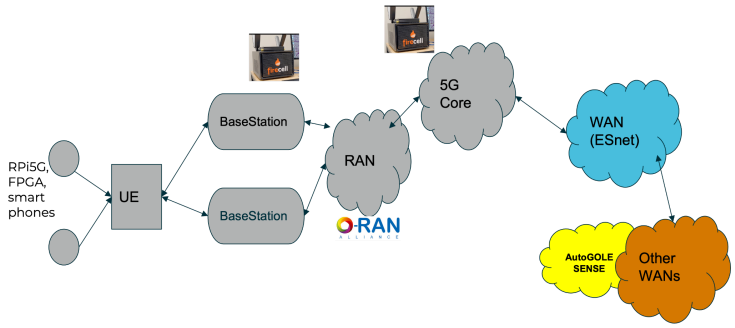


Fig1: RAN to WAN connectivity through base stations

To explore new relationships between completely diverse datasets of networking devices and determine the edge-to-core dependencies, we will analyze scattered multiple network statistics to build knowledge graphs to understand the 5G wireless application network relationships. Methods of unsupervised feature learning to find relationships between multiple diverse datasets and clustering, will help identify patterns and anomalies in environment and network data logs. We have done this using NS3 and this data will be made openly available for researchers to use. This will also be shown during our demo.

Verizon collaboration: We will also be interfacing with Verizon and use their provided SIM cards to send data over the Verizon provided 5G channels. This is to show the heterogeneity connectivity of our setup.

Purpose:

The SC demo 2023 shows the processing at the edge: (1) Acting as a filter to high quality data from noise. (2) Compressing data and/or transforming it into sparse representations that conserve network bandwidth. (3) Providing local feedback. For example, the control node could provide instant feedback to the instrument about whether the image is in focus, with adjustments and accelerating data acquisition, increasing the utilization. Immediate feedback on data quality will also lead to better overall quality of collected data. Inserting this processing for immediate feedback will enable effective use of handheld 5G devices. With the 5G wireless connectivity, thousands of sensors can be connected to Edge Computing (EC) nodes. With the amount of raw observational data, it is crucial to develop an end to-end pipeline and make sure valuable observation data is safely collected and is available to be used for science. We will show machine learning libraries that have been designed specifically for this purpose, doing edge-based calculations and collective machine learning training for optimum object classification using graph neural networks.



Fig 2: Raspberry Pi Hats

Fig 2 shows our current hardware such as Raspberry Pis (with 5G sensors) that is able to connect to FIRECELL base stations. In the future we are expanding this to FPGA to allow more data processing and fast responses for higher resolution of the Region-of-Interest at edge nodes.

Future Work:

Our current work has led to the design of a new 5G control plane that houses machine learning and also provides end-to-end connectivity to firecell base stations. In the future we are integrating these devices with RAN and RIC controllers to allow one-step deployment for updated 5G. We are using open source OAI deployments for this.

Involved Parties

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- Kevin Cronk, AWS, kccronk@amazon.com
- Ian Parnes, AWS, ipparnes@amazon.com