# Open Call 2 - 3rd party identity card

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| Project acronym/name | **6G-SANDBOX**<br>*Supporting Architectural and technological Network evolutions through an intelligent, secureD and twinning enaBled Open eXperimentation facility*<br>**PowerStorm: Energy-Aware Streaming Analytics Job Scheduling for Edge Computing** |
| Logo (if any) | University of Cyprus |
| Organisation name(s) | **University of Cyprus** |

**Objective, goal, use case**

Energy profiling and optimization are expected to play a crucial role in realizing the 5G/6G-enabled Internet of Things (IoT), as deploying computing tasks closer to the network edges ensures better response times where data is generated. Despite this, research evaluating the energy performance of such deployments on next-generation networks remains limited. Our primary objective was to evaluate the energy efficiency and performance of distributed streaming processing deployed on 5G/6G infrastructures. To achieve that, we deployed Apache Storm and evaluated various schedulers, including the default system's scheduler, a resource-aware scheduler, and **PowerStorm**, a scheduler designed to balance performance and energy consumption for streaming analytics in 5G-enabled edge computing scenarios.

**Concept, approach**

Initially, we revisited and refactored our PowerStorm framework, ensuring it was clean, modular, and configurable for the various trials we planned. Then, we purchased and configured a diverse set of User Equipment (UE) compute devices (Raspberry Pi 5s, Jetson Nanos, NX Xavier, and AGX Orin), alongside necessary 5G toolkits and smart meter plugs. Moreover, we deployed a monitoring stack (NetData and Prometheus) to capture energy and utilization metrics. During 6-15 of November 2024, we visited the Berlin Pilot testbed and we deployed our UE devices, integrating them into the Pilot's 5G/6G infrastructure. Our experimentation was conducted across three distinct configurations: (1) a baseline using Ethernet-connected edge nodes; (2) a setup using three virtual machines with diverse processing capabilities; and (3) a deployment over the 5G RAN using our User Equipment (UE) devices. Across all setups, we executed the same Apache Storm analytical pipeline, generating workloads through 5G-connected UEs to evaluate schedulers' real-world performance under different network and compute conditions.

**Results (testing, validation) and Impact**

Our experiments demonstrate that streaming processing engines can be effectively deployed on 5G/6G networks. PowerStorm consistently outperformed other configurations in both latency and throughput, particularly with 5G-connected User Equipment (UE). In local Ethernet networks, PowerStorm reduced energy use by ~15%, compared to 5.9% with the Resource-Aware configuration. On 5G and Edge Cluster setups, PowerStorm's energy use rose modestly (13.2%), while Resource-Aware saw a 135.9% increase. In a 5G RAN environment, PowerStorm's energy increase was just 0.43%, versus 93.7% for Resource-Aware.

These findings underscore PowerStorm's role in enabling high-performance, energy-efficient streaming over next-generation networks. Our contribution enhances edge computing, reduces energy consumption, and supports real-time, data-intensive applications with societal and environmental benefits. To support further research and development, we have made our framework and experimental results openly available to the community (https://github.com/UCY-LINC-LAB/6G-SANDBOX-PowerStorm).