Kubernetes Pod Scheduling Based on Energy Efficiency Metrics

Students

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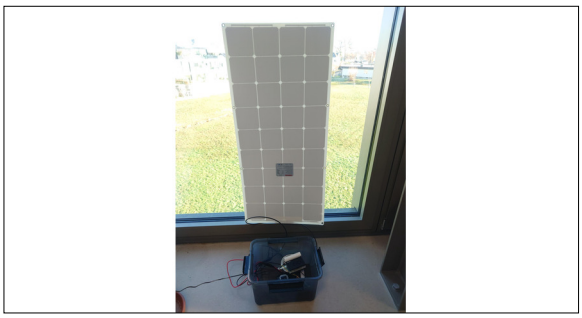
Initial Situation: In modern cloud environments, Kubernetes has become the de facto standard for orchestrating containerized applications. However, traditional Kubernetes pod scheduling algorithms primarily focus on resource allocation metrics such as CPU and memory utilization. While effective for performance, these methods often neglect energy consumption. This is where our project comes in. Our goal is to design a scheduler that works alongside the traditional scheduler, with a specific focus on renewable generated energy availability.

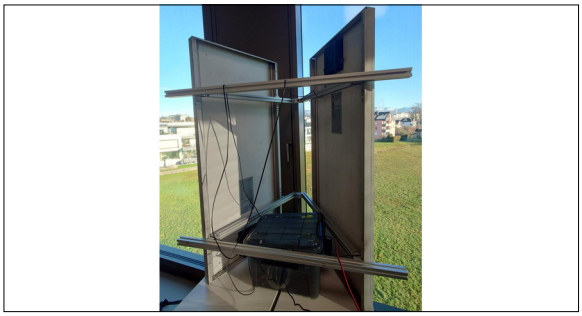
Approach / Technology: This project introduces an energy-aware Kubernetes pod scheduling approach that integrates energy availability metrics into the scheduling decision process. The proposed solution enhances the default Kubernetes scheduler by adding a new metric: the available energy for each worker node. For scheduling logic, we consider both the newly assigned priority of a pod and the available energy. Decisions are made based on these metrics, ranging from stopping pods to shutting down entire nodes. Additionally, we implemented a "move" function that allows Kubernetes pods to be manually transferred to another node. This feature demonstrates how workloads can be relocated seamlessly without noticeable service disruption.

Result: The project was deployed on a solar-powered infrastructure to validate its effectiveness. The system successfully managed pod scheduling by automatically shifting workloads when solar energy was unavailable, and the battery charge dropped to critical levels. Critical system parameters, such as battery thresholds, were made configurable and easily accessible through an intuitive graphical user interface (GUI). To enhance user engagement and improve target audience understanding, containerized workloads were represented as freight containers, giving the project a playful and visually intuitive design. These findings highlight the potential of energy-aware scheduling to improve the sustainability and cost-effectiveness of Kubernetes-based cloud infrastructures, making it a promising step toward greener data center operations.

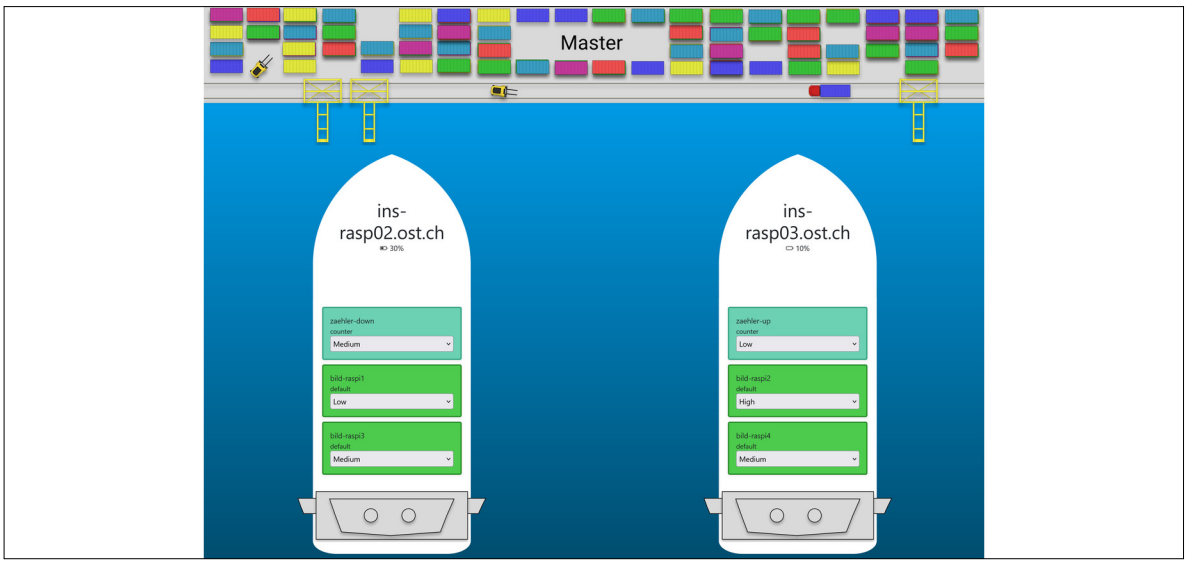
Finished solar panel connected to the Raspberry Pi housed in a weatherproof container.
Fabio Daniel Marti



Different version of the solar panel station.
Fabio Daniel Marti



Overview of Kubernetes pods as containers in ships, illustrating their deployment across nodes.
Own presentment



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Subject Area
Networks, Security & Cloud Infrastructure, Application Design, Internet Technologies and Applications