MintEDGE: Multi-tier Simulator for Energy-aware Strategies in Edge Computing

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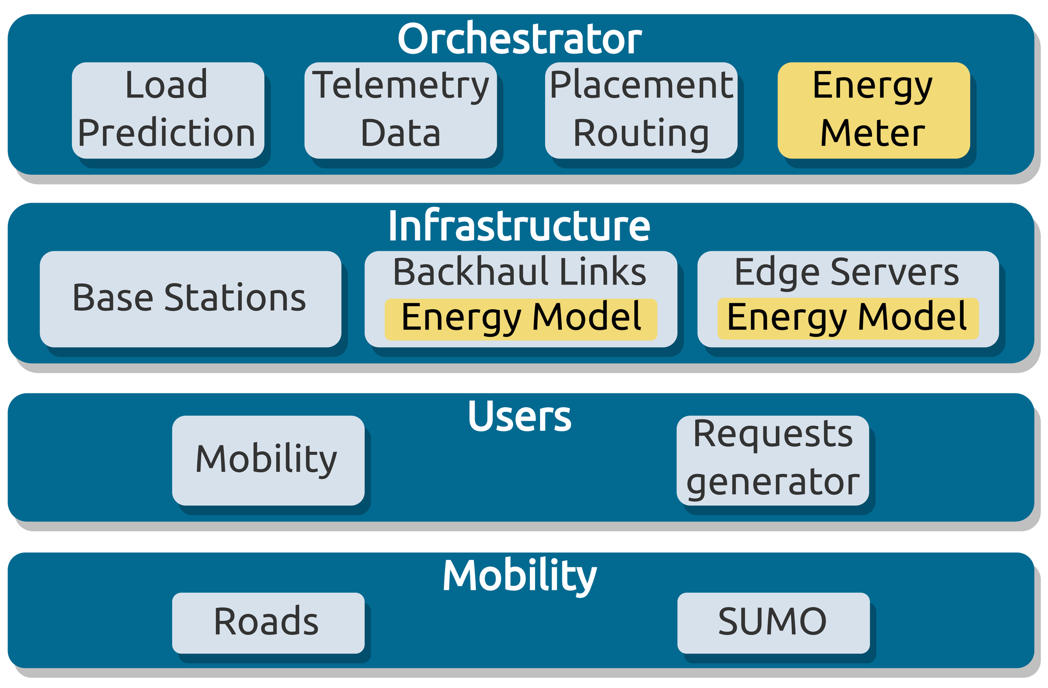
Abstract

Edge computing offers fast response times by moving computing resources to the network's edge. However, the widespread deployment of edge computing raises concerns regarding its sustainability. We present MintEDGE, a simulation framework that models a fully configurable edge-enabled cellular network empowering researchers to design and assess energy-saving strategies for edge computing. MintEDGE is released under a permissive MIT license.

Design Choices

- **Modular Orchestrator**: Orchestrator tasks are easily replaceable, especially placement algorithms or AI-related tasks.
- **Agnostic w.r.t. the Radio Access Network**: We provide a high abstraction level that makes MintEDGE lightweight and easy to adapt to other RANs.
- **Configuration flexibility**: MintEDGE provides fully configurable hardware, applications and workloads.
- **Simulation of large-scale realistic scenarios**: MNOs extend their services across vast geographical areas. MintEDGE is designed with a focus on efficiency.
- **Energy consumption with easy-to-replace models**: MintEDGE puts its focus on the energy consumption associated with placement strategies.
- **Realistic mobility modelling**: MintEDGE allows to customize mobility patterns (leveraging SUMO [1]) and to represent the non-random behaviours of the population.

Architecture



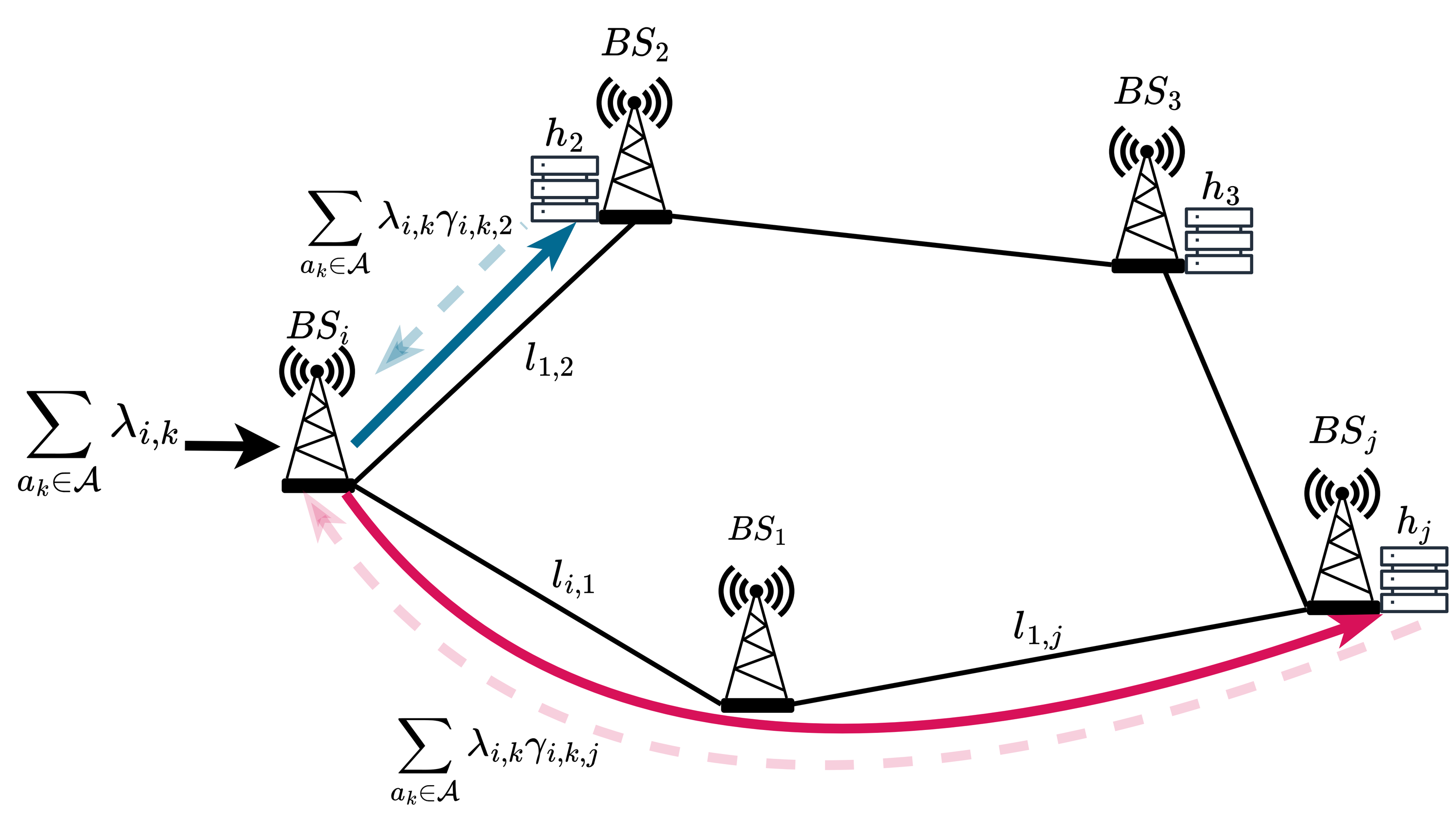
The orchestrator gives a global view of the system, places services and allocates resources.

Models infrastructure's QoS and energy consumption behaviour. Easy to import real-world data.

The users initiate requests as they move through the scenario.

Gets user positions with SUMO. Real-world traces and maps.

Network Model



Workload of a server:

$$O_j = \sum_{a_k \in \mathcal{A}} \sum_{BS_i \in \mathcal{B}} \gamma_{i,k,j} o_k \lambda_{i,k} \quad \forall a_k \in \mathcal{A}$$

Data traversing a link $\ell_{o,p}$:

$$V_{o,p} = \sum_{a_k \in \mathcal{A}} \sum_{BS_i \in \mathcal{B}} \sum_{BS_j \in \mathcal{B}} \left(V_k^{in} + V_k^{out}\right) \lambda_{i,k} \gamma_{i,k,j} p_{i,j}^{o,p} \quad \forall \ell_{o,p} \in \mathcal{L}$$

Energy Model

Energy model based on LEAF [6] adding boot energy. Linear energy model: lightweight but accurate. Easy to replace with other models, such as non-linear relation between data and energy consumption.

Servers Energy:

$$E^{\mathcal{H}} = \sum_{h_m \in \mathcal{H}} \eta_m \left(E_m^{idle} + O_m E_m\right)$$

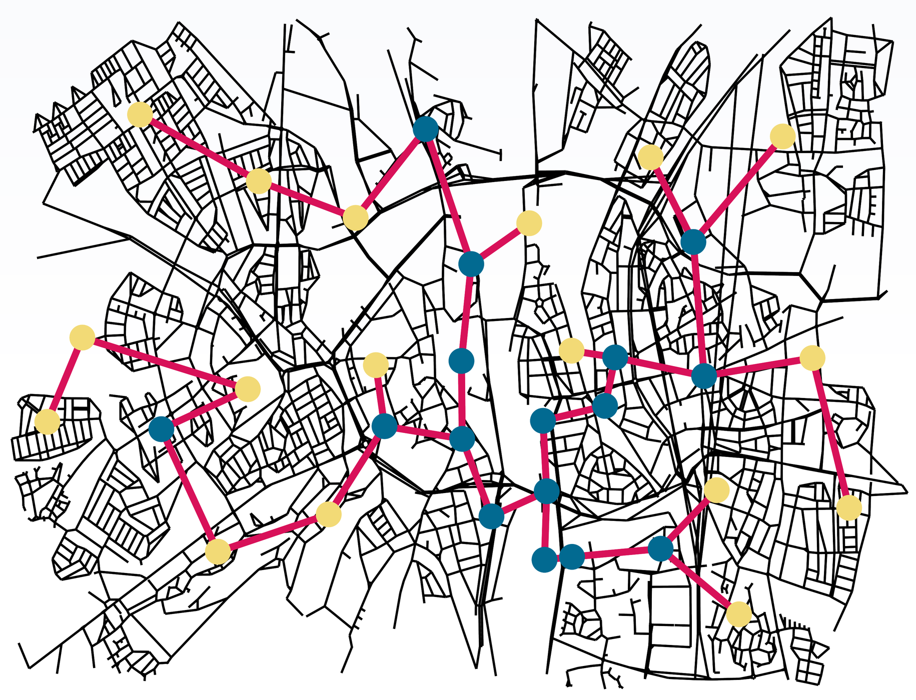
Backhaul energy:

$$E^{\mathcal{L}} = \sum_{\ell_{o,p} \in \mathcal{L}} \sigma_{o,p} V_{o,p}$$

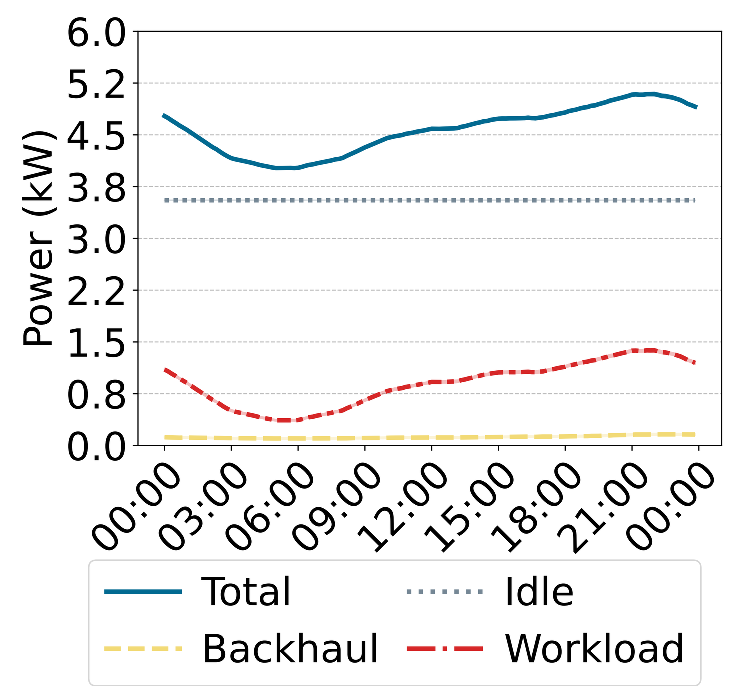
Boot energy:

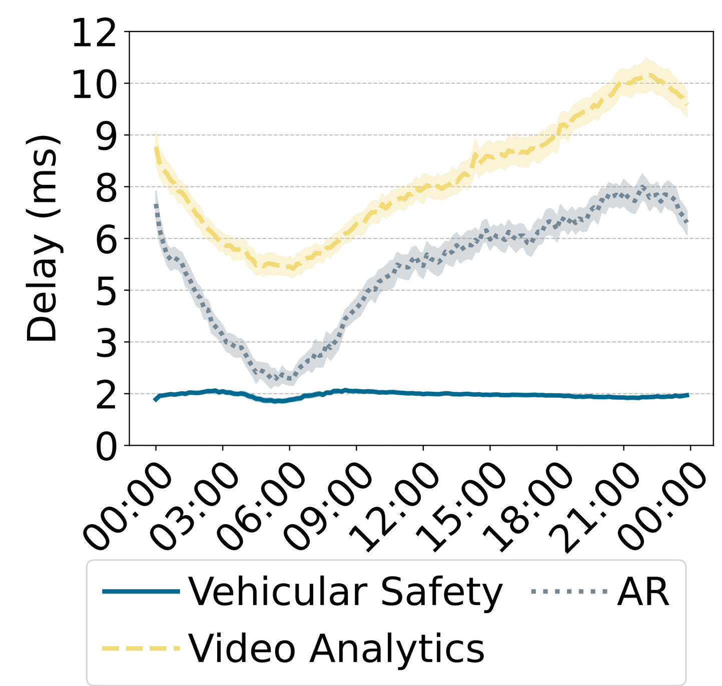
$$E_m^{boot} = T_m^s P_m^s$$

Evaluation and Results



	Augmented Reality	Video Analysis	Vehicular Safety
Users	500	100	2000
λ	0.5	6	10
V^{in}	1500 kB	1500 kB	1600 B
V^{out}	25 kB	20 B	100 B
o_k	50000	30000	7000
T^{max}	15 ms	30 ms	5 ms





Conclusions

MintEDGE is an open-source simulator that enables the research community to explore energy-aware strategies in edge computing. This work describes the architecture and modelling of MintEDGE and demonstrates its ability to simulate large-scale scenarios obtaining energy and QoS metrics. We plan to improve the efficiency of MintEDGE by parallelizing user processes and using less storage to save results. Moreover, we plan to make it easier to use.

References

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