

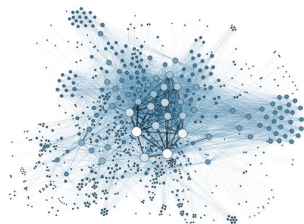
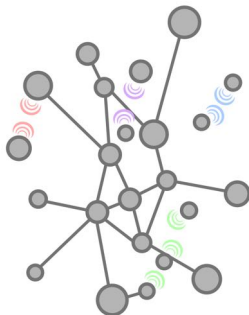
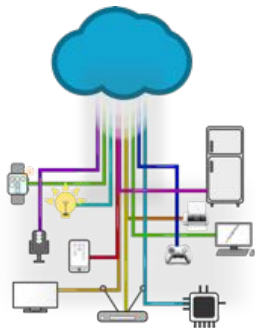
A Large-Scale Wired Network Energy Model for Flow-Level Simulations

**Loic Guegan, Betsegaw Lemma Amersho,
Anne-Cécile Orgerie, Martin Quinson**

Univ Rennes, Inria, CNRS, IRISA, Rennes, France

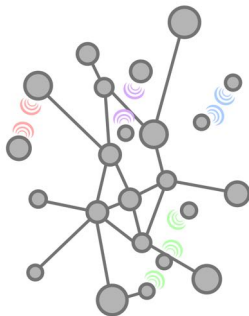
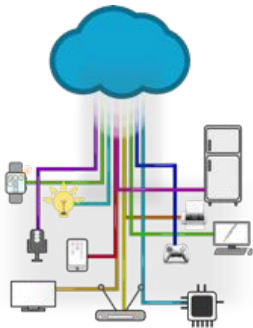
June 2019





Constraints

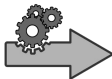
- IoT, Fog, Cloud
- A lot of devices
- Energy consuming



Constraints

- IoT, Fog, Cloud
- A lot of devices
- Energy consuming

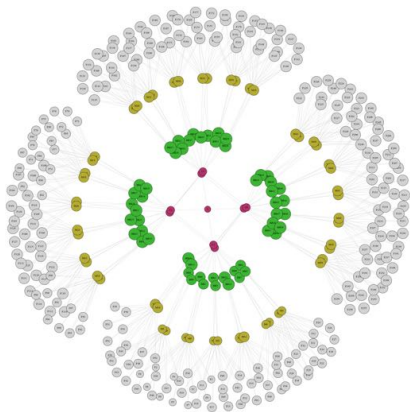
Simulations



- Reproducible experiments
- Save time and money
- Use any platform

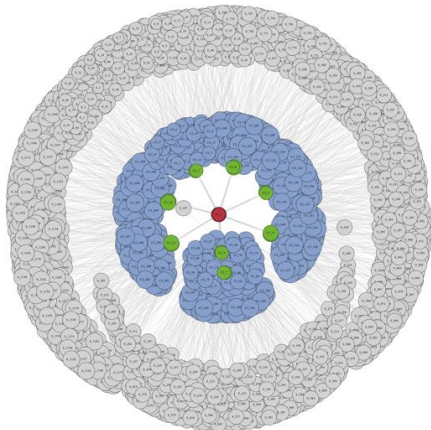
Italy ISP [1]

(372 Nodes, 718 Links)



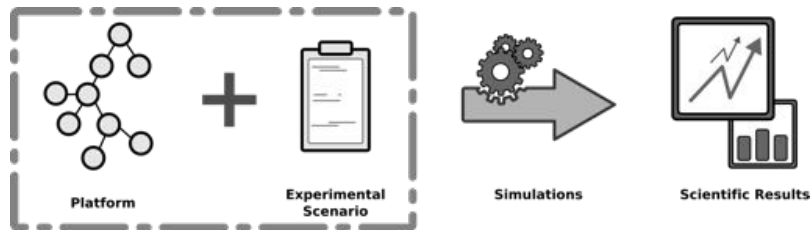
3-tiers Data Center

(2072 Nodes, 2696 Links)



[1] L. Chiaraviglio, M. Mellia, et F. Neri, « Energy-aware backbone networks: a case study », in Communications Workshops, 2009. ICC Workshops 2009. IEEE International Conference on, 2009, p. 1–5.

Problem Statement

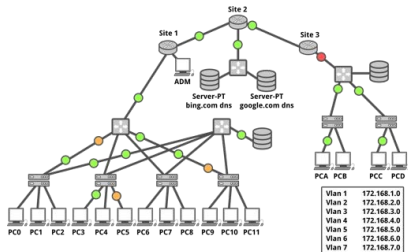


Simulator challenges

- Scalability \implies *Big enough* and *Fast enough*
- Validity \implies Ensure acceptable accuracy

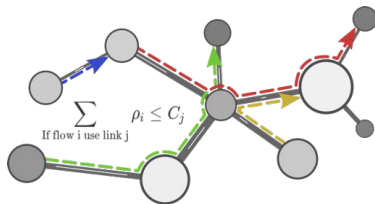
Network Simulators Performance Models

Packet-Level ns-3, OMNET++



- Full network stack 😞
- Close to reality 😊
- Very slow 😞
- Hard to instantiate 😞

Flow-Level




- High level of abstraction 😞
- Fast 😊
- Easier to instantiate 😊
- Challenging validity 😞


Wired Networks Energy Simulators


- **ns-3/ECOFEN**

⇒ Accurate 

⇒ Scalability 

- **GreenCloud (ns-2)**

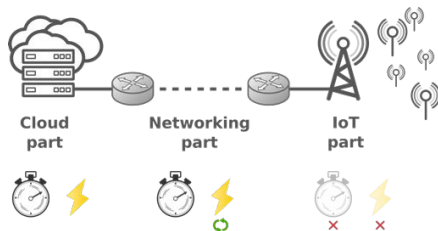
⇒ Cloud Only 

⇒ Scalability 

- **SimGrid**

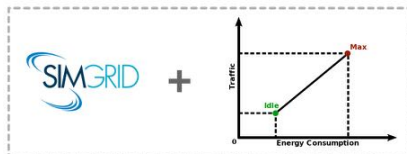
⇒ High Scalability 

⇒ Energy Model 



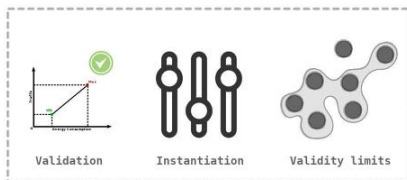
Step 1 \implies Energy Models

- Propose energy models
- SimGrid integration



Step 2 \implies Validation

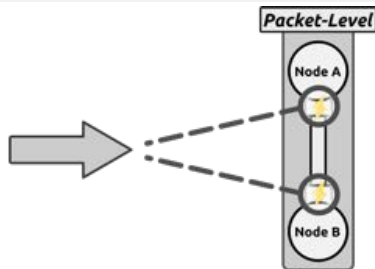
- Instantiation (How ?)
- Validity limits (When ?)



Flow-Level Network Energy

$$E_{total} = \underbrace{E_{idle}}_{\text{Static}} + \underbrace{\sum_{i \in S} N_{p_i} \times E_{p_i} + N_{b_i} \times E_{b_i}}_{\text{Dynamic}}$$

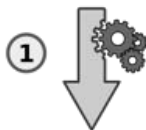
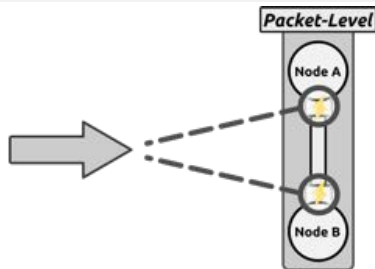
011 110 000 110 011 100



Flow-Level Network Energy

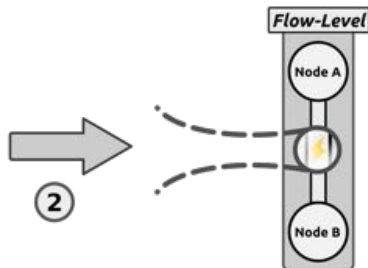
$$E_{total} = \underbrace{E_{idle}}_{\text{Static}} + \underbrace{\sum_{i \in S} Np_i \times Ep_i + Nb_i \times Eb_i}_{\text{Dynamic}}$$

011 110 000 110 011 100

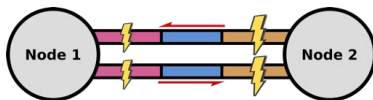
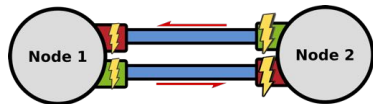


$$E_{total} = E_{idle} + \sum_{i \in L} LinkEnergy_i \times LinkUsage_i$$

0100110101011000101100

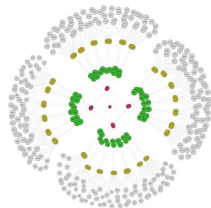


Heterogeneous Energy Model

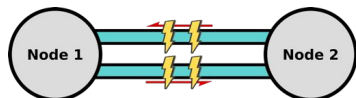
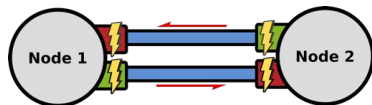


Properties:

- Fit with reality
- Harder instantiation
- A lot of links ! $\times 3$
Italy ISP: 718 \rightarrow 2154



Homogeneous Energy Model



Properties:

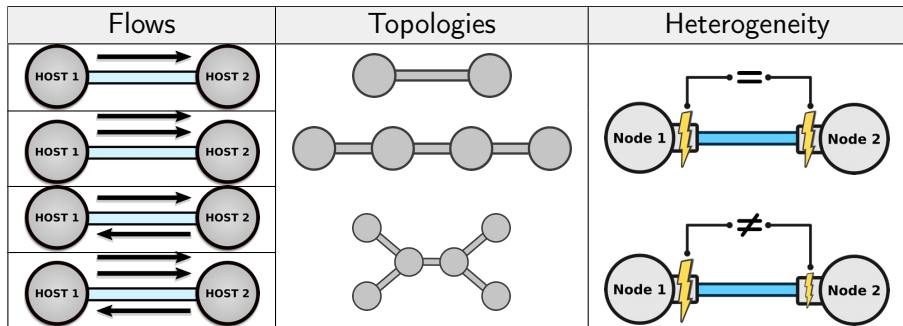
- Instantiation → Easy
- Faster
- Homogeneous Platforms 🚫

Validation



A.-C. Orgerie et al., « Simulation Toolbox for Studying Energy Consumption in Wired Networks », in CNSM: International Conference on Network and Service Management, 2017, p. 1–5.

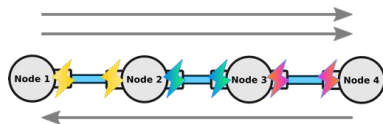
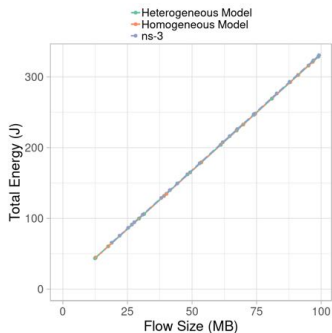
Micro-Benchmarks



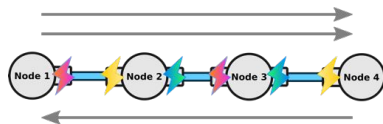
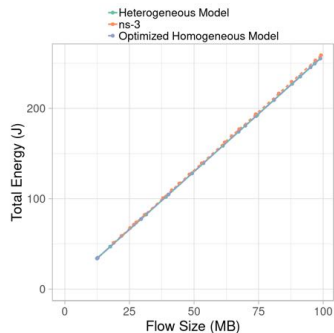
Totally \Rightarrow $\underbrace{24}_{\substack{\text{Scenarios} \\ 4 \times 3 \times 2}} \times \underbrace{20}_{\text{FlowSizes/Scenario}} \times \underbrace{3}_{\text{Homo|Hete|NS}} = 1440 \text{ simulations}$



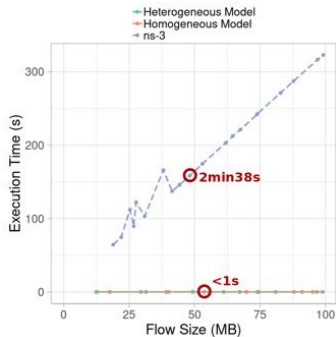
Homogeneous Platform



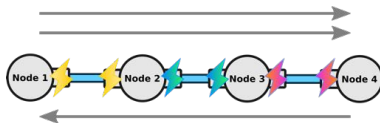
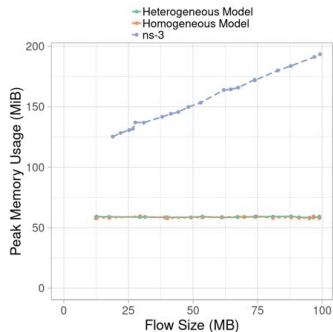
Heterogeneous Platform



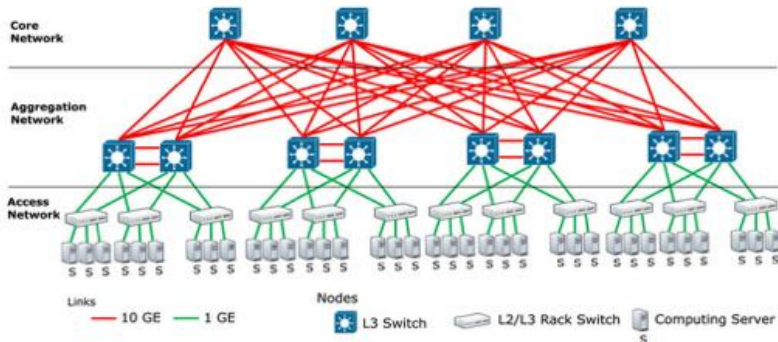
Execution Time



Memory Usage

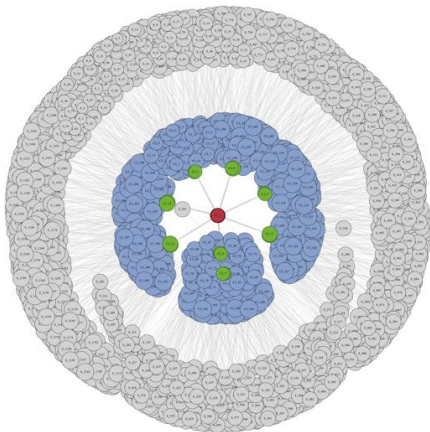


A real use case from the literature



D. Kliazovich, P. Bouvry, et S. U. Khan, « GreenCloud: a packet-level simulator of energy-aware cloud computing data centers », The Journal of Supercomputing, vol. 62, n°3, p. 1263-1283, déc. 2012

2072 Nodes, 2696 Links

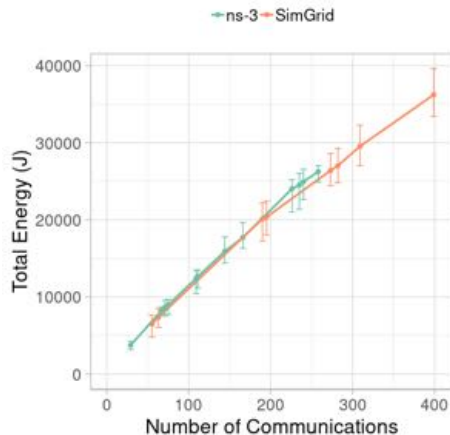


Parameters:

- Heterogeneous Platform
- #Communications:
 - ns-3 \rightarrow [10, 300]
 - SimGrid \rightarrow [10, 1000]
- Energy Models:
 - 1 Homogeneous
 - 2 ns-3

Overall port energy consumption

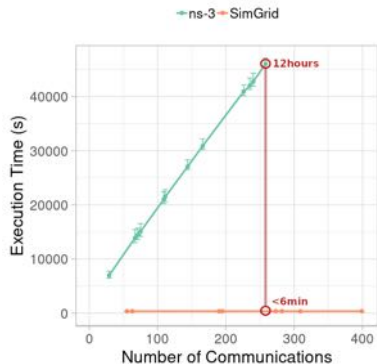
Power Profile



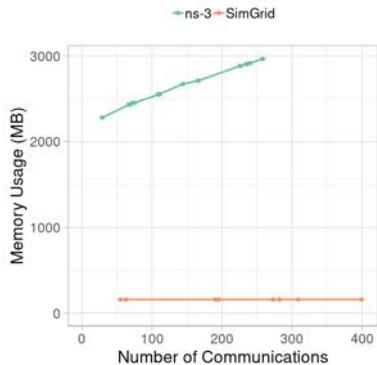
BW	Energy/Byte	Energy/Packet
1Gbps	3.4nJ	197.2nJ
10Gbps	14nJ	1504nJ

Relative Error < 4%

Execution Time



Memory Usage



Problem:

- 1 Futur platforms are larger
- 2 No scalable energy models

Major Contributions:

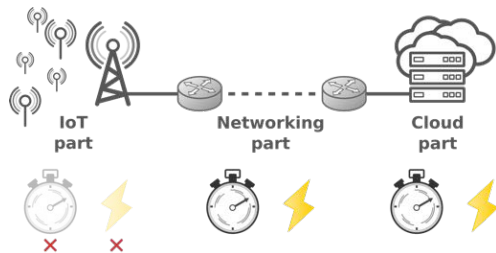
- 1 **Efficient and accurate energy model of wired networks**
- 2 Validation process

Reproducible Artefacts

- 1 Energy model \Rightarrow Part of SimGrid release
- 2 Experiments: <https://gitlab.inria.fr/lguegan/flowlvlwiredenergy>

loic.guegan@irisa.fr

WiFi performance/energy models



Futur work:

- Wireless Performance Model
- Wireless Energy Model