Intership Proposal: "Performance Evaluation and Optimization of Energy Packets Networks"

Keywords: Product-form, Queueing networks, Markov chains.

Host team: Dyogene Research team, Inria Paris.

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Background:
The Energy Packet Network (EPN) models the interaction between intermittent sources of energy that come from batteries or renewal energy sources such as solar or wind and Information Technology devices that consume energy [1]. It has attracted the attention of many researchers of different fields due to its wide range of applications in wireless sensors, mobile networks, computer systems design, data centers and optimization of power distribution policies. The key idea of EPNs is to represent energy with packets of discrete units called Energy Packets (EPs). Each EP models a certain number of Joules. Since the EPs are produced by an intermittent source of energy (typically solar and wind), the flow of EPs is associated with some random processes. EPs are consumed by some devices after some random duration to perform requested works or can also be stored in a battery from which they can also leak after a random delay.

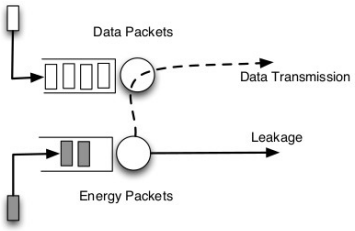

Figure 1: A single block EPN model where the energy packets start the transfer.

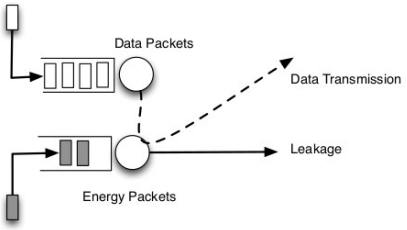

Figure 2: A single block EPN model where the data packets start the transfer.

All the EPN models that have been presented in the literature can be divided in two types depending on the initiator of the transfer. On the one hand, there are the models where the energy packets initiate the transfer (see Figure 1). For this case, when the energy packets are sent to the data queue and are lost if there is no data packet. On the other hand, the data packets can start the transfer (see Figure 2), in which case the data packets are sent to the energy queue and are routed to the next data queue if there are energy packets and lost otherwise. We note that, in both cases, when a successful transfer occurs, the energy packet is removed from the system, whereas the data packet is sent to the next station or leaves the system. Most of the EPN models that has been considered so far are particular cases of G-networks [2, 3]. Since the steady-state distribution of packets in the queues of the G-networks is given by a product form expression, it is also the case for these EPN models. As a result, one can study the performance of each node of the EPN network independently, which simplifies substantially the analysis of models with energy harvesting.

Goal of the intership:
The goal of the intership is to investigate the existence of a product-form expression of the distribution of packets in the queues of EPN models. Recent research has studied this problem in an EPN model where the energy packets start the transfer and the battery has a finite buffer [4]. A possible research to be carried out in this intership is to study the existence of a product-form expression of the distribution of packets in the queues of the aforementioned model but considering that the data packets start the transfer. Furthermore, two different energy management systems can be studied for this model: first, a centralized setting in which there is a single battery that feeds all the data queues and, second, a decentralized setting in which each data packet has a battery. The existence of the product form of these systems would allow us to compare the performance of both systems to determine how decentralization of the energy management affects on the performance of the system. Another possibility is to consider queueing

models (with only data packets) where a product-form expression is available (see [6] for a survey in this topic) and investigate the existence of a product form in related EPN models, both where the energy packet start the transfer and the data packet start the transfer.

Expected ability of the student and additional information:
An important background in discrete probability and Markov chains is necessary. As a part of the internship, the student can carry out a research visit of two or three weeks to the University of the Basque Country (Spain). For more information, please contact ana.busic@inria.fr, jean-michel.fourneau@uvsq.fr and josu.doncel@ehu.eus

References

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