A TWO-QUEUE MODEL FOR OPTIMISING THE VALUE OF INFORMATION IN ENERGY-HARVESTING SENSOR NETWORKS

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Energy harvesting wireless sensor networks have been widely studied and explored over the past few years due to their industrial applications, and in particular in the context of the Internet of Things. We propose a discrete-time queueing model with two queues for studying the optimal transmission policy of an energy-harvesting sensor node. Such a node gathers its energy from its surroundings for sensing and transmissions. In particular, we study a sensor node that operates energy neutral, i.e., all energy for sensing and transmissions is harvested, and a small on-board battery is provided for temporary energy storage. By discretising energy into “energy chunks”, the battery can be modeled as a first queue in the queueing model at hand. The arrivals in this queue correspond to harvested energy, whereas departures correspond to energy expenditure. A second queue is introduced to track the value of the information present at the sensor node, although the queueing dynamics are less standard. The value of the information is a discrete time unit which drops one unit per time slot to reflect the loss of value if the information is transmitted later. In addition, this second queue empties completely when there is a transmission which sometime is referred to as a queue with disasters. On the other hand, newly sensed data replaces the existing information provided its value exceeds the present value of the current information. The sensor node cannot always transmit at the end of each slot, i.e., there is no transmission opportunity, which is a natural assumption when the data is collected by a wireless sink. Instead, there is a transmission opportunity with some fixed probability at the end of each slot. At each opportunity, the sensor node decides whether to transmit the data or not depending on the amount of available energy and the value of information. To characterise the optimal transmission policy, we formulate the control problem as a Markov Decision Process with a level-dependent block-triangular transition probability matrix.