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The Overall Pulse model for water demand of aggregated residential users

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Abstract

The models for the end-user demand give a detailed description of the water request, which takes into account the consumes of each dwelling. Therefore, these approaches can model the water demand at WDS nodes by aggregating the single request of each user.
The effectiveness of a novel approach the Overall Pulse model (OP)- to describe the aggregated water demand has been tested. In fact, the OP model, unlike the commonly used rectangular pulse models (e.g. PRP, NSRP), does not aim to reconstruct single demand pulses as they occur when home faucets and hydro-sanitary appliances are operated, but allows the generation of the water demand as it is observed at the house water meter. This feature makes the model very versatile, allowing the direct modeling of either a single user or of a group of n users. The possibility of 'pre-aggregation' of the water demand makes it easier to take into account the spatial variability of the model parameters. In the paper, the performance of the OP model is investigated, and to this aim the generated time series are compared with the observed ones of real users. In addition, the comparison of series obtained by means of the classical PRP approach and of the OP model show the effectiveness of the latter.

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Keywords: Water demand, Monte Carlo generation, stochastic process, PRP model, OP model

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1. Introduction

The rectangular pulse point processes, originally studied to model the rain events [1, 2], have been widely used in technical literature for generating synthetic time series of the residential water demand (e.g. [3, 4, 5]).

Buchberger and Wu [3] used the Poisson Rectangular Pulse (PRP) process to describe the water request of residential users, by examining the actual demand of some monitored dwellings. Although the PRP process is theoretically a very interesting approach, because it tries to model the behavior of the users regarding water consumption, the performances of the PRP showed the need of improvements.

Therefore, Alvisi et al. [4] and Alcocer-Yamanaka et al. [6] suggested to take into account the cluster effect of the water demand, while Garcia et al. [7] proposed a practical criterion to define the non-homogeneous process describing the pulse occurrence during the day.

However, the above mentioned approaches attempt to model all the pulses, as they occur at hydro-sanitary devices of a dwelling. Moreover, the estimation of the PRP parameters often needs the reconstruction of single pulses, while the available information about the residential demand is obtained only by means of the water counters [8]. Hence, a specific monitoring campaign was developed to obtain reliable estimations of the PRP parameters, by installing water meters inside some residences in order to monitor the consumptions of each hydro-sanitary device [9].

Also the Overall Pulse (OP) model [10] is a rectangular pulse process, but it directly generates the total request for each discretized time interval Δt. In this way, the OP model presents a double advantage. First of all, this approach does not need to generate the single pulses of the residential request. Second, the model is capable of taking into account also the overall demand of more users. This latter feature is analyzed in this paper, namely the effectiveness of the OP model to describe water demand of clustered users is investigated.

2. Generation of time series by means of the OP model

The OP approach generates synthetic time series of the water requested by the residential users, where the demand is modeled effectively by means of rectangular pulses. Unlike classical end user models, the OP model does not describe the water demand at each hydro-sanitary device of a dwelling, but it models the overall request of a dwelling for each interval Δt of the time discretization. In other words, the OP model simulates the flow which can be measured by means of the water meter of a residence, whereas the pressure is adequate to satisfy the demand [11].

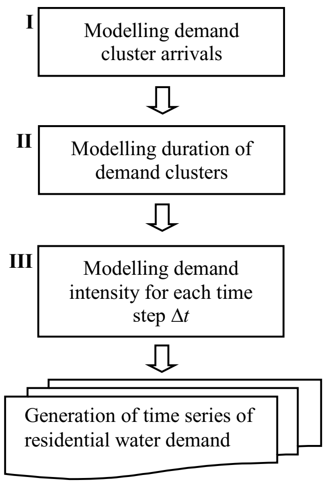

Fig.1. Flow-chart of the OP model.