We extend the standard Poisson process in three ways in order for the resulting model to reflect the key features of a realistic arrival process. As a first step, we generalize a nonhomogeneous process by introducing a time-varying arrival rate $\lambda(t)$. Second, to induce overdispersion we multiply the deterministic trend $\lambda(t)$ by a (time-dependent) busyness factor $\Lambda(t) = \Lambda_j$ for $t \in [j\Delta, (j+1)\Delta)$ with the $\Lambda_j \sim \Lambda$ independent random variables ($\Lambda \geq 0$, $E\Lambda = 1$, $\text{Var}(\Lambda) < \infty$) and a sample frequency of $\frac{1}{\Delta}$. We top it off by implementing dependence between rates of different time periods, which is done via the form of the $\Lambda_j$. This results in a nonhomogeneous stochastic arrival rate that allows for (order I) contributions from the past to the current rate, to account for both overdispersion and dependence within different time slots, as follows:

$$\Lambda(t) = \lambda(t) \cdot \sum_j \left( c_\alpha \sum_{\ell=0}^{J} \alpha^\ell W_j (\ell) 1_{[j\Delta,(j+1)\Delta]}(t) \right),$$

for $W_j \sim W$ and $W$ some nonnegative random variable ($E W = 1$, $\text{Var}(W) < \infty$) and $\alpha \in (0,1)$ that comes with a normalizing constant $c_\alpha$.

We are interested in the effect of such an arrival process on the performance of an infinite-server system. As it turns out, in a rapidly changing random environment (i.e., $\Delta$ is small relative to $\Lambda$) the overdispersion of the arrival process hardly affects system behavior, whereas in a slowly changing random environment it is fundamentally different; this general finding applies to both the central limit and the large deviations regime. Having studied these effects, we do an attempt to apply MOL staffing for the corresponding finite-server counterpart.