PERFORMANCE MODELING AND DIMENSIONING OF LATENCY-CRITICAL TRAFFIC IN 5G NETWORKS

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➢ CONTEXT AND OBJECTIVE

➢ 5G services:

- Enhanced Mobile BroadBand (eMBB): Upgraded wireless connectivity for high-quality video, audio, and data transfer.
- Ultra Reliable Low Latency Communications (URLLC): Time critical services with stringent delay (1ms) and reliability (99,999%) constraints.
- Massive Machine Type Communications (mMTC): Communication for a large number of devices, facilitating machine-to-machine interactions.

➢ Present use case:

- Industrial Internet of Things (IIoT)
- IIoT integrates mobile connectivity into industrial applications, enabling flexible production and incorporating mobile robots and Automated Guided Vehicles.
- We hence rely on URLLC for transporting such traffic.

➢ Objective:

- Modeling performance of URLLC based on outage probability, i.e., probability that the latency exceeding a maximal allowed budget does not exceed a target reliability constraint.
- Network dimensiong in terms of required resources in order to meet a target outage probability.

➢ MODEL

➢ Outage probability :

- The outage probability**:**

$$\boldsymbol{\theta(a,\delta)} = \sum_{r=1}^{R-1} \frac{\boldsymbol{r}}{\boldsymbol{R}} \boldsymbol{q_{\delta R+r}} + \mathbf{1} - \sum_{b=0}^{\delta R} \boldsymbol{q_b}.$$

where: q_b is the probability that b resources will be needed in the future to serve the backlogged traffic. δ and R are the delay budget and the nb of available resources, respectively.

➢ Model adaptation to URLLC:

- Heterogeneous Modulation and Coding Schemes (MCS): Users are subject to different radio conditions and each user uses adequate MCS.

- Integrating radio errors: transmission is subject to losses due to errors in radio link, our model accounts for retransmissions in this case.

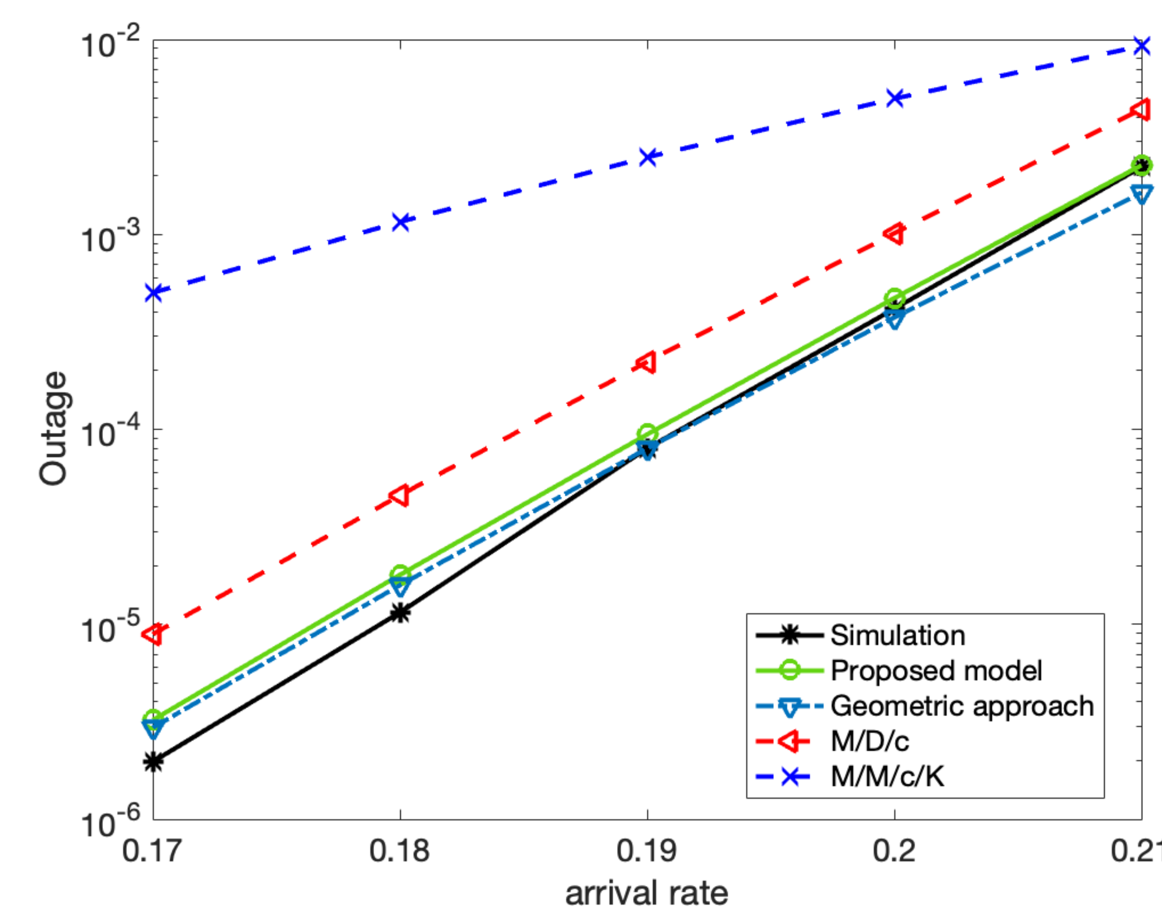
- The outage probability becomes:

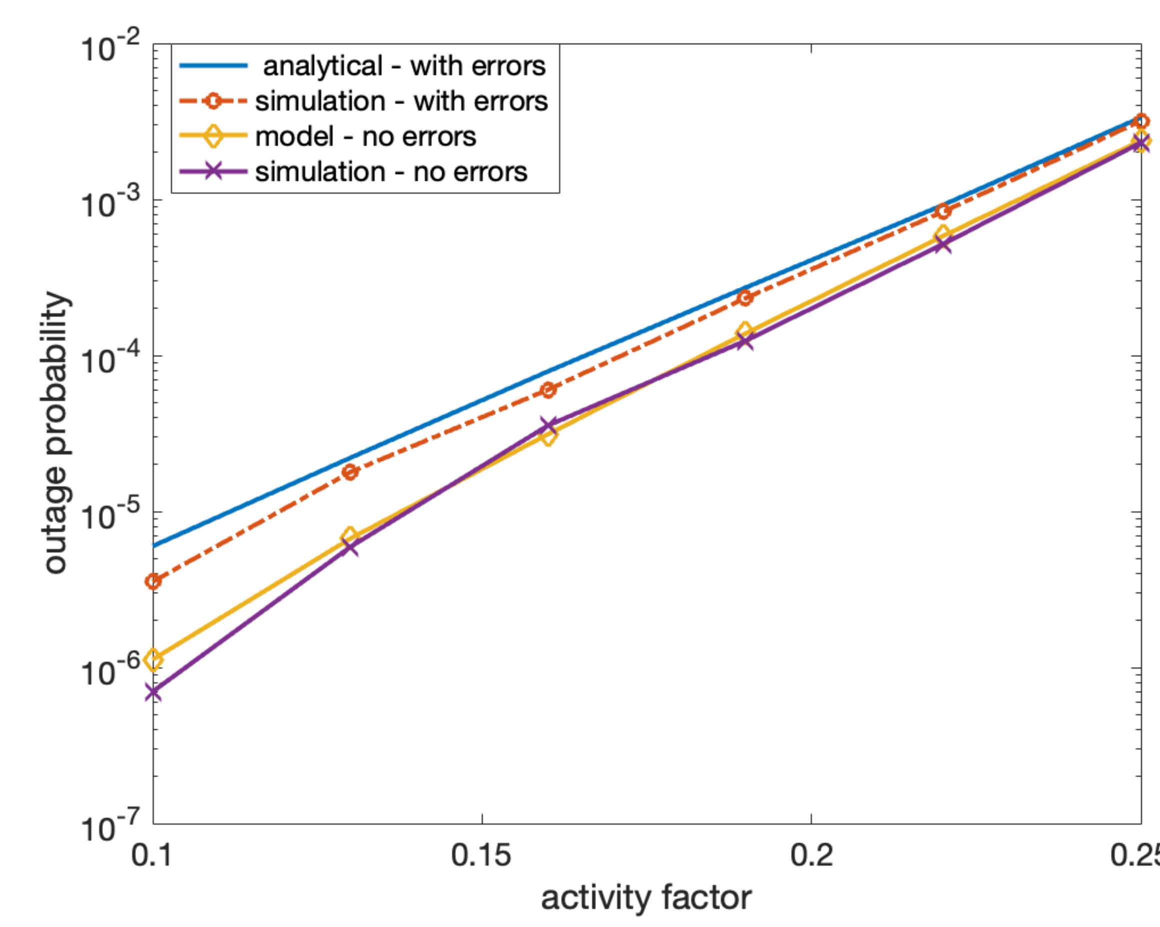
$$\theta'(a,\delta) = \varepsilon \sum_{\delta 1}^{\delta-1} [(\sum_{b_1=(\delta_1-1)R+1}^{\delta_1 R} q_{b1})(1 - \sum_{b_2=0}^{(\delta-\delta_1)R} q_{b2})] + (1-\varepsilon)\theta(a,\delta)$$

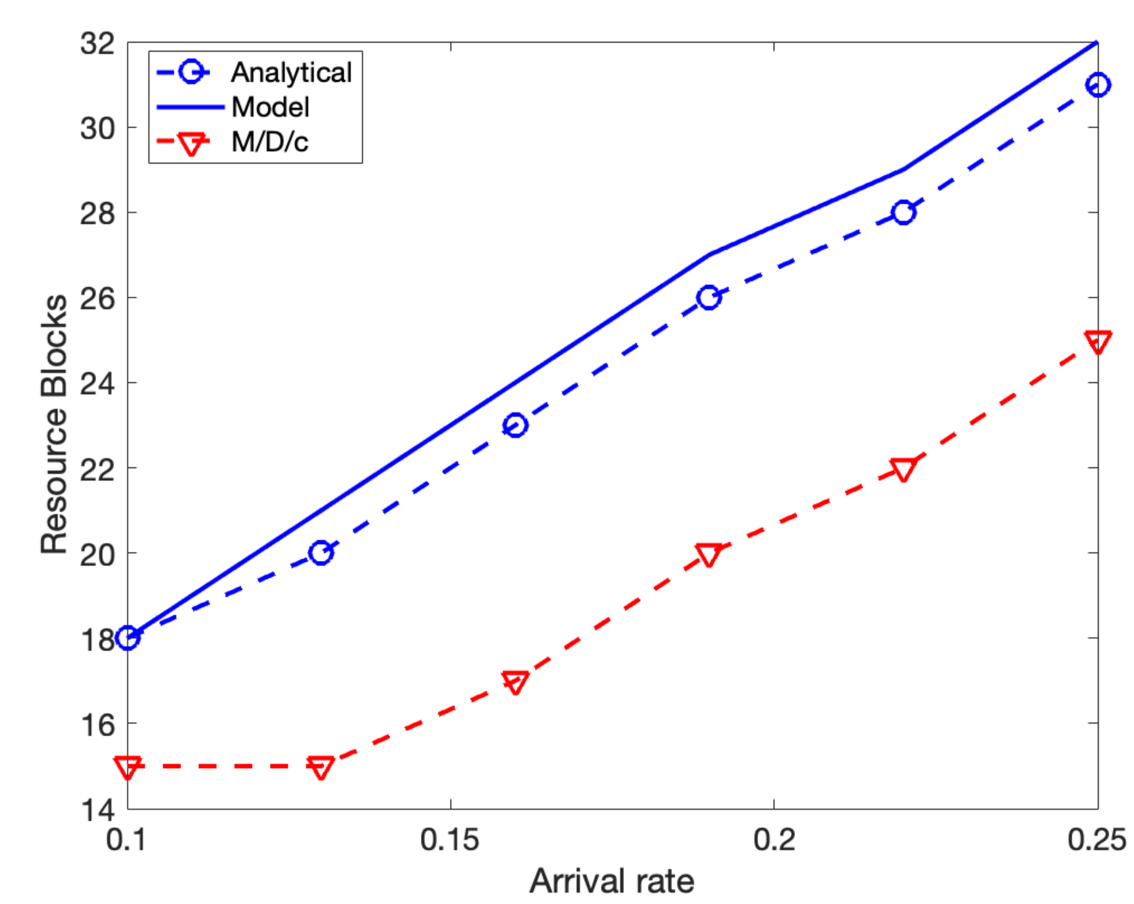
where: ε is the loss probability of a packet, $\theta(a,\delta)$ is same as above but with multiplying arrival rate by $\frac{1}{1-\varepsilon}$.

- We propose low complexity model for outage computation:
  - Binomial and Poisson arrival distributions
  - We approximate the tail of the distribution $q = (q_1, q_2, q_3, \dots)$ by the mean of geometric tail approach, using the following relation:

$$q_j = q_M \eta^{j-M}$$







PERSPECTIVES

- Performance model for the case of dynamic resource reservation policies.
- Coexistence between eMBB and URLLC: issue of modelling on two time scales, small for URLLC and larger for eMBB. Need for delayed reservations for URLLC in this case.
- Case of unknown arrivals, and need for learning them.

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