Generalization of probabilistic scheduling models for realizing URLLC applications

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❑ BACKGROUND

1) Grant Free (GF) scheduling pre-allocates resources to a group of UEs so
   - UEs do not require a scheduling process (shortening latency)
   - But they may experience collisions (worsening reliability)
2) How to improve the reliability requirement?
   - UEs can make redundant transmissions called "repetitions"
3) Then, how many repetitions and how many resources should be made to a group of UEs to achieve the reliability requirement?
   - This problem was addressed in the reference paper [1].
4) However, the paper presented the models only with examples.
5) For this reason, we mathematically generalized the GF scheduling models for its extensibility; to deal with various URLLC use cases.

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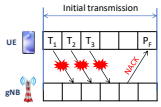
❑ Generalized GF scheduling models: Without Early Stopping

1) In literature, this model is also known as "K-repetition GF model"
2) Two main parts in the model;
   1) Left-hand side: the cumulative binomial distribution calculates the probability that a certain number of UEs are active,
   2) Right-hand side: the success probability when number of repetitions and the number of resources are given at dedicated and shared resources
3) You can think this as the weighted average of the success probability

$$ {}_{s}\mathbb{P} = {}^{UE}_{on}P\left(1 - {}^{DR}_{f}P_{i\in N_1} \cdot {}^{SR}_{f}P_{i\in N_2}\right) $$

Joint probability showing the failure of ALL repetitions



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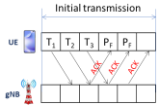
❑ Generalized GF scheduling models: With Early Stopping

1) In literature, this model is also known as "Proactive GF model"
2) Two main parts in the model;
   1) Left-hand side: the cumulative binomial distribution calculates the probability that a certain number of UEs are active,
   2) Right-hand side: the geometric distribution which determine the probability of consecutively observing non-relevant events before observing a relevant one.
      - Failure probabilities occur k-1 times before the first success takes place at k^{th} transmission.
      - E.g., $\{S_1 + F_1S_2 + F_1F_2S_3 + \dots + F_1F_2 \dots S_k\}$

$$ {}_{s}\mathbb{P} = {}^{UE}_{on}P\left({}^{DR}_{s}P_{i\in N_1} + {}^{SR}_{s}P_{i\in N_2}\right) $$



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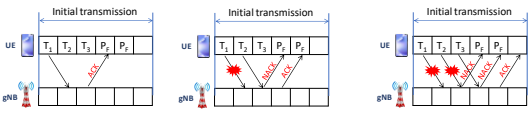
❑ Generalized GF scheduling models: With Early Stopping

- E.g., $\{S_1 + F_1S_2 + F_1F_2S_3 + \dots + F_1F_2 \dots S_k\}$



The first attempt Success | The second attempt Success | The third attempt Success

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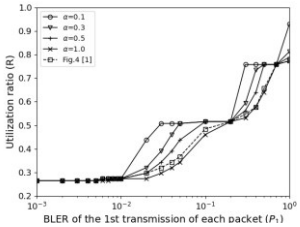
❑ A result produced based on the extended models



- The models are correctly generalized,
  - the models can reproduce the key result in the reference paper.
- The models can be easily extended,
  - we can tune tune the behavior of the models by introducing a new parameter.

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