### Introduction

#### System Model and Usecase

- **System Model**
  - Communication needs of specific applications are declared as message flows.
  - A message flow \( \gamma_i \) is a tuple \((A_i, C_i, T_i)\) where \(A_i\) denotes the application to which the message flow belongs to, \(C_i\) denotes the maximum message size (in bytes) and \(T_i\) denotes the minimum interval between subsequent messages of the flow (in seconds).
  - App designers decide how many levels of criticality \( L = \{0, \ldots, m\} \) to support, and then to allow the specification of the QoS requirements of each message flow at each of those levels.

- **Usecase**

### Multi-Network resource management

- Formulate a critically-aware QoS allocation problem for each message flow of each application, of its allowed criticality level of service and its allocated network interface.

- Propose the use of simple bin-packing algorithms and devise critically-aware best fit (CABF) and its variant \(\text{CABF}_{\text{inv}}\).

#### Algorithm 1: Criticality-Aware Best Fit (CABF)

**Result:** Set of 3-tuples indicating the allocated network and configured criticality level for all message flows that can be provided service

**Inputs:** set \( T \) of message flows, set \( N \) of networks

**Output:** set \( Q \) of 3-tuples \((\gamma_i, T, C)\), each of them representing the allocation of a message flow \( \gamma_i \) to a network \( T \) at criticality level \( C \)

1. \( Q = \emptyset \)
2. for \( i = 1 \) to \( |T| \) do
   1. \( Q = \text{BestFit}(T, Q, C) \)
   2. if \( T \neq \emptyset \) do
      1. \( Q = Q \cup \{ (\gamma_i, T, C) \} \)
   3. return \( Q \)

#### Evaluation

- Both variants of the proposed resource management algorithm (CABF and \(\text{CABF}_{\text{inv}}\)) perform better than the baseline bin-packing algorithms (first-fit, best-fit, worst-fit).
- We implemented \(\text{CABF}_{\text{inv}}\) to try to provide service to all message flows (rather than focus on increasing service for the most critical flows).

- For experimentation, we considered criticality-aware allocation of network resources using \(\text{CABF}_{\text{inv}}\) using a number of realistic scenarios and evaluate the percentage of served requests and the corresponding criticality levels they were assigned.

- We consider the four available networks have following maximum bandwidths Wi-Fi (700 Kbps), NB-IoT UL (10 Kbps), LoRa SF7-125KHz (5 Kbps) and Sigfox UL (80 Kbps).

#### Conclusion

- Resiliency and reliability requirements of IoT applications vary from non-critical (best delivery efforts) to safety-critical with time-bounded guarantees.
- We systematically investigated how to meet these applications mixed-criticality QoS requirements in multi-communication networks.
- Our work will help build reliable applications on IoT Edge and provide solutions from the perspective of communication networks to improve service quality and fault tolerance on resource-constrained edge devices.