

# Paper Title\*

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**Abstract—**  
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## I. INTRODUCTION

## II. SYSTEM MODEL

### A. Graph Model

$V^c$  is set of cloud nodes.  $V^f$  is set of fog nodes.  $V^e$  is set of edge nodes.  $V^s$  is set of sensor nodes.

$$V^c = \{v_1^c, v_2^c, \dots, v_{l_c}^c\} \Rightarrow |V^c| = l_c \quad (1a)$$

$$V^f = \{v_1^f, v_2^f, \dots, v_{l_f}^f\} \Rightarrow |V^f| = l_f \quad (1b)$$

$$V^e = \{v_1^e, v_2^e, \dots, v_{l_e}^e\} \Rightarrow |V^e| = l_e \quad (1c)$$

$$V^s = \{v_1^s, v_2^s, \dots, v_{l_s}^s\} \Rightarrow |V^s| = l_s \quad (1d)$$

$C^c$  is set of capacity of cloud nodes.  $C^f$  is set of capacity of fog nodes.  $C^e$  is set of capacity of edge nodes.

$$C^c = \{c_1^c, c_2^c, \dots, c_{l_c}^c\} \quad (2a)$$

$$C^f = \{c_1^f, c_2^f, \dots, c_{l_f}^f\} \quad (2b)$$

$$C^e = \{c_1^e, c_2^e, \dots, c_{l_e}^e\} \quad (2c)$$

$T$  is set of tasks.

$$T = \{t_1, t_2, \dots, t_{l_t}\} \Rightarrow |T| = l_t \quad (3a)$$

$$(3b)$$

Each task expresses as follows:

$$t_k \in T \Rightarrow t_k = (w_k, \delta_k, o_k) \quad (4)$$

$w_k$  shows computation workload of task.  $\delta_k$  is completion deadline of task and  $o_k$  determines the owner of task.

Price unit sets are defined as following:

$$P^c = \{p_1^c, p_2^c, \dots, p_{l_c}^c\} \quad (5a)$$

$$P^f = \{p_1^f, p_2^f, \dots, p_{l_f}^f\} \quad (5b)$$

$$P^e = \{p_1^e, p_2^e, \dots, p_{l_e}^e\} \quad (5c)$$

$P^c$ ,  $P^f$  and  $P^e$  are unit price set of using cloud nodes, fog nodes and edge nodes respectively.

Transmission delay sets that show required time for transmitting packets from sensors to each computational node are defined as follows:

$$T^{c,tr} = \{\tau_1^{c,tr}, \tau_2^{c,tr}, \dots, \tau_{l_c}^{c,tr}\} \quad (6a)$$

$$T^{f,tr} = \{\tau_1^{f,tr}, \tau_2^{f,tr}, \dots, \tau_{l_f}^{f,tr}\} \quad (6b)$$

$$T^{e,tr} = \{\tau_1^{e,tr}, \tau_2^{e,tr}, \dots, \tau_{l_e}^{e,tr}\} \quad (6c)$$

We define execution rate for each computational node as follows:

$$R^c = \{r_1^c, r_2^c, \dots, r_{l_c}^c\} \quad (7a)$$

$$R^f = \{r_1^f, r_2^f, \dots, r_{l_f}^f\} \quad (7b)$$

$$R^e = \{r_1^e, r_2^e, \dots, r_{l_e}^e\} \quad (7c)$$

### B. Variables

We define three integer variables for allocating tasks between nodes.

$$x_{k,h}^c = \begin{cases} 1 & \text{task } k \text{ is allocated to cloud node } h \\ 0 & \text{o.w.} \end{cases} \quad (8a)$$

$$x_{k,j}^f = \begin{cases} 1 & \text{task } k \text{ is allocated to fog node } j \\ 0 & \text{o.w.} \end{cases} \quad (8b)$$

$$x_{k,i}^e = \begin{cases} 1 & \text{task } k \text{ is allocated to edge node } i \\ 0 & \text{o.w.} \end{cases} \quad (8c)$$

$$\tau_k = \sum_{i=1}^{l_e} u_s^i \quad (8d)$$

$$(8e)$$

## REFERENCES