1 Notations and Definitions
A summary of the notations used in this paper is provided in Table 1. The symbols are listed in the order introduced in the paper.

2 Power-Performance Tradeoff
2.1 Minimization of Average Response Time
In this section, we show the power-performance tradeoff and the impact of various parameters for the constant-speed model in minimization of average response time with average power consumption constraint.

In Figure 1, we examine the impact of the speed of data communication on the average response time of all offloadable and non-offloadable tasks generated on the UE for the constant-speed model. We show $T$ as a function of $c_i = c + 0.5(i - 1)$ MB/second, where $c = 10.0, 15.0, 20.0, 25.0, 30.0$ MD/second.

In Figure 2, we examine the impact of the amount of data communication on the average response time of all offloadable and non-offloadable tasks generated on the UE for the constant-speed model. We show $T$ as a function of $P_i$ for $d = 0.6, 0.7, 0.8, 0.9, 1.0$ MD.

In Figure 3, we examine the impact of the energy consumption of data communication on the average response time of all offloadable and non-offloadable tasks generated on the UE for the constant-speed model. We show $T$ as a function of $P_i$ for $J = 0.02, 0.04, 0.06, 0.08, 0.10$ Joules.

Our observations are similar to those for the idle-speed model in the main paper.

2.2 Minimization of Average Power Consumption
In this section, we show the power-performance tradeoff and the impact of various parameters for the constant-speed model in minimization of average power consumption with average response time constraint.

In Figure 4, we examine the impact of the speed of data communication on the average power consumption of all offloadable and non-offloadable tasks generated on the UE for the constant-speed model. We show $P$ as a function of $T^*$ for $c_i = c + 0.5(i - 1)$ MB/second, where $c = 6.0, 7.0, 8.0, 9.0, 10.0$ MD/second.

In Figure 5, we examine the impact of the amount of data communication on the average power consumption of all offloadable and non-offloadable tasks generated on the UE for the constant-speed model. We show $P$ as a function of $T^*$ for $d = 1.0, 1.1, 1.2, 1.3, 1.4$ MD.

Algorithm 7: Minimize Cost-Performance Ratio

Input: $p_1, p_2, \ldots, p_n, \lambda_0, \lambda, \tau_0, \tau, \Delta, \xi, \alpha, P_0, J$, and $\lambda_i, \tau_i, \tau_i^2, \delta, c_i$, where $1 \leq i \leq n$.
Output: $(\lambda_1, \lambda_2, \ldots, \lambda_n)$ and the minimized $R$.

1. Initialize the search interval of $P^*$ as $(lb, ub)$;
2. while (the length of the search interval is $\geq \epsilon$) do
3. $P^* \leftarrow$ the middle point of the search interval;
4. Calculate $T_1$ with $P^*$ by using Algorithm 5;
5. Calculate $T_2$ with $P^* + \Delta$ by using Algorithm 5;
6. Calculate $R_1 = P^* T_1$;
7. Calculate $R_2 = (P^* + \Delta) T_2$;
8. Calculate $\partial R / \partial P^* = (R_2 - R_1) / \Delta$;
9. if $(\partial R / \partial P^* < 0)$ then
10. Change the search interval to the right half;
11. else
12. Change the search interval to the left half;
13. end if
14. end do;
15. $P^* \leftarrow$ the middle point of the search interval;
16. Calculate $T$ by using Algorithm 5;
17. return $(\lambda_1, \lambda_2, \ldots, \lambda_n)$ and $R = P^* T$.

In Figure 6, we examine the impact of the energy consumption of data communication on the average power consumption of all offloadable and non-offloadable tasks...
generated on the UE for the constant-speed model. We show $P$ as a function of $T^*$ for $J = 0.10, 0.12, 0.14, 0.16, 0.18$ Joules.

Our observations are similar to those for the idle-speed model in the main paper.

### 3 Minimization of Cost-Performance Ratio

In this section, we solve the problem of minimization of the cost-performance ratio.

#### 3.1 A Numerical Algorithm

Our optimization problem to minimize the cost-performance ratio can be solved by using the algorithms in Section 6.1. Our numerical method is given in Algorithm 7. The algorithm uses the classical bisection method based on the observation that $R = P^*T$ is a convex function, and $\partial R / \partial P^*$ is an increasing function of $P^*$. The overall time complexity of Algorithm 7 is $O(n(\log(I/\epsilon))^4)$.

#### 3.2 Numerical Examples and Data

In this section, we demonstrate numerical examples and data.

We use the same UE and MEC parameter setting in Section 6.2.

In Tables 2–3, we show numerical data for minimizing the cost-performance ratio for the idle-speed model and
the constant-speed model respectively. For the idle-speed model, we get \( P = 4.1099212 \) Watts, \( T = 5.2600537 \) seconds, \( R = 21.6146195 \), and \( \lambda = 4.2256870 \) tasks/second. For the constant-speed model, we get \( P = 4.1147908 \) Watts, \( T = 5.6422605 \) seconds, \( R = 23.2319559 \), and \( \lambda = 4.2399796 \) tasks/second. As expected, the constant-speed model has higher cost-performance ratio than the idle-speed model.

From both Tables 2 and 3, we make the following observations. (1) Lower indexed MECs receive all the offloadable tasks designated to them, due to their relatively low \( \lambda_i \). (2) Higher indexed MECs do not receive all the offloadable tasks designated to them, and the remaining offloadable tasks are processed by the UE itself, due to their relatively high \( \lambda_i \). (3) Compared with the idle-speed model, the constant-speed model results in reduced \( S_0 \) and \( \lambda_0 \), increased \( \lambda \), increased \( T_i \) for all \( i = 0, 4, 5, 6, 7 \), increased \( T \), reduced \( P \), and increased \( R \).

### 3.3 Power-Time Product

In this section, we show the power-time product and the impact of various parameters.

In Figures 7 and 10, we examine the impact of the speed of data communication on the cost-performance ratio of all offloadable and non-offloadable tasks generated on the UE for both power consumption models. We show \( R \) as a function of \( P^* \) for \( c_i = c + 0.5(i - 1) \) MB/second, where \( c = 10.0, 15.0, 20.0, 25.0, 30.0 \) MD/second.

In Figures 8 and 11, we examine the impact of the amount of data communication on the cost-performance ratio of all offloadable and non-offloadable tasks generated on the UE for both power consumption models. We show \( R \) as a function of \( P^* \) for \( \bar{d} = 0.6, 0.7, 0.8, 0.9, 1.0 \) MD.

In Figures 9 and 12, we examine the impact of the energy consumption of data communication on the cost-performance ratio of all offloadable and non-offloadable tasks generated on the UE for both power consumption models. We show \( R \) as a function of \( P^* \) for \( J = 0.02, 0.04, 0.06, 0.08, 0.10 \) Joules.

We have the following observations. (1) These figures all demonstrate that the power-time product has an optimal value, i.e., increasing \( P^* \) reduces the cost-performance ratio \( R \); however, beyond certain value, \( R \) increases. (2) Figures 7, 8, 10, and 11 show that for the same power constraint, increasing the speed of data communication or decreasing

#### TABLE 2

<table>
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<tr>
<th>( p_i )</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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<tbody>
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<td>0.1028571</td>
<td>0.1228571</td>
<td>0.1428571</td>
<td>0.1628571</td>
<td>0.1828571</td>
<td>0.2028571</td>
</tr>
<tr>
<td>( \lambda_i )</td>
<td>0.3728571</td>
<td>0.4628571</td>
<td>0.5528571</td>
<td>0.6428571</td>
<td>0.7328571</td>
<td>0.8228571</td>
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</tr>
<tr>
<td>( \lambda_i )</td>
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<td>2.5000000</td>
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#### TABLE 3

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<td>3.0000000</td>
<td>3.5000000</td>
<td>4.0000000</td>
<td>4.5000000</td>
</tr>
</tbody>
</table>
the amount of data communication results in noticeable
decrement in the cost-performance ratio. The reason is that
the processing times of offloaded tasks on all the MECs
are reduced. (3) However, Figures 9 and 12 show that
decreasing the energy consumption of data communication
only increases the speed of the UE and slightly decreases
the cost-performance ratio.

Fig. 1. The average response time $T$ vs. the average power consumption $P^*$ (varying $c_i$, constant-speed model).

Fig. 2. The average response time $T$ vs. the average power consumption $P^*$ (varying $d$, constant-speed model).

Fig. 3. The average response time $T$ vs. the average power consumption $P^*$ (varying $J$, constant-speed model).
Fig. 4. The average power consumption $P$ vs. the average response time $T^{*}$ (varying $c_i$, constant-speed model).

Fig. 5. The average power consumption $P$ vs. the average response time $T^{*}$ (varying $\bar{d}$, constant-speed model).

Fig. 6. The average power consumption $P$ vs. the average response time $T^{*}$ (varying $J$, constant-speed model).

Fig. 7. The cost-performance ratio $R$ vs. the average power consumption $P^{*}$ (varying $c_i$, idle-speed model).

Fig. 8. The cost-performance ratio $R$ vs. the average power consumption $P^{*}$ (varying $\bar{d}$, idle-speed model).

Fig. 9. The cost-performance ratio $R$ vs. the average power consumption $P^{*}$ (varying $J$, idle-speed model).
Fig. 10. The cost-performance ratio $R$ vs. the average power consumption $P^*$ (varying $c_i$, constant-speed model).

Fig. 11. The cost-performance ratio $R$ vs. the average power consumption $P^*$ (varying $d$, constant-speed model).

Fig. 12. The cost-performance ratio $R$ vs. the average power consumption $P^*$ (varying $J$, constant-speed model).