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Energy-aware strategies for reliability-oriented real-time task allocation on heterogeneous platforms

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Energy-aware strategies for reliability-oriented real-time task allocation on heterogeneous platforms

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Abstract: Low energy consumption and high reliability are widely identified as increasingly relevant issues in real-time systems on heterogeneous platforms. In this paper, we propose a multi-criteria optimization strategy to minimize the expected energy consumption while enforcing the reliability threshold and meeting all task deadlines. The tasks are replicated to ensure a prescribed reliability threshold. The platforms are composed of processors with different (and possibly unrelated) characteristics, including speed profile, energy cost and failure rate. We provide several mapping and scheduling heuristics towards this challenging optimization problem. Specifically, a novel approach is designed to control (i) how many replicas to use for each task, (ii) on which processor to map each replica and (iii) when to schedule each replica on its assigned processor. Different mappings achieve different levels of reliability and consume different amounts of energy. Scheduling matters because once a task replica is successful, the other replicas of that task are cancelled, which calls for minimizing the amount of temporal overlap between any replica pair. The experiments are conducted for a comprehensive set of execution scenarios, with a wide range of processor speed profiles and failure rates. The comparison results reveal that our strategies perform better than the random baseline, with a gain of 40% in energy consumption, for nearly all cases. The absolute performance of the heuristics is assessed by a comparison with a lower bound; the best heuristics achieve an excellent performance, with an average value only 4% higher than the lower bound.

Key-words: real-time systems, independent tasks, stochastic execution times, reliability, scheduling, energy-aware systems, heterogeneous platforms.
Stratégies écoénergétiques pour l’allocation de tâches en temps réel axée sur la fiabilité sur des plateformes hétérogènes

Résumé : La faible consommation d’énergie et la haute fiabilité sont identifiées comme des problèmes de plus en plus pertinents dans les systèmes en temps réel sur des plateformes hétérogènes. Dans cet article, nous proposons une stratégie d’optimisation multicritères pour minimiser la consommation d’énergie attendue tout en respectant le seuil de fiabilité et en respectant toutes les échéances des tâches. Les tâches sont répliquées pour garantir un seuil de fiabilité prescrit. Les plateformes sont composées de processeurs avec des caractéristiques différentes (et éventuellement sans corrélation), y compris la vitesse, le coût énergétique et le taux d’échec. Nous fournissons plusieurs heuristiques de mapping et de planification pour ce problème d’optimisation difficile. Plus précisément, une nouvelle architecture est conçue pour contrôler (i) le nombre de répliques à utiliser pour chaque tâche, (ii) sur quel processeur doit-on mapper chaque réplique et (iii) comment planifier chaque réplique sur le processeur qui lui est affecté. Différents mappings atteignent différents niveaux de fiabilité et consomment différentes quantités d’énergie. La planification est importante car une fois qu’une réplique de tâche réussit, les autres répliques de cette tâche sont annulées, ce qui nécessite de minimiser le chevauchement en temps entre toute paire de répliques. Les expériences sont exécutées pour un grand ensemble de scénarios, avec une large gamme de vitesse et de taux d’échec pour les processeurs. Les résultats révèlent que nos stratégies fonctionnent mieux que la référence aléatoire, avec un gain de 40 % en consommation d’énergie, dans presque tous les cas. La performance absolue de l’heuristique est évaluée en comparant avec une borne inférieure. La meilleure heuristique atteint une excellente performance, avec une valeur moyenne de seulement 4 % supérieure à la borne inférieure.

Mots-clés : systèmes temps-réel, tâches indépendantes, temps d’exécution stochastiques, fiabilité, ordonnancement, économies d’énergie, plates-formes hétérogènes
1 Introduction

Real-time systems are composed of periodic tasks that are regularly input to a parallel computing platform and must complete execution before their deadlines. In many applications, another requirement is reliability: the execution of each task is prone to transient faults, so that several replicas of the same task must be executed in order to guarantee a prescribed level of reliability. Recently, several strategies have been introduced with the objective to minimize the expected energy consumption of the system while matching all deadlines and reliability constraints \[10, 9\].

This work aims at extending these energy-aware strategies in the context of heterogeneous platforms. Heterogeneous platforms have been used for safety-critical real-time systems for many years \[5\]. With the advent of multiple hardware resources such as multi-cores, GPUs, and FPGAs, modern computing platforms exhibit a high level of heterogeneity, and the trend is increasing. The multiplicity of hardware resources with very different characteristics in terms of speed profile, reliability level and energy cost, raises an interesting but challenging problem: given several device types, which ones should we keep and which ones should we discard in order to achieve the best possible tri-criteria trade-off (time, energy, reliability)? Needless to say, this optimization problem is NP-hard, even with two identical error-free processors, simply because of matching deadlines.

This work provides several mapping and scheduling heuristics to solve the tri-criteria problem on heterogeneous platforms. The design of these heuristics is much more technical than in the case of identical processors. Intuitively, this is because the reliability of a replica of task \( \tau_i \) depends upon the processor which executes it. More precisely, the reliability \( R(\tau_i, m_k) \) of a replica of \( \tau_i \) mapped on processor \( m_k \) is \( R(\tau_i, m_k) = e^{-\lambda_k c_{i,k}} \), where \( c_{i,k} \) is the execution time of \( \tau_i \) on \( m_k \), and \( \lambda_k \) the failure rate of \( m_k \). The total reliability of \( \tau_i \) is a function of the reliability of all replicas (which we will explicit in Equation 4); hence, it is not known until the end of the mapping process (unless we pre-compute an exponential number of reliability values). Then there are many processors to choose from, and those providing a high reliability, thereby minimizing the number of replicas needed to match the reliability threshold, may also require a high energy cost per replica: in the end, it might be better to use less reliable but also less energy-intensive processors. Furthermore, the reliability is not enough to decide for the mapping: if two processors offer similar reliabilities for a task, it might be better to select the one with smaller execution time, in order to increase the possibility of mapping other tasks without exceeding any deadline. Altogether, we face a complicated decision, and we provide several criteria to guide the mapping process.

Overall, the objective is to minimize the expected energy consumption while matching all deadlines and reliability constraints. The expected en-
Energy consumption is the average energy consumed over all failure scenarios. Consider a sample execution: whenever the execution of a task replica succeeds, all the other replicas are instantaneously deleted; therefore, the actual amount of energy consumed depends both upon the error scenario (which replica is the first successful) and upon the overlap between replicas (some replicas are partially executed and interrupted when the successful one completes). Given a mapping, the scheduling aims at reducing overlap between any two replicas of the same task. Note that having an overlap-free scheduling is not always possible because of utilization constraints. Also, deciding whether an overlap-free scheduling exists for a given mapping is NP-hard [8], even for deterministic tasks.

Finally, in actual real-time systems, tasks often complete before their worst-case execution time, or WCET, so that execution times are routinely modeled as stochastic. For instance, one typically assumes that the execution time of \( \tau_i \) on \( m_k \) follows a uniform probability distribution in the range \([\beta_{b/w} c_{i,k}, c_{i,k}]\) for some constant \( \beta_{b/w} < 1 \) (ratio of best case over worst case). In the end, the expected energy consumption must also be averaged over all possible values for execution times in addition to over all failure scenarios. Our mapping heuristics aim at minimizing energy consumption based upon a lower-bound formula that assumes no overlap between any two replicas of the same task, while our scheduling heuristics aim at minimizing such an overlap. To assess the performance of our heuristics, we use a comprehensive set of execution scenarios, with a wide range of processor speed profiles and failure rates. When the failure rate is low, most heuristics are equivalent, but when the failure rate is higher, only a few heuristics achieve a good performance. Because we have no guarantee on the performance of the global mapping and scheduling process, we analytically derive a lower bound for the expected energy consumption of any mapping. This bound cannot always be met. Nevertheless, we show that the performance of our best heuristics remain quite close to this bound in the vast majority of simulation scenarios.

The main contributions of the paper are the following:

- The formulation of the tri-criteria optimization problem;
- The design of several mapping and scheduling heuristics;
- The characterization of a lower bound for performance;
- An experimental evaluation based on a comprehensive set of simulations scenarios, showing that two of the heuristics always achieve the best performance, and are always very close to the lower bound.

The rest of the paper is organized as follows. Section 2 provides a detailed description of the optimization problem under study, including a few notes on its complexity. The mapping and scheduling heuristics are described in Section 3 and 4 respectively. The performance lower bound is introduced in
Section 5. Section 6 is devoted to a comprehensive experimental comparison of the heuristics. Section 7 presents related work. Finally, Section 8 gives concluding remarks and hints for future work.

Table 1: Key Notations

<table>
<thead>
<tr>
<th>Notation</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>$N$ and $M$</td>
<td>number of tasks and of processors</td>
</tr>
<tr>
<td>$p$</td>
<td>period (deadline) for each task instance</td>
</tr>
<tr>
<td>$c_{i,k}$</td>
<td>WCET for task $\tau_i$ on processor $m_k$</td>
</tr>
<tr>
<td>$u_{i,k} = \frac{c_{i,k}}{p}$</td>
<td>utilization of task $\tau_i$ executing on processor $m_k$</td>
</tr>
<tr>
<td>$u_k$</td>
<td>utilization of $m_k$ (sum of utilization of replicas assigned to $m_k$)</td>
</tr>
<tr>
<td>$R_i$</td>
<td>target reliability threshold for task $\tau_i$</td>
</tr>
<tr>
<td>$\lambda_k$</td>
<td>failure rate of processor $m_k$</td>
</tr>
<tr>
<td>$P(m_k)$</td>
<td>power consumed per time unit on processor $m_k$</td>
</tr>
<tr>
<td>$E_s$</td>
<td>total static energy consumption</td>
</tr>
<tr>
<td>$E_d(\tau_i, m_k)$</td>
<td>dynamic energy cost of task $\tau_i$ on processor $m_k$</td>
</tr>
<tr>
<td>$R(\tau_i, m_k)$</td>
<td>reliability of task $\tau_i$ on processor $m_k$</td>
</tr>
</tbody>
</table>

2 Model

The inputs to the optimization problem are a set of real-time independent tasks, a set of non-identical processors and a reliability target. Key notations are summarized in Table 1.

2.1 Platform and tasks

The platform consists of $M$ heterogeneous processors $m_1, m_2, \ldots, m_M$ and a set of $N$ periodic atomic tasks $\tau_1, \tau_2, \ldots, \tau_N$. Each task $\tau_i$ has WCET $c_{i,k}$ on the processor $m_k$. The WCETs among different processors are not necessarily related. In the experiments, we generate the $c_{i,k}$ values with the method proposed in [2], where we have two parameters to control the correlation among task execution times and processors (see Section 6.1 for details). Each periodic task $\tau_i$ generates a sequence of instances with period $p$, which is equal to its deadline. In this work, we assume that all tasks have the same period $p$, so that a single instance of each task must execute every $p$ seconds. Note that assuming that all tasks are atomic and with same period is the standard assumption for real-time task graphs (or DAGs) [21].

As already mentioned, real-time tasks usually complete execution earlier than their estimated WCET; execution times are assumed to be data-dependent and non-deterministic, randomly sampled from some probability distribution whose support is upper bounded by the WCET. See Section 6.1 for details on the generation of actual execution times from WCET values. The utilization $u_{i,k}$ of task $\tau_i$ executing on processor $m_k$ is defined as

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\[ u_{i,k} = \frac{c_{i,k}}{p} \]  

The utilization of a processor is the sum of the utilizations of all tasks that are assigned to it.

### 2.2 Power and energy

The power consumed per time unit on processor \( m_k \) is expressed as

\[ P(m_k) = P_{k,s} + gP_{k,d} \tag{1} \]

where \( P_{k,s} \) is the static power; \( g \) represents the system state and indicates whether dynamic power \( P_{k,d} \) is currently being consumed by \( m_k \): when \( m_k \) executes a task, \( g = 1 \), otherwise \( g = 0 \). To summarize, we have 2M input values, \( \{P_1,s, P_2,s, \ldots P_{M,s}\} \) for static powers and \( \{P_1,d, P_2,d, \ldots P_{M,d}\} \) for dynamic powers.

The dynamic energy consumption \( E_d(\tau_i, m_k) \) of task \( \tau_i \) on processor \( m_k \) is estimated using the WCET:

\[ E_d(\tau_i, m_k) = P_{k,d} \times c_{i,k} \tag{2} \]

but we use the value derived from the actual execution time in the experiments. The total static energy consumption is simply given by

\[ E_s = \sum_{k \in Used} P_{k,s} \times p \tag{3} \]

where \( Used \) denotes the index set of the processors used by the schedule.

### 2.3 Reliability

We consider transient faults, modeled by an Exponential probability distribution of rate \( \lambda_k \) on processor \( m_k \). Thus, fault rates differ from one processor to another. This is a very natural assumption for a heterogeneous platform made of different-type processors. At the end of the execution of each task, there is an acceptance test to check the occurrence of soft errors induced by the transient faults. It is assumed that acceptance tests are 100% accurate, and that the duration of the test is included within the task WCET [10].

The reliability of a task instance is the probability of executing it successfully, in the absence of software faults. The reliability of task \( \tau_i \) on processor \( m_k \) with WCET \( c_{i,k} \) is \( R(\tau_i, m_k) = e^{-\lambda_k \times c_{i,k}} \). During the mapping phase, task \( \tau_i \) will have several replicas executing on different processors, in order to match some reliability threshold. Let \( alloc(i) \) denote the index set of the processors executing a replica of \( \tau_i \). The mapping achieves the following reliability \( R(\tau_i) \) for task \( \tau_i \):

\[ R(\tau_i) = 1 - \Pi_{k \in alloc(i)}(1 - R(\tau_i, m_k)) \tag{4} \]
Indeed, the task will succeed if at least one of its replicas does: the success probability is thus equal to 1 minus the probability of all replicas failing, which is the expression given in Equation (4).

Each task $\tau_i$ has a reliability threshold $R_i$ which is an input of the problem and that must be met by the mapping. In other words, the constraint writes $R(\tau_i) \geq R_i$ for $1 \leq i \leq N$. Because the tasks are independent, it is natural to assume that they might have different reliability thresholds: a higher threshold means that more resources should be assigned for the task to complete successfully with a higher probability. In the experiments we use $R_i = R$ for all tasks, but our heuristics are designed to accommodate different thresholds per task.

### 2.4 Optimization Objective

The objective is to determine a set of replicas for each task, a set of processors to execute them, and to build a schedule of length at most $p$, so that expected energy consumption is minimized, while matching the deadline $p$ and reliability threshold $R_i$ for each task $\tau_i$.

As already mentioned in the introduction, the expected energy consumption is an average made over all possible execution times randomly drawn from their distributions, and over all failure scenarios (with every component weighted by its probability to occur). An analytical formula is out of reach, and we use Monte-Carlo sampling in the experiments. However, we stress the following two points:

- To guide the design of the heuristics, we use a simplified objective function; more precisely, we use WCETs instead of (yet unknown) actual execution times, and we conservatively estimate the dynamic energy of a task as the sum of the dynamic energy of all its replicas. Because mapping decisions are based upon WCETs, the number of enrolled processors does not depend upon actual execution times and the static energy is always the same for all scenarios, namely the length of the period times the sum of the static powers of the enrolled processors (see Equation (3)).

- To assess the absolute performance of the heuristics, we derive a lower bound for the dynamic energy. This bound is based upon actual execution times but neglects scheduling constraints and assumes no overlap between any two task replicas, hence it is not reachable in general. However, we show that our best heuristics achieve performance close to this bound.

### 2.5 Complexity

The global optimization problem is obviously NP-hard, since it is a generalization of the makespan minimization problem with a fixed number of
parallel processors [4]. The optimization of the sole scheduling phase is also NP-hard: if the number of replicas has already been decided for each task, and if the assigned processor of each replica has also been decided, the scheduling phase aims at minimizing the expected energy consumption by avoiding overlap between the replicas of a same task [8]. Even if the task deadline was not constraining (very large deadline with respect to the worst-case execution time of tasks), the problem would remain NP-hard. We formally state this latter problem and show that it is NP-hard.

**Definition 1** \((\text{MinEnergyMaxReliability})\). Consider an heterogeneous platform composed of \(M\) heterogeneous processors, \(m_1, ..., m_M\), and \(N\) (non-periodic) tasks \(\tau_1, \tau_2, ..., \tau_N\). Executing task \(\tau_i\) on processor \(m_k\) has an energy cost of \(E(\tau_i, m_k)\) and has a probability of success of \(R(\tau_i, m_k)\). Let \(\mathcal{E}\) and \(\mathcal{R}\) be two constants. The \text{MinEnergyMaxReliability} decision problem is: is it possible to schedule the tasks on the processors so that: (i) the total energy consumed does not exceed \(\mathcal{E}\); and (ii) the probability that all tasks succeed is at least \(\mathcal{R}\)?

**Lemma 1.** Problem \text{MinEnergyMaxReliability} is \(NP\)-complete.

**Proof.** We prove this result by a reduction from the \(2\)-\text{partition} problem [4].

Let \(I_1\) be an instance of \(2\)-\text{partition} with \(N\) positive integers, \(a_1, ..., a_N\). Let \(S = \sum_{i=1}^{N} a_i\). The question is: is it possible to find a subset \(A\) of \(\{1, ..., N\}\) such that

\[
\sum_{\substack{1 \leq i \leq N \\ni i \in A}} a_i = \sum_{\substack{1 \leq i \leq N \\ni i \notin A}} a_i = \frac{S}{2}.
\]

From \(I_1\) we build an instance \(I_2\) of \text{MinEnergyMaxReliability} as follows. We have \(M = 2\) processors. Then we have \(N\) tasks each having the same execution times on both processors: \(c_{i,1} = c_{i,2} = a_i\). The failure rates are defined by: \(\lambda_1 = \frac{1}{S}\) and \(\lambda_2 = 1\). The static energy is null, \(P_{1,s} = P_{2,s} = 0\), and the dynamic energy is defined by \(P_{1,d} = 1\), \(P_{2,d} = \frac{1}{S}\). Therefore, we have:

\[
\begin{align*}
E(\tau_i, m_1) &= a_i \quad \text{and} \quad R(\tau_i, m_1) = e^{-\frac{a_i}{S}} \\
E(\tau_i, m_2) &= \frac{a_i}{S} \quad \text{and} \quad R(\tau_i, m_2) = e^{-a_i}
\end{align*}
\]

Finally, we let \(\mathcal{E} = \frac{1}{2}(S + 1)\) and \(\mathcal{R} = e^{-\frac{1}{2}(S+1)} = e^{-\mathcal{E}}\).

One can easily check that the size of \(I_2\) is polynomial in the size of \(I_1\), that all the \(E(\tau_i, m_k)\)'s are positive and that all the \(R(\tau_i, m_k)\)'s are strictly between 0 and 1.

Let us consider any mapping of the \(M\) tasks on the two processors. Let \(A\) be the index set of tasks mapped on processor 1 in this mapping, and let

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\( A = \sum_{i \in A} a_i \). The total energy \( E \) consumed by this mapping is:

\[
E = \left( \sum_{1 \leq i \leq N} E(\tau_i, m_1) \right) + \left( \sum_{1 \leq i \leq N} E(\tau_i, m_2) \right)
\]

\[
= \left( \sum_{1 \leq i \leq N} a_i \right) + \left( \sum_{1 \leq i \leq N} \frac{a_i}{S} \right)
\]

\[
= A + \frac{1}{S}(S - A)
\]

\[
= A \left( 1 - \frac{1}{S} \right) + 1 = A \frac{S - 1}{S} + 1
\]

The reliability \( R \) of the whole set of tasks is:

\[
R = \left( \prod_{1 \leq i \leq N} R(\tau_i, m_1) \right) \times \left( \prod_{1 \leq i \leq N} R(\tau_i, m_2) \right)
\]

Taking logarithms, we obtain:

\[
\ln(R) = \left( \sum_{1 \leq i \leq N} \ln(R(\tau_i, m_1)) \right) + \left( \sum_{1 \leq i \leq N} \ln(R(\tau_i, m_2)) \right)
\]

\[
= \left( \sum_{1 \leq i \leq N} \frac{-a_i}{S} \right) + \left( \sum_{1 \leq i \leq N} (-a_i) \right)
\]

\[
= \left( -\frac{A}{S} \right) + (- (S - A))
\]

\[
= -S + \mathcal{A}(1 - \frac{1}{S}) = -S + \mathcal{A} \frac{S - 1}{S}
\]
Now let us assume that $\mathcal{I}_2$ has a solution:

$\begin{align*}
\begin{cases}
E \leq \mathcal{E} \\
R \geq \mathcal{R}
\end{cases} & \iff \\
\begin{cases}
E \leq \mathcal{E} \\
\ln(R) \geq \ln(\mathcal{R})
\end{cases}
\end{align*}$

$\begin{align*}
\begin{cases}
A \frac{S - 1}{S} + 1 \leq \frac{1}{2}(S + 1) \\
-S + A \frac{S - 1}{S} \geq -\frac{1}{2}(S + 1)
\end{cases} & \iff \\
\begin{cases}
A \frac{S - 1}{S} \leq \frac{1}{2}(S - 1) \\
A \frac{S - 1}{S} \geq \frac{1}{2}(S - 1)
\end{cases}
\end{align*}$

Therefore, $\mathcal{I}_2$ has a solution if and only if $\mathcal{I}_1$ has a solution.

---

3 Mapping

In the mapping phase, we need to define the number of replicas for each task, as well as the execution processor for every replica, aiming at meeting the reliability target while minimizing the energy cost. One difficulty introduced by platform heterogeneity is that we do not know the number of replicas needed for each task to reach its reliability threshold, before completing the mapping process, because different processors have different failure rates and speeds and, hence, they provide different reliabilities for each replica. Therefore, the simpler three-step method of [10, 8] cannot be applied.

As shown in Algorithm 1, given a set of tasks with their reliability targets and a set of heterogeneous processors, we first order the tasks according to TASKMAPCRITERIA, which includes:

- $deW \ (inW)$: decreasing (increasing) average work size $\bar{c}_i = \frac{c_{i,1} + c_{i,2} + \cdots + c_{i,M}}{M}$;
- $deMinW \ (inMinW)$: decreasing (increasing) minimum work size $\bar{c}_i = \min_{1 \leq k \leq M} c_{i,k}$;
- $deMaxW \ (inMaxW)$: decreasing (increasing) maximum work size $\bar{c}_i = \max_{1 \leq k \leq M} c_{i,k}$;
- $random$: random ordering.
Then, for each task in the ordered list, we order the processors for mapping its replicas according to ProcMapCriteria, which includes:

- \textit{inE}: increasing energy cost;
- \textit{deR}: decreasing reliability;
- \textit{deP}: decreasing ratio of \( \frac{-\log_{10}(1-R(\tau_i,m_k))}{E(\tau_i,m_k)} \) (explained below);
- \textit{random}: random ordering.

### Table 2: Example

<table>
<thead>
<tr>
<th>( m_k )</th>
<th>( E(\tau_i,m_k) )</th>
<th>( R(\tau_i,m_k) )</th>
<th>( \frac{R(\tau_i,m_k)}{E(\tau_i,m_k)} )</th>
<th>( \frac{-\log_{10}(1-R(\tau_i,m_k))}{E(\tau_i,m_k)} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>0.9</td>
<td>0.9</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>0.99</td>
<td>0.495</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>0.99</td>
<td>0.99</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>0.9</td>
<td>0.45</td>
<td>0.5</td>
</tr>
</tbody>
</table>

We use the example shown in Table 2 to explain how to design a better criteria in ProcMapCriteria. Assume there are four processor sets with different energy and reliability configurations. Considering only the reliability, we cannot distinguish between the second and third sets. Apparently, the third set is better since its processors consume less energy and provide the same level of reliability. The problem is the same when ordering processors only according to energy cost. This gives us a hint that we need to consider energy and reliability interactively. A first idea would be to use the ratio \( \frac{R(\tau_i,m_k)}{E(\tau_i,m_k)} \), which expresses the reliability per energy unit of task \( \tau_i \) executing on processor \( m_k \). But consider a task instance with a reliability target \( R_i = 0.98 \): it requires either one processor from the second set or two processors from the first set. Both solutions match the reliability goal with the same energy cost 4. We aim at a formula that would give the same weight to both solutions. The ratio \( \frac{-\log_{10}(1-R(\tau_i,m_k))}{E(\tau_i,m_k)} \) is a good candidate, because the total energy cost is the sum of all processors while the reliability is a product. This discussion explains how we have derived the third criteria \( \textit{deP} \) in ProcMapCriteria, namely to order processors by decreasing ratio of \( \frac{-\log_{10}(1-R(\tau_i,m_k))}{E(\tau_i,m_k)} \).

For the mapping phase, we add replicas for task \( \tau_i \) in the order of the processor list until the reliability target \( \mathcal{R}_i \) is reached. The algorithm uses the probability of failure \( \text{PoF} = 1 - R(\tau_i) = \prod_{k \in \text{alloc}(i)} (1 - R(\tau_i,m_k)) \) (Equation (4)). The mapping process always ensures that: (i) no two replicas of the same task are assigned to the same processor; (ii) the utilization \( u_k \) of each processor does not exceed 1.
Algorithm 1: Replication setting and mapping

Input: A set of tasks \( \tau_i \) with reliability targets \( R_i \);
      a set of heterogeneous processors \( m_k \)
Output: An allocation \( \sigma_m \) of all replicas on the processors

begin
order all the tasks with TaskMapCriteria and renumber them \( \tau_1, \ldots, \tau_N \)
/* initialize the utilization of all processors to zero */
\( u \leftarrow [0, \ldots, 0] \)
/* iterate through the ordered list of tasks */
for \( i \in [1, \ldots, N] \) do
    /* order processors for each task */
    order all processors for task \( \tau_i \) with ProcMapCriteria and renumber
    them \( \text{proc}_1, \ldots, \text{proc}_M \)
    /* this ordered list may differ from task to task */
    \( k = 1 \)
    \( PoF = 1 \)
    while \( 1 - PoF < R_i \) do
        \( \text{temp} = u_k + u_{i,k} \)
        if \( \text{temp} \leq 1 \) then
            \( u_k = \text{temp} \)
            \( PoF = PoF \times (1 - R(\tau_i, m_k)) \)
            add one replica of \( \tau_i \) on \( \text{proc}_k \)
        end if
        \( k++ \)
    end while
    if \( k > m \) then
        return not feasible
    end if
end for
return \( \sigma_m \)
4 Scheduling

In the scheduling phase, we aim at ordering the tasks mapped on each processor, with the objective to minimize the energy consumption during execution. Recall that the success of any replica leads to the immediate cancellation of all the remaining replicas, a crucial source of energy saving. Our approach is to identify a primary replica for each task, then all its other replicas become secondaries. The goal of the proposed scheduling is to avoid overlap between the execution of the primary and secondary replicas for each task: the primary must be terminated as soon as possible, while the secondaries must be delayed as much as possible. Whenever a primary replica of a task succeeds, the energy consumption will be minimal for that task if no secondary replica has started executing yet. Our scheduling algorithm uses a layered approach: first we map the first replica of each task, which we call the primary replica; and then, in a round-robin fashion, we map the remaining replicas (if they exist), which we call the secondaries. Here is a detailed description of Algorithm 2:

1. First we order tasks by criterion TaskSchedCriteria, for which we propose:
   • deNR (inNR): decreasing (increasing) number of replicas;
   • deU (inU): decreasing (increasing) total utilization (sum up the utilization of all replicas);
   • random: random ordering.

2. Then we process the list of tasks in that order, and select a primary replica for each task, which we execute as soon as possible on its assigned processor, right after already scheduled primary replicas (if any). We use two different criteria PrimarySchedCriteria for selecting primary replicas:
   • time: choose the processor that can complete the execution of the replica the earliest (given already made scheduling decisions);
   • energy: choose the processor that can execute the replica with smallest dynamic energy.

3. Once primary replicas have all been scheduled, we reverse the order of the list of tasks, and we schedule the remaining replicas (considered in a round-robin fashion in the reversed list) as late as possible on their assigned processor. The idea is to minimize potential overlap between primary and secondaries for each task, hence to delay secondary replicas until the end of the period. The rationale for reverting the task list is that the primary replica of some task \( \tau \) at the end of the list may have been scheduled after some other primary replica \( \tau' \), hence the idea to process the secondary replica of \( \tau' \) before that of \( \tau \) and push it further away at the end of the period.
4. Finally, there only remains to detail which secondary replica of a task is scheduled first (whenever the task has three replicas or more). We also have two criteria \textsc{SecondarySchedCriteria} for choosing secondary replicas:

- \textit{time}: choose the replica whose start-up time can be the latest (given already made scheduling decisions); the idea is to minimize overlap by maximizing slack;
- \textit{energy}: choose the replica whose energy is the highest; the idea is again to minimize overlap, thereby increasing the probability of this costly replica to be cancelled.

As we have two different criteria for both selecting primaries and secondaries, in total, we have four possible combinations, namely time-time, time-energy, energy-time and energy-energy. For the baseline scheduling (\textit{randomShuffling}), we randomly order tasks on each processor and execute them in sequence and as early as possible (no idle time until the end of the period).

\begin{algorithm}
\hspace*{1em} \textbf{Input:} An allocation $\sigma_m$ of all replicas on the processors  \\
\hspace*{1em} \textbf{Output:} An order of execution on each processor  \\
\hspace{1em} \textbf{begin}  \\
\hspace{2em} order all the tasks with \textsc{TaskSchedCriteria} and renumber them $\tau_1, \ldots, \tau_N$  \\
\hspace{2em} /* insert the primary replica for each task at the beginning of each processor schedule */  \\
\hspace{2em} for $i \in [1, \ldots, N]$ do  \\
\hspace{3em} if \textsc{PrimarySchedCriteria} is “time” then  \\
\hspace{4em} schedule the primary replica of task $\tau_i$ that could finish at the earliest  \\
\hspace{3em} else if \textsc{PrimarySchedCriteria} is “energy” then  \\
\hspace{4em} schedule the primary replica of task $\tau_i$ that consumes the minimum energy  \\
\hspace{2em} /* insert the secondaries backwards from the end of each processor schedule */  \\
\hspace{2em} reverse the task ordering  \\
\hspace{2em} while there is still at least one replica to be scheduled do  \\
\hspace{3em} for $i \in [1, \ldots, N]$ do  \\
\hspace{4em} if there is still a replica of $\tau_i$ to be scheduled then  \\
\hspace{5em} if \textsc{SecondarySchedCriteria} is “time” then  \\
\hspace{6em} schedule the secondary replica of task $\tau_i$ that could start the latest  \\
\hspace{5em} else if \textsc{SecondarySchedCriteria} is “energy” then  \\
\hspace{6em} schedule the secondary replica of task $\tau_i$ that consumes the maximum energy
\end{algorithm}
5 Lower bound

In this section, we explain how to derive a lower bound for the expected energy consumption of a solution to the optimization problem, namely a mapping/scheduling heuristic that uses some of the selection criteria outlined in Sections 3 and 4.

For each problem input, namely $N$ tasks $\tau_i$ with reliability thresholds $R_i$, $M$ processors $m_k$ with failure rates $\lambda_k$, and with all WCET $c_{i,k}$, we compute a solution, i.e., a mapping and ordering of all replicas. We first use Monte-Carlo simulations (see Section 6) and generate several sets of values for the actual execution time $w_{i,k}$ of $\tau_i$ on $m_k$. The values $w_{i,k}$ are drawn uniformly across processors as some fraction of their WCET $c_{i,k}$ (refer to Section 6.1 for details).

Now, for each set of values $w_{i,k}$, we generate a set of failure scenarios, compute the actual energy consumed for each scenario, and report the average of all these values as the expected energy consumption. A failure scenario operates as follows. We call an event the end of the execution of a task replica on some processor. At each event, we flip a biased coin (weighted with the probability of success of the replica on that processor) to decide whether the replica is successful or not. If it is, we delete all other replicas of the same task. At the end of the execution, we record all the dynamic energy that has been actually spent, accounting for all complete and partial executions of replicas, and we add the static energy given by Equation (3). This leads to the energy consumption of the failure scenario. We average the values over all failure scenarios and obtain the expectation, denoted as $E\left(\{w_{i,k}\}\right)$.

In addition, we also compute a lower bound $LB\left(\{w_{i,k}\}\right)$ as follows. Our goal is to accurately estimate the energy consumption of an optimal solution. Because the static energy depends upon the subset of processors that are used in the solution (see Equation (3)), we need to try all possible subsets. Given a processor subset $S$, we consider each task $\tau_i$ independently, and try all possible mappings of replicas of $\tau_i$ using only processors in $S$. Thus we explore all subsets $T$ of $S$. A subset $T$ is safe if mapping a replica of $\tau_i$ on each processor of $T$ meets the reliability criteria $R_i$, and if no strict subset of $T$ is safe. Note that safe sets are determined using the WCETs $c_{i,k}$, and not using the $w_{i,k}$, because this is part of the problem specification. Now for each safe subset $T$, we try all possible orderings (there are $k!$ of them if $|T| = k$); for each ordering, we compute the expected value of the dynamic energy consumption as follows: if, say, $T = \{m_1, m_3, m_4\}$ and the ordering is $m_3, m_4, m_1$, then we compute

$$P_{3,d}w_{i,3} + (1 - e^{-\lambda_3 w_{i,3}})P_{4,d}w_{i,4} + (1 - e^{-\lambda_3 w_{i,3}})(1 - e^{-\lambda_4 w_{i,4}})P_{1,d}w_{i,1}.$$

We see that we optimistically assume no overlap between the three repli-
cas, and compute the dynamic energy cost as the energy of the first replica (always spent) plus the energy of the second replica (paid only if the first replica has failed) plus the energy of the third replica (paid only if both the first and second replicas have failed). Note that here we use execution times and failure probabilities based upon the actual execution times $w_{i,k}$ and not upon the WCETs $c_{i,k}$. The value of the sum depends upon the ordering of the processors in $T$, hence we check the 6 orderings and retain the minimal value. We do this for all safe subsets and retain the minimal value. Finally we sum the results obtained for each task and get the lower bound for the original processor subset $S$. We stress that this bound is not necessarily tight, because our computation assumes no overlap for any replica pair, and does not check the utilization of each processor (which may exceed 1). The final lower bound $LB(\{w_{i,k}\})$ is the minimum over all processor subsets. Although the computation has exponential cost, due to the exploration of all processor subsets $S$, the computation of the expected energy for a given ordering in a subset $T$ of $S$ obeys a closed-form formula.

6 Performance evaluation

This section assesses the performance of our different strategies to map and schedule real-time tasks onto heterogeneous platforms. In Section 6.1, we describe the parameters and settings used during the experimental campaign. We present the results in Section 6.2. The algorithms are implemented in C++ and in R. The related code, data and analysis are publicly available in [1].

6.1 Experimental methodology

In the experiments, we have $M = 10$ processors and $N = 20$ tasks which have all the same period $p = 100$. The set of WCETs is generated by the method proposed in [2], as mentioned in Section 2.1. The WCET values are controlled by the correlation factor between the different tasks ($\text{cor}_{\text{task}}$) and between the different processors ($\text{cor}_{\text{proc}}$). These two parameters vary between 0 and 1.\footnote{We ignored the case when $\text{cor}_{\text{task}} = 0$ and $\text{cor}_{\text{proc}} = 1$ for the parameter set with big failure rate, because when tasks are completely unrelated, there (very likely) is a task with very long execution time on all processors ($\text{cor}_{\text{proc}} = 1$). The number of replicas needed to meet its reliability goal will exceed the number of available processors.} For example, $\text{cor}_{\text{task}} = 0$ (resp. $\text{cor}_{\text{proc}} = 0$) means that the WCET values between different tasks on one processor (resp. between different processors for one task) are completely randomly generated. Inversely, $\text{cor}_{\text{task}} = 1$ (resp. $\text{cor}_{\text{proc}} = 1$) means that the WCET values between different tasks on one processor (resp. between different processors for one task) are all the same. We also define a parameter basicWork as the
estimated total utilization of the system with a single replica per task, in
order to study the impact of system pressure:

\[
basicWork = \sum_{i,k}^{c_{i,k}}\frac{M^2p}{M^2} = \sum_{i,k}^{u_{i,k}}\frac{M^2}{M^2}
\]  

(5)

In Equation (5), we use the average WCETs on the \( M \) processors \( \sum_{i,k}^{c_{i,k}} \) to estimate the execution time of task \( \tau_i \). We have \( M \) processors available
during period \( p \), hence \( basicWork \) represent an estimate of the fraction of time
processors are used if each task has a single replica. In the experiments, we vary \( basicWork \) from 0.1 to 0.3.

To generate the actual execution times of tasks from their WCETs, we
use two parameters. The first one, \( \beta_{b/w} \), is global to all tasks: \( \beta_{b/w} \) is
the ratio between the best-case execution time and the worst-case execution
time. It is the smallest possible ratio between the actual execution time of
a task and its WCET. Therefore, the actual execution time of task \( \tau_i \) on
processor \( m_k \) belongs to \([\beta_{b/w}c_{i,k}, c_{i,k}]\). We consider five possible values of
\( \beta_{b/w} \): 0.2, 0.4, 0.6, 0.8, and 1. The second parameter, \( \beta_i \), is task dependent:
\( \beta_i \) describes whether the instance of a task is a small one or a large one. \( \beta_i \) is
randomly drawn in \([0,1]\). A value of \( \beta_i = 0 \) means that task \( \tau_i \) has the
shortest execution time possible, and \( \beta_i = 1 \) means that the actual execution
is equal to its worst case execution time. Overall, the actual execution time
of task \( \tau_i \) on processor \( m_k \) is thus defined as:

\[
w_{i,k} = (\beta_{b/w} + (1 - \beta_{b/w})\beta_i)c_{i,k}
\]

For a processor \( m_k \) in the platform, we fix the static power \( P_{k,s} \) at 0.001
as in previous papers [21, 20, 24]. But for the dynamic power and the failure
rate, we have two sets of parameters. The first set also follows values similar
to those of the previous papers [21, 20, 24]. For this set, we have a relatively
large power and a very small failure rate. Therefore, the replicas using this
first set of parameters succeed in almost all cases. Thus, to evaluate our
heuristics in the context when failures occur more frequently, we introduce a
second set of parameters where the replicas have a smaller power and a larger
failure rate. For the first set, we choose randomly the dynamic power \( P_{k,d} \)
between 0.8 and 1.2, and the failure rate \( \lambda_k \) between 0.0001 and 0.00023.
And for the second set, we have \( P_{k,d} \) 10 times smaller (between 0.08 and
0.12), and \( \lambda_k \) 100 times larger (between 0.01 and 0.023). With the second
set of parameters, the actual reliability of one replica ranges from 0.1 to 0.99.
To be more realistic, in our experiments, processors with a larger dynamic power \( P_{k,d} \) have a smaller failure rate \( \lambda_k \). It means that, a more reliable
processor costs always more energy than a less reliable one. We guarantee
this by ordering inversely the \( P_{k,d} \)’s and the \( \lambda_k \)’s after generating the random
values.

We vary the local reliability target \( R_i \) between 0.9 and 0.98 for the first
set and between 0.8 and 0.95 for the second set. This is to give the system a
reasonable freedom while mapping and scheduling. The reliability target is

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relatively high, implying that tasks need plural replicas to reach it. Therefore, we give more tolerance (smaller reliability threshold) to the second set with a larger failure rate, because otherwise we may not be able to find feasible mappings.

Table 3: Ratio of energy consumption to the baseline of different mapping and scheduling ordering tasks criteria

<table>
<thead>
<tr>
<th>map</th>
<th>sch</th>
<th>deNR</th>
<th>inNR</th>
<th>deU</th>
<th>inU</th>
<th>random</th>
</tr>
</thead>
<tbody>
<tr>
<td>deW</td>
<td>0.5655</td>
<td>0.5662</td>
<td>0.5655</td>
<td>0.5660</td>
<td>0.5663</td>
<td></td>
</tr>
<tr>
<td>inW</td>
<td>0.5631</td>
<td>0.5635</td>
<td>0.5630</td>
<td>0.5635</td>
<td>0.5635</td>
<td></td>
</tr>
<tr>
<td>deMinW</td>
<td>0.5658</td>
<td>0.5662</td>
<td>0.5657</td>
<td>0.5661</td>
<td>0.5665</td>
<td></td>
</tr>
<tr>
<td>inMinW</td>
<td>0.5637</td>
<td>0.5642</td>
<td>0.5637</td>
<td>0.5642</td>
<td>0.5641</td>
<td></td>
</tr>
<tr>
<td>deMaxW</td>
<td>0.5658</td>
<td>0.5664</td>
<td>0.5657</td>
<td>0.5663</td>
<td>0.5665</td>
<td></td>
</tr>
<tr>
<td>inMaxW</td>
<td>0.5639</td>
<td>0.5633</td>
<td>0.5629</td>
<td>0.5633</td>
<td>0.5633</td>
<td></td>
</tr>
<tr>
<td>random</td>
<td>0.5633</td>
<td>0.5639</td>
<td>0.5633</td>
<td>0.5638</td>
<td>0.5639</td>
<td></td>
</tr>
</tbody>
</table>

6.2 Results

In this section, we analyze the impact of the different parameters on the performance of the heuristics. Due to lack of space, we will only analyze in detail a set of representative results in the paper. The comprehensive set of all results is available in the appendix. We choose as default values $\beta_{b/w} = 1$, basicWork = 0.3, $R_i = 0.95$ for the set with big failure rate, and $R_i = 0.98$ for the set with small failure rate. This set of parameters is chosen to constrain the solution so that we can observe the most interesting results. For cor\textsubscript{task} and cor\textsubscript{proc}, we fix them at 0.5 as default value. Each experiment is the average of 10 sets of WCET values. For each set, we generate 10 sets of random $P_{k,d}$ and $\lambda_k$ values. For each $P_{k,d}$ and $\lambda_k$ generated, the final result is the average of 10 executions. Overall, we run 1,000 randomly generated experiments for each set of $\beta_{b/w}$, basicWork, $R_i$, cor\textsubscript{task} and cor\textsubscript{proc} values. The total number of experiments ran is 3,075,000 for each heuristic. Each result is represented as a ratio to the random baseline method which is defined as follows: for each task, we add replicas randomly on available processors until reaching its reliability target during the mapping phase; for scheduling, we randomly order replicas mapped on each processor and execute them in sequence and as soon as possible. We also compare different strategies with the lower bound proposed in Section 5. We report on these figures the average number of replicas needed in total for 20 tasks (on the left side) and of failures that occur for the 1,000 random trials for each setting (on the right side). These numbers are reported in black above the horizontal axis in each figure.
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6.2.1 Ordering tasks for mapping and scheduling

In Table 3, we calculated the ratio of combinations of different mapping and scheduling methods to the baseline method, when considering different criteria for ordering tasks. We can see that, in the whole set of experiments, all criteria for ordering tasks perform equally well (around 56%). The difference between the best and the worst performance is only around 0.36%. Hence these criteria do not critically influence energy consumption. In the following results, for the task ordering, we only consider the decreasing average WCET ($deW$) for the mapping, and the decreasing utilization ($deU$) for the scheduling, which give priority to the tasks that putting more pressure to the system. We then focus on selecting processors during the mapping phase, and on choosing primary and secondary replicas during the scheduling phase.

6.2.2 Processor correlation

Figures 1 and 2 show results when processor correlation varies, under small and big failure rate respectively. We found that our strategies consume less than 25% of the energy needed by the baseline strategy when $cor_{proc} = 0$, and the result is close to the lower bound. But we can observe that this percentage increases with $cor_{proc}$.

For the mapping phase, in Figure 1a we observe that, in the small failure rate case, ordering the processors by decreasing reliability ($deR$) has a worse performance than ordering them by increasing energy cost ($inE$) or decreasing proportion ($deP$) in nearly all cases. This is reasonable because, in this case, the reliability of all tasks on all processors is relatively high. Therefore, we cannot have significant improvements by using more reliable processors, but these can cost much more energy. Furthermore, $inE$ and $deP$
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Figure 2: Ratio of energy consumption using different mapping and scheduling strategies under big failure rate, when varying \( \text{cor}_{\text{proc}} \), with basicWork = 0.3, \( \beta_{b/w} = 1 \), \( R_i = 0.95 \) and \( \text{cor}_{\text{task}} = 0.5 \).

(a) Comparing mapping strategies when using time-time as scheduling strategy

(b) Comparing scheduling strategies when using deP as mapping strategy

perform similarly and have a performance close to that of the lower bound, except when \( \text{cor}_{\text{proc}} \approx 1 \). In the big failure rate case (Figure 2a), we see that, when \( \text{cor}_{\text{proc}} \) is not equal to 1, inE performs better than deR. But when \( \text{cor}_{\text{proc}} \) increases to 1, the performance of deR catches up. And in all cases, deP performs better than, or similarly to the best strategy between deR and inE.

And for the scheduling strategies, Figure 1b and 2b show that, there is little difference between our different criteria, the random one excepted. But we can still observe more difference in the big failure rate case. With \( \text{cor}_{\text{proc}} \neq 1 \), we have energy criteria for primary replica choosing slightly better than time, and when \( \text{cor}_{\text{proc}} = 1 \), the energy becomes worse than the time.

This is because, for most of the cases, the reliability of our replica is high, so that we can simply choose the replica which costs the least energy as primary, and delete all secondary when it finishes successfully. But in the case of \( \text{cor}_{\text{proc}} = 1 \), the WCETs of each task on different processors are the same, so the order of the processors for any task is the same, and is relative to the power and reliability parameters (\( P_{k,d} \) and \( \lambda_k \)). This can result in a few fully used processors, with the other processors being empty. Also, for time criteria, primary replicas will be randomly balanced on different fully used processors, because every replica of a task has the same WCET. But for energy, the processors which cost less energy are the same for all tasks. Then these processors will execute all mapped replicas as primary, and others will execute all mapped replicas as secondary, which increases the overlap. This is why, when \( \text{cor}_{\text{proc}} = 1 \), we cannot save as much energy as in other cases, and this is why the energy criteria performs worse than the time criteria.
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Figure 3: Ratio of energy consumption using different mapping and scheduling strategies under small failure rate when varying $\beta_{b/w}$, with basicWork = 0.3, $R_i = 0.98$ and cor\_task = 0.5.

Figure 4: Ratio of energy consumption using different mapping and scheduling strategies under big failure rate when varying $\beta_{b/w}$, with basicWork = 0.3, $R_i = 0.95$ and cor\_task = 0.5.

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6.2.3 Task variability

Figures 3 and 4 present the results with small and big failure rates when $\beta_{b/w}$ varies. We observe that, for almost all the mapping and scheduling criteria, the results are similar whatever the value of $\beta_{b/w}$. This is because we map and schedule tasks based on their WCETs, so the mapping and scheduling results are independent of the value of $\beta_{b/w}$. Furthermore, each task $i$ has the same $\beta_i$ on the different processors. Therefore the energy consumption ratios tend to be similar. But in the case of $\text{cor}_{\text{proc}} \approx 1$, we can see from Figure 4b (under big failure rate where more than one replica per task needed) that the ratio of all scheduling criteria increases slightly with $\beta_{b/w}$, and the two strategies using $\text{energy}$ as primary replica choosing criteria increase faster than the two others which use $\text{time}$. In fact, when we have a larger value of $\beta_{b/w}$, the actual execution time is closer to the WCET. So that, although the mappings and schedulings are the same for different $\beta_{b/w}$, replicas will take longer time during the actual execution. At the same time, as explained in the previous paragraph, we have a more serious overlap in the case of $\text{cor}_{\text{proc}} = 1$ and for $\text{energy}$ criteria. This is why $\text{cor}_{\text{proc}} = 1$ performs differently when varying $\beta_{b/w}$. However this phenomenon is not obvious ($\approx 5\%$), so we can always conclude that the result is independent of $\beta_{b/w}$. When $\beta_{b/w}$ is small, actual execution times can greatly differ from the WCETs used for mapping and scheduling. However, in this case, our heuristics have a performance similar to that of the lower bound, which shows that they are very robust.

Figure 5: Ratio of energy consumption using different mapping and scheduling strategies when varying $\text{basicWork}$ and $R_i$, under small failure rate, with $\beta_{b/w} = 1$ and $\text{cor}_{\text{task}} = 0.5$. 

(a) Comparing mapping strategies when using time-time as scheduling strategy

(b) Comparing scheduling strategies when using $\text{deP}$ as mapping strategy
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6.2.4 Utilization and reliability threshold

From Figures 5 and 6, we observe the performance of different mapping and scheduling criteria when varying $\text{basicWork}$ and $\mathcal{R}_i$. We remark that the results are similar under big and small failure rates when we have $\text{cor}_{\text{proc}}$ not close to 1. For example, we can see the case $\text{cor}_{\text{proc}} = 0.5$ in the first row of Figures 5 and 6. During the mapping phase, $\text{deR}$ has a slightly worse performance than $\text{inE}$ and $\text{deP}$, which perform similarly to the lower bound. During the scheduling phase, all criteria have similar performance, including the random strategy and the lower bound.

On the contrary, with $\text{cor}_{\text{proc}} \approx 1$, the heuristics perform differently with big and low failure rates. For the small failure rate, during the mapping phase, we see from the second row of Figure 5a that $\text{deR}$ is worse than $\text{inE}$ and $\text{deP}$ and has a performance similar to the random case, while $\text{inE}$ and $\text{deP}$ provide results similar to the lower bound. During the scheduling phase, all criteria have similar performance, including the random strategy and the lower bound. For the big failure rate case, during the mapping phase, the second row of Figure 6a shows that the difference between different criteria becomes smaller when $\text{basicWork}$ and $\mathcal{R}_i$ increase. Inversely, the difference with the lower bound becomes larger, but it is still less than 10% (except random), even in the worst case. For small values of $\text{basicWork}$ and $\mathcal{R}_i$, $\text{deR}$ performs worse, but when $\text{basicWork}$ and $\mathcal{R}_i$ increase, $\text{deR}$ becomes similar to $\text{inE}$, or even better. $\text{deP}$ has always better or similar performance than $\text{deR}$ and $\text{inE}$. For the scheduling phase, from the second row of Figure 6b, we can still find similar performance on all our criteria, but their difference with the lower bound increases to 10% as in the mapping phase. The reason is that with the increase of system load, it becomes harder to map all replicas to
their best processors, while the lower bound is calculated without considering utilization constraints.

6.2.5 Number of failures

We counted the number of replicas that failed during the execution in each experiment. In the set with small failure rate, we have on average 0.44% failed replicas. Thus, in most of the cases, it is enough to have a single replica mapped on the processor that costs the least energy, because failures are scarce. On the contrary, in the set with big failure rate, the average rate of failed replicas increases to 7.57%. We can observe that the deP mapping method used in conjunction with time criterion for choosing primary replica when processors are highly correlated, or with energy criterion in other cases achieves the best performance, or a performance similar to the best observed one, in both cases. This confirms that the performance of our best heuristics is not affected by the failure rate.

6.2.6 Success rate

All the tested heuristics were able to find a valid solution in all tested configurations with small failure rate. And in the big failure rate cases, heuristics were able to build valid solutions for more than 99.94% of the instances. The very high success rate of our experiments shows the robustness of our approach.

6.2.7 Summary

In conclusion, our strategies can save more than 40% of the energy consumed by the baseline, except in the high processor correlation case. The ratio to the baseline can be as low as 20% in the best case.

As for the different criteria used in the heuristics, we find that the deP method is the best processor ordering during the mapping phase.

For scheduling, we can find from the result that, all our primary-secondary choosing criteria have a similar result as the lower bound, except a difference of 10% in the case of $\text{cor}_{\text{proc}} \approx 1$. This means that our primary-secondary choosing heuristic performs well. On the other hand, we point out that strategies with the same method for choosing the primary replica but different methods for choosing secondary replicas, perform similarly. Hence the strategy for choosing the primary replica has much more impact than the one for choosing secondary replicas. We can find that, time-time and time-energy criteria performs better when $\text{cor}_{\text{proc}} \approx 1$, and energy-energy and energy-time have better performance in other cases.

The performance of these best heuristics is only 17.0% higher than the lower bound in the worst case. Furthermore, we report a median value only 3.5% higher than that of the lower bound; and the average value is only
4.3% higher. We can confidently conclude that our best strategies perform remarkably well over the whole experimental setting.

7 Related work

7.1 Scheduling for heterogeneous platforms

There is a huge literature on scheduling for heterogeneous platforms, and even dedicated workshops. Here, we only refer some very recent work closely related to our problem but dealing with non-periodic tasks. [20] maximizes the reliability of an energy-constrained DAG executed on a heterogeneous platform while using DVFS. Conversely, [24] minimizes the energy consumption of a reliability-constrained DAG executed on a heterogeneous platform while using or not DVFS. A group of authors published a book [22] and several articles on the problem of DAG scheduling on heterogeneous platforms. In Chapter 2 of book [22] and in [23] these authors consider the energy minimization when scheduling a DAG with or without DVFS. In [21] they considered the same problem while satisfying some reliability goal. However, these two results do not consider reliability.

Overall, these studies do not consider real-time applications. The deadlines constraining real-time tasks and applications make problems significantly harder to tackle.

7.2 Scheduling of real-time applications on homogeneous platforms

There is a very significant literature on real-time scheduling for multiprocessor systems. However, most work is devoted to homogeneous processor systems, as exemplified by the survey [3] which ignores altogether heterogeneous systems, and by the more recent survey [16] where only 9 of the 78 references deal with heterogeneous platforms. [10] minimizes the energy when scheduling independent tasks with different deadlines on a homogeneous platform while satisfying some threshold on reliability. The study [8] improved the solution from [10] in particular by carefully avoiding overlaps between primary and secondary replicas. [9] considers the same problem; however, it uses checkpointing to cope with failures when all other work consider replication.

We refer the interested reader to [8, 10, 3, 16] for a comprehensive overview of the related work for homogeneous platforms. Heterogeneous platforms make the problem even harder because processors can have different speeds, energy costs, and failure rates. Therefore, the processor preferred for one task by one of the objectives and constraints—deadline satisfaction, energy minimization, reliability threshold satisfaction—may be the worst
processor for another objective or constraint. Heuristics have thus to perform complicated trade-offs in our three-criteria settings.

7.3 Scheduling of real-time applications on heterogeneous platforms

Some related work targets the scheduling of real-time applications on heterogeneous platforms, but without considering fault tolerance. For instance, [27] targets the execution of a DAG, but considering neither energy consumption nor fault-tolerance (when DAGs are scheduled, tasks are always assumed to have the same deadline). [7] targets the execution of independent tasks that access shared resources, the access to resources being exclusive. Their objective is to maximize the number of instances for which a solution is found. [12], [15] and [26] minimize energy consumption by using DVFS, [12] when scheduling independent tasks, [15] a DAG, and [26] a moldable application. [19] considers the scheduling of independent tasks and DAGs under an energy constraint, while [18] considers the scheduling of independent tasks under a thermal constraint. [25] proposes a fully polynomial-time approximation scheme (FPTAS) for minimizing the energy consumption for a set of independent tasks executed on a set of heterogeneous (unrelated) processing elements.

Some of the related work considers the execution of real-time applications on heterogeneous failure-prone platforms but is limited to coping with a single failure per task or per processor. [13] maximizes the reliability of the considered DAG but does not consider energy consumption and follows the primary/backup technique and, thus, is limited to at most one failure per task of the DAG. [14] attempts to maximize resource utilization (and does not consider energy) when scheduling a set of independent tasks. It assumes that at most one processor can fail, which enables the simultaneous scheduling of several backup tasks on the very same processor as at most one of them will need to be executed. [11] minimizes the energy consumed for the execution of a DAG while satisfying a reliability threshold. The proposed solution uses DVFS and Power Mode Management (i.e., the ability to switch off idle processors to low-power inactive state). This solution, however, cannot produce a schedule more reliable than the original one. It also supports at most one fault per processor. [6] minimizes the energy consumed for the execution of a set of independent tasks while satisfying a reliability threshold using DVFS and following a primary-backup approach.

Very few studies consider the execution of real-time applications on heterogeneous failure-prone platforms and can cope with two or more failures per task. [17] minimizes the energy consumed for the execution of a set of independent tasks while satisfying a reliability threshold. The proposed solution uses DVFS. This solution, however, is based on a primary-backup approach that is then extended. This approach, by design, cannot produce
a schedule more reliable than the original one with two replicas per task, strongly relies on DVFS, and schedules several replicas of a same task on the same processor (what most other approaches forbid). [5] targets the execution of a DAG on a heterogeneous platform while satisfying a reliability threshold. However, the objective is not the minimization of energy consumption but the maximization of the utilization of energy consumption, which can be seen as a yield of reliability improvement with respect to increase energy consumption. As a consequence, [5] produces energy greedy schedules (see subplots (a-1), (b-1), and (c-1) of Figure 1 in [5]). In Chapter 3 of the already mentioned book [22], the authors consider cost minimization (which can be energy minimization) when scheduling a DAG under deadline and reliability constraints. Therefore, we consider the same problem but for a set of independent tasks rather than for a DAG. Because of the dependence between tasks and the chosen as-soon-as-possible scheduling of [22], this solution tends to schedule simultaneously the different replicas of a single task. As already pointed out in the studies [8, 10] that this can lead to a significant waste of energy. Therefore, it would have been unfair to compare our solution to that of [22] applied on independent tasks.

From what precedes, we have only identified a single existing solution that enables to schedule real-time tasks on heterogeneous platforms while minimizing energy consumption and satisfying some bound on the overall reliability. However, this solution being dedicated to DAGs lacks the possibility to minimize the overlapping between replicas of a same task, what have been previously proved to be crucial [8] and what we specifically targeted (cf. Section 4).

8 Conclusion

In this work, we have studied the problem of executing periodic real-time tasks on an heterogeneous platform, with several objectives: minimizing the energy consumption, guaranteeing some reliability thresholds, and meeting all deadlines. For each task, we decide how many replicas should be launched, and on which processors to map them. We tagged one replica per task as “primary” replica and the other ones as “secondary” replicas. To obtain an absolute measure for the evaluation of our heuristics, we have computed a theoretical lower bound on energy consumption. Extensive simulations show that our best heuristic always achieve very good performance, very close to the lower bound (on average only 4% higher than this lower bound). This performance was reached by considering processors in the deP order when mapping the replicas of a task (roughly speaking, deP is the ratio of a task failure rate by its energy cost), by executing primary replicas as soon as possible and secondary ones as late as possible, and by tagging replicas as “primary” using an earliest completion time criterion when processors are
highly correlated, using an smallest energy criterion otherwise. Furthermore, while all decisions are taken with the worst-case execution times (WCETs) of tasks as only input, the simulations used the actual execution times; the best heuristic always achieved excellent performance even when the actual execution times were far smaller than the WCETs, showing the robustness of our approach.

Future work will aim at extending the algorithms to periodic graphs of tasks instead of independent task sets. The dependences between tasks will dramatically complicate the mapping and scheduling problems.

Acknowledgments

This paper is partially supported by funding under Chinese National Key Research, Development Project 2017YFB1001800, NSFC 61972150, 61572195, and a JORISS grant from ENS de Lyon and ECNU. The work of Yiqin Gao was supported by the LABEX MILYON (ANR-10-LABX-0070) of Université de Lyon, within the program “Investissements d’Avenir” (ANR-11-IDEX-0007) operated by the French National Research Agency (ANR). Corresponding author is Yiqin GAO.

References


RR n° 9324
\( \beta_{b/w} \) (Mapping)

The following section presents ratio of energy consumption using different mapping strategies under big failure rate when varying \( \beta_{b/w} \).
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{task}} = 0.25; \ \text{basicWork} = 0.1; \ \mathcal{R} = 0.85 \)

---

**Mapping**
- LowerBound
- deP
- deR
- inE
- random

---

RR n° 9224

Energy-aware strategies on heterogeneous platforms

34
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.25; \text{basic Work} = 0.1; \mathcal{R} = 0.9 \]
Energy-aware strategies on heterogeneous platforms

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**cor proc** = 0.25

**baselWork** = 0.45

**R** = 0.95

**RR** = 0.9324
Energy-aware strategies on heterogeneous platforms

\( \text{corr}_{\text{task}} = 0.25; \ \text{basicWork} = 0.2; \ \text{R} = 0.8 \)
### Energy-aware strategies on heterogeneous platforms

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**Mapping Details:**

- $\beta_{	ext{b/w}}$
- Random
- $\lambda_{\text{basicWork}} = 0.25$
- $R = 0.85$

**Ratio to the Baseline:**

- $\text{LowerBound}_{\text{deP}}$
- $\text{deP}_{\text{dP}}$
- $\text{deR}_{\text{dP}}$

RR n° 3924
Energy-aware strategies on heterogeneous platforms

![Graph showing energy-aware strategies on heterogeneous platforms](image-url)
Energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{task}} = 0.25; \text{basicWork} = 0.3; R = 0.85 \)
\( \text{cor}_{\text{task}} = 0.25; \text{basicWork} = 0.3; \mathcal{R} = 0.9 \)
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.25; \text{basicWork} = 0.3; \text{R} = 0.95 \]
Energy-aware strategies on heterogeneous platforms

![Diagram of energy-aware strategies on heterogeneous platforms](image-url)
$\text{cor}_{\text{task}} = 0.5; \text{basicWork} = 0.1; R = 0.95$

Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

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Energy-aware strategies on heterogeneous platforms

cor\textsubscript{task} = 0.5; basicWork = 0.2; \mathcal{R} = 0.95

\begin{figure}
\centering
\includegraphics[width=\textwidth]{figure.png}
\caption{Ratio to the baseline}
\end{figure}
Energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{task}} = 0.5; \text{basicWork} = 0.3; R = 0.8 \)

![Graph showing energy-time and time-energy relationships]
Energy-aware strategies on heterogeneous platforms

<table>
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<tr>
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Ratio to the baseline

$\beta_{b/w}$

LowerBound, deP, deR, inE, random
### Energy-aware strategies on heterogeneous platforms

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**Mapping**

- LowerBound
- deP
- deR
- inE
- Random
- BasicWork
- R

**RR n° 9324**
$\text{cor}_{\text{task}} = 0.75$; $\text{basicWork} = 0.1$; $\mathcal{R} = 0.8$
\begin{align*}
cor_{\text{task}} &= 0.75; \quad basicWork = 0.1; \quad R = 0.85
\end{align*}
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.75; \text{basicWork} = 0.1; \mathcal{R} = 0.9 \]
\( \text{cor}_{\text{task}} = 0.75; \text{basicWork} = 0.1; \mathcal{R} = 0.95 \)

Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

cor\_task = 0.75; basicWork = 0.2; R = 0.8
$cor_{task} = 0.75$; $\text{basicWork} = 0.2$; $R = 0.85$
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Ratio to the baseline

RR n° 9324
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.75; \quad \text{basicWork} = 0.3; \quad R = 0.8 \]
Energy-aware strategies on heterogeneous platforms

cor\_task = 0.75; basic\_Work = 0.3; R = 0.85

![Graph showing energy-efficiency ratios for different values of cor\_proc and cor\_task.](image)

- Mapping: LowerBound, deP, deR, inE, random
- x-axis: \( \beta / \omega \) - y-axis: Ratio to the baseline

- Various lines representing different mapping strategies (LowerBound, deP, deR, inE, random) for varying cor\_proc and cor\_task values.
Energy-aware strategies on heterogeneous platforms

$$\text{cor}_{\text{task}} = 0.75; \text{basicW}_{\text{ork}} = 0.3; \mathcal{R} = 0.9$$
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.75; \text{basicWork} = 0.3; \ R = 0.95 \]

\( \text{mapping} = \text{LowerBound, deP, deR, inE, random} \)
Energy-aware strategies on heterogeneous platforms

RR n° 9324
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 1; \text{basicWork} = 0.1; R = 0.85 \]

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*Diagram showing the relationship between energy and time for different correlation values.*

**Mapping:** LowerBound, deP, deR, inE, random

**Legend:**
- LowerBound
- deP
- deR
- inE
- random
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

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Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 1; \text{basicWork} = 0.2; \mathcal{R} = 0.8 \]

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\[ \text{Ratio to the baseline} \]

\[ \beta_{\text{b/w}} \]

\[ \text{LowerBound} \]
\[ \text{deP} \]
\[ \text{deR} \]
\[ \text{inE} \]
\[ \text{random} \]

\[ \text{Energy} \]
\[ \text{Time} \]
\[ \text{Random Shuffling} \]
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\[ \text{Time} \]

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\[ \text{Time} \]
energy-aware strategies on heterogeneous platforms

$cor_{task} = 1; \text{ basicWork} = 0.2; \mathcal{R} = 0.85$

Ratio to the baseline

$\beta_{b/w}$

Mapping: LowerBound, deP, deR, inE, random
Energy-aware strategies on heterogeneous platforms

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RR n° 9324
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

<table>
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β \text{b/w} Ratio to the baseline

- lowerBound
- basicWork
- \text{inE}
- \text{deP}
- \text{deR}
- \text{R}
- \text{R}R

cor task = 1; basicWork = 0.3; R = 0.85
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 1; \text{basicWork} = 0.3; \ R = 0.95 \]

\[ \text{cor}_{\text{proc}} = 0 \]

\[ \text{cor}_{\text{proc}} = 0.25 \]

\[ \text{cor}_{\text{proc}} = 0.5 \]

\[ \text{cor}_{\text{proc}} = 0.75 \]

\[ \text{cor}_{\text{proc}} = 1 \]

\[ \beta \]

\[ \text{b/w} \]

\[ \text{Ratio to the baseline} \]

\[ \text{mapping} = \text{LowerBound} \]

\[ \text{deP } \]

\[ \text{deR } \]

\[ \text{inE } \]

\[ \text{random} \]
The following section presents ratio of energy consumption using different scheduling strategies under big failure rate when varying $\beta_{b/w}$. 
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.25; \text{basicWork} = 0.1; \mathcal{R} = 0.8 \]
cor_{task} = 0.25; basicWork = 0.1; \mathcal{R} = 0.85
Energy-aware strategies on heterogeneous platforms

cor_task = 0.25; basicWork = 0.1; R = 0.9

- LowerBound
- energy-time
- time-energy
- randomShuffling

Ratio to the baseline

0.00 0.25 0.50 0.75 1.00

β/bw

0.2 0.4 0.6 0.8 1.0 2.0 4.0 6.0 8.0 10.0
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.25; \ \text{basicWork} = 0.1; \ \mathcal{R} = 0.95 \]
Energy-aware strategies on heterogeneous platforms

cor_{task} = 0.25; basicWork = 0.2; \mathcal{R} = 0.8
Energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{task}} = 0.25; \ basicWork = 0.2; \ R = 0.85 \)

\( \text{cor}_{\text{proc}} = 0 \)

\( \text{cor}_{\text{proc}} = 0.25 \)

\( \text{cor}_{\text{proc}} = 0.5 \)

\( \text{cor}_{\text{proc}} = 0.75 \)

\( \text{cor}_{\text{proc}} = 1 \)
Energy-aware strategies on heterogeneous platforms
cor_{task} = 0.25; basicWork = 0.2; \mathcal{R} = 0.95

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| cor_{proc} = 0.25; basicWork = 0.2; \mathcal{R} = 0.95 |
|------------|----------------|-------------------|-----------------|-------------------|----------------|
| \beta_{bw} | cor_{task} = 0 | cor_{task} = 0.25 | cor_{task} = 0.5 | cor_{task} = 0.75 | cor_{task} = 1 |
| 0.00       | 0.25           | 0.50              | 0.75            | 1.00              | 1.25           |
| 0.25       | 0.40           | 0.60              | 0.80            | 1.00              | 1.25           |
| 0.50       | 0.40           | 0.60              | 0.80            | 1.00              | 1.25           |
| 0.75       | 0.40           | 0.60              | 0.80            | 1.00              | 1.25           |
| 1.00       | 0.40           | 0.60              | 0.80            | 1.00              | 1.25           |

Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.25; \text{basicWork} = 0.3; R = 0.8 \]

The figure shows the performance of different scheduling strategies (LowerBound, energy-energy, time-energy, randomShuffling) with varying parameters: \( \text{cor}_{\text{proc}} \) and \( \beta_{hw} \) (ratio to the baseline). The x-axis represents \( \beta_{hw} \) ranging from 0.2 to 1.0, and the y-axis represents the ratio to the baseline. Different colors correspond to different strategies.
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

cor$_{task} = 0.25$; basicWork = 0.3; $R = 0.9$

<table>
<thead>
<tr>
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Ratio to the baseline

scheduling
- LowerBound
- energy-time
- time-energy
- randomShuffling
Energy-aware strategies on heterogeneous platforms

corr = 0.25; basicWork = 0.3; R = 0.95
Energy-aware strategies on heterogeneous platforms

![Graphs and charts showing energy-efficiency comparisons.](image-url)

- **deP**, **deR**, **maE**, **random**
- Various parameters and settings tested
- Ratios to the baseline
- Energy-efficiency analysis

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Energy-aware strategies on heterogeneous platforms
$\text{cor}_{\text{task}} = 0.5; \text{basicWork} = 0.1; R = 0.9$

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<th>$\text{cor}_{\text{proc}}$</th>
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**Energy-aware strategies on heterogeneous platforms**

- **LowerBound**: Energy-time
- **energy-energy**: Energy-time
- **time-energy**: randomShuffling
cor_{task} = 0.5; basicWork = 0.1; R = 0.95
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.5; \text{basicWork} = 0.2; R = 0.85 \]
Energy-aware strategies on heterogeneous platforms

cor_{task} = 0.5; basicWork = 0.2; R = 0.9

cor_{proc} = 0

cor_{proc} = 0.25

cor_{proc} = 0.5

cor_{proc} = 0.75

cor_{proc} = 1

<table>
<thead>
<tr>
<th>β/w</th>
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Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.5; \text{basicWork} = 0.2; R = 0.95 \]
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.5; \quad \text{basicWork} = 0.3; \quad R = 0.8 \]

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Energy-aware strategies on heterogeneous platforms

\[ \beta/b_w \]

scheduling

LowerBound  energy-time  time-time
energy-energy  time-energy  randomShuffling

RR n 9241
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.5; \text{basicWork} = 0.3; \mathcal{R} = 0.85 \]
$\text{cor}_{\text{task}} = 0.5; \text{basicWork} = 0.3; R = 0.9$

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<th>time-energy</th>
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Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.5; \text{basicWork} = 0.3; R = 0.95 \]

![Graph showing energy-time and time-energy ratios for different scheduling strategies and \( \beta_{\text{bw}} \) values.](image)

Legend:
- LowerBound
- energy-energy
- time-time
- energy-time
- time-energy
- randomShuffling

\[ \text{LowerBound} \quad \text{energy-energy} \quad \text{time-time} \quad \text{energy-time} \quad \text{time-energy} \quad \text{randomShuffling} \]
$\text{cor}_{\text{task}} = 0.75; \text{basicWork} = 0.1; R = 0.8$

Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

cor \text{task} = 0.75; \text{basicWork} = 0.1; \mathcal{R} = 0.85

cor \text{proc} = 0

cor \text{proc} = 0.25

cor \text{proc} = 0.5

cor \text{proc} = 0.75

cor \text{proc} = 1

\text{Ratio to the baseline}

\beta_{b/w}

\text{scheduling}

\text{LowerBound}  \quad \text{energy-energy}  \quad \text{time-energy}  \quad \text{randomShuffling}
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.75; \quad \text{basicWork} = 0.1; \quad R = 0.9 \]

\[ \text{cor}_{\text{proc}} = 0 \]

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\[ \text{cor}_{\text{proc}} = 0.75 \]

\[ \text{cor}_{\text{proc}} = 1 \]

\[ \beta_{\text{b/w}} \]

Ratio to the baseline

- LowerBound
- energy-time
- time-energy
- randomShuffling

Energy-aware scheduling on heterogeneous platforms
\( \text{cor}_{\text{task}} = 0.75; \text{basicWork} = 0.1; R = 0.95 \)
cor\textsubscript{task} = 0.75; basicWork = 0.2; \mathcal{R} = 0.8
Energy-aware strategies on heterogeneous platforms

\[
cor_{task} = 0.75; \; basicWork = 0.2; \; R = 0.85
\]
$cor_{task} = 0.75$; $basicWork = 0.2$; $R = 0.9$

Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.75; \text{basicWork} = 0.2; R = 0.95 \]

![Graph showing energy-time (R) and time-energy (S) ratios for different scheduling strategies.](image)
Energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{task}} = 0.75; \ \text{basicWork} = 0.3; \ \mathcal{R} = 0.8 \)

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\( \beta_{b/w} \)

Ratio to the baseline

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Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.75; \ \text{basicWork} = 0.3; \ \mathcal{R} = 0.85 \]
Energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{task}} = 0.75; \ \text{basicWork} = 0.3; \ \mathcal{R} = 0.9 \)
Energy-aware strategies on heterogeneous platforms

cor\textsubscript{task} = 0.75; basicWork = 0.3; R = 0.95
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 1; \ \text{basicWork} = 0.1; \ \mathcal{R} = 0.8 \]

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\[ \beta_{bw} \]

Ratio to the baseline

- LowerBound
- BasicWork
- Energy-energy
- Time-energy
- RandomShuffling

\[ \text{scheduling} \]

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Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

![Graph depicting energy-aware strategies on heterogeneous platforms.](image)
Energy-aware strategies on heterogeneous platforms

RR n° 9324
Energy-aware strategies on heterogeneous platforms

core = 1; basicWork = 0.2; R = 0.8
Energy-aware strategies on heterogeneous platforms

\( cor_{\text{task}} = 1; basicWork = 0.2; R = 0.85 \)
cor\textsubscript{task} = 1; basicWork = 0.2; R = 0.9
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 1; \text{basicWork} = 0.2; R = 0.95 \]

![Graph showing energy-aware strategies on heterogeneous platforms](image-url)
$cor_{task} = 1; \text{basicWork} = 0.3; \mathcal{R} = 0.8$

<table>
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<th>$cor_{proc}$</th>
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$scheduling$ (LowerBound, energy-time, time-energy, randomShuffling)
$cor_{\text{task}} = 1; basicWork = 0.3; R = 0.85$
Energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{task}} = 1; \text{basicWork} = 0.3; R = 0.9 \)
cor_{\text{task}} = 1; \text{basicWork} = 0.3; R = 0.95
Correlation (Mapping)

The following section presents ratio of energy consumption using different mapping strategies under big failure rate, when varying $cor_{proc}$ and $cor_{task}$. 
Energy-aware strategies on heterogeneous platforms

RR n° 9324
\( \beta_{\text{b/w}} = 0.2; \) basicWork = 0.1; \( R = 0.95 \)

Processor correlation vs. energy and time for different correlation coefficients and mapping strategies.
Energy-aware strategies on heterogeneous platforms

Processor correlation

Ratio to the baseline

mapping

LowerBound
dE
dP
dR
random

β_b/w = 0.2; basic/weight = 0.2; R = 0.85

RR n° 9324
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th></th>
<th>energy-energy</th>
<th>energy-time</th>
<th>randomShuffling</th>
<th>time-energy</th>
<th>time-time</th>
</tr>
</thead>
<tbody>
<tr>
<td>cor</td>
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<td>1.20</td>
<td>1.80</td>
<td>2.30</td>
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<tr>
<td>cor</td>
<td>20.60</td>
<td>20.70</td>
<td>22.00</td>
<td>24.00</td>
<td>25.80</td>
</tr>
<tr>
<td>cor</td>
<td>0.50</td>
<td>0.70</td>
<td>1.20</td>
<td>1.80</td>
<td>2.30</td>
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<td>cor</td>
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<td>24.00</td>
<td>25.80</td>
</tr>
</tbody>
</table>

Processor correlation
Ratio to the baseline

Mapping

\[ \beta_{\text{loc}} = 0.2; \beta_{\text{loc}} = 0.2; R = 0.9 \]

RR n° 9324
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.2; \ basicWork = 0.2; \ R = 0.95 \]

[Graph showing energy-time and time-energy trade-offs for different correlation values (cor\_task 0.25, 0.5, 0.75, 1).]

Legend:
- LowerBound
- deP
- deR
- inE
- random

\[ \beta_{b/w} = 0.2; \ basicWork = 0.2; \ R = 0.95 \]
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

**Processor correlation**

Ratio to the baseline

\( \beta_{b/w} = 0.4; \; \text{basicWork} = 0.1; \; \mathbb{R} = 0.85 \)

\( \beta_{b/w} = 0.5; \; \text{basicWork} = 0.1; \; \mathbb{R} = 0.85 \)

\( \beta_{b/w} = 0.6; \; \text{basicWork} = 0.1; \; \mathbb{R} = 0.85 \)

\( \beta_{b/w} = 0.7; \; \text{basicWork} = 0.1; \; \mathbb{R} = 0.85 \)

\( \beta_{b/w} = 0.8; \; \text{basicWork} = 0.1; \; \mathbb{R} = 0.85 \)
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>energy-energy</th>
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<th>time-time</th>
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<tr>
<td>cor task = 0.5</td>
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<td>cor task = 0.9</td>
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</table>

\[
\beta_{b/w} = 0.4; \text{ basicWork} = 0.1; \ R = 0.9
\]
### Energy-aware strategies on heterogeneous platforms

#### Processor correlation

**Ratio to the baseline**

**β** = 0.4; **basicWork** = 0.2; **R** = 0.8

<table>
<thead>
<tr>
<th>energy-energy</th>
<th>energy-time</th>
<th>randomShuffling</th>
<th>time-energy</th>
<th>time-time</th>
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<td>correlation: 0.75</td>
<td>correlation: 0.5</td>
<td>correlation: 0.25</td>
<td>correlation: 0.0</td>
</tr>
</tbody>
</table>

**β** = 0.4; **basicWork** = 0.2; **R** = 0.8

<table>
<thead>
<tr>
<th>energy-energy</th>
<th>energy-time</th>
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<td>correlation: 0.25</td>
<td>correlation: 0.0</td>
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</tbody>
</table>

**β** = 0.4; **basicWork** = 0.2; **R** = 0.8

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<th>energy-time</th>
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<th>time-time</th>
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<td>correlation: 0.5</td>
<td>correlation: 0.25</td>
<td>correlation: 0.0</td>
</tr>
</tbody>
</table>

**β** = 0.4; **basicWork** = 0.2; **R** = 0.8

<table>
<thead>
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<th>energy-energy</th>
<th>energy-time</th>
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<td>correlation: 0.5</td>
<td>correlation: 0.25</td>
<td>correlation: 0.0</td>
</tr>
</tbody>
</table>
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.4; \ \text{basicWork} = 0.2; \ \mathcal{R} = 0.85 \]

![Graph showing energy correlation and time correlation for different COF levels](image)

- **LowerBound**
- doP
- doR
- imE
- random

Ratio to the baseline

Processor correlation

Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

\[ \beta_{\text{bw}} = 0.4; \ \text{basic}\_\text{work} = 0.2; \ R = 0.9 \]

RR n° 9324
Energy-aware strategies on heterogeneous platforms

![Graph showing energy-time and time-energy correlations across different mapping methods and correlation values.]

- **Processor correlation mappings** display lower bounds for various metrics such as basic work, best protocols, and R.
- The graphs illustrate the impact of processor correlation on energy and time efficiency, with different correlation values showing varying degrees of energy savings or time improvements.

**Key Points**
- **Energy-energy mapping** shows strong correlation for #β = 0.4, basic work ≤ 0.2, and R = 0.95.
- **Time-time mapping** also demonstrates significant gains with the same parameters.
- The randomShuffling method exhibits moderate correlation effects compared to other mappings.

**Conclusion**
- Energy-aware strategies significantly improve efficiency on heterogeneous platforms by optimizing processor mapping and correlation rates.

---

**References**
- [Energy-aware scheduling strategies](#)
- [Heterogeneous platform optimization](#)
- [Performance metrics and benchmarks](#)
Energy-aware strategies on heterogeneous platforms

### Processor correlation

<table>
<thead>
<tr>
<th>$\beta_{w,R}$</th>
<th>0.4</th>
<th>0.3</th>
<th>0.25</th>
<th>0.2</th>
<th>R = 0.85</th>
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<td>$\text{R} n$</td>
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### Ratio to the baseline

<table>
<thead>
<tr>
<th>$\text{LowerBound}$</th>
<th>deP</th>
<th>deR</th>
<th>inE</th>
<th>randomShuffling</th>
<th>time-energy</th>
<th>time-time</th>
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</thead>
<tbody>
<tr>
<td>$\text{deP}$</td>
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<td>0.50</td>
<td>0.75</td>
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<td>1.25</td>
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<td>$\text{deR}$</td>
<td>0.00</td>
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<td>0.50</td>
<td>0.75</td>
<td>1.00</td>
<td>1.25</td>
</tr>
<tr>
<td>$\text{inE}$</td>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
<td>1.00</td>
<td>1.25</td>
</tr>
<tr>
<td>randomShuffling</td>
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<td>0.50</td>
<td>0.75</td>
<td>1.00</td>
<td>1.25</td>
</tr>
<tr>
<td>time-energy</td>
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<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
<td>1.00</td>
<td>1.25</td>
</tr>
<tr>
<td>time-time</td>
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<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
<td>1.00</td>
<td>1.25</td>
</tr>
</tbody>
</table>

**Legends**
- Processor correlation
- LowerBound
- deP
- deR
- inE
- randomShuffling
- time-energy
- time-time

**Note:** The diagrams show various mappings and correlations for different parameters, illustrating the energy-aware strategies on heterogeneous platforms.
Energy-aware strategies on heterogeneous platforms

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{plot.png}
\caption{Processor correlation ratio to the baseline for different mapping algorithms and correlation levels.}
\end{figure}

The figure above shows the processor correlation ratio to the baseline for different mapping algorithms and correlation levels. The algorithms include energy-energy, energy-time, randomShuffling, time-energy, and time-time. The correlation levels are indicated on the x-axis, with values ranging from 0.00 to 1.25. The y-axis represents the mapping strategies, with labels indicating the specific mapping configurations.

\textbf{Legend:}
- LowerBound
- deP
- deR
- inE
- random

The plot reveals how the processor correlation changes with varying correlation levels and mapping strategies. The trends observed can help in understanding the energy-aware strategies on heterogeneous platforms, which is the focus of the study.
$\beta_{b/w} = 0.6; \text{basicWork} = 0.1; R = 0.8$

Energy-aware strategies on heterogeneous platforms

mapping LowerBound deP deR injE random
Energy-aware strategies on heterogeneous platforms

![Graphs showing processor correlation, ratio to the baseline, and energy-time mapping for different configurations.](image-url)
Energy-aware strategies on heterogeneous platforms

![Graphs showing energy-aware strategies on heterogeneous platforms](image)

- **Energy-energy**: Processors correlation to baseline
- **Energy-time**: Mapping correlation to baseline
- **RandomShuffling**: Processor correlation to baseline
- **Time-energy**: Time correlation to baseline
- **Time-time**: Time correlation to baseline

**Parameter Values**
- $\beta_{br} = 0.6$
- $\beta_{br,k} = 0.1$
- $R = 0.9$

**Legend**
- Processor correlation
- Mapping correlation
\( \beta_{b/w} = 0.6; \text{basicWork} = 0.1; \ R = 0.95 \)

Image of a graph with various processor correlation values. The graph shows a comparison of energy ratios across different mapping schemes (LowerBound, deP, R), with time-energy and energy-time axes. The legend highlights the different mapping schemes, with markers indicating their performance relative to a baseline.
Energy-aware strategies on heterogeneous platforms

$\beta_{b/w} = 0.6; basicWork = 0.2; R = 0.8$
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.6; \ basicWork = 0.2; \ R = 0.9 \]

<table>
<thead>
<tr>
<th>COF task</th>
<th>Processor correlation</th>
<th>Ratio to the baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25</td>
<td>0.00</td>
<td>0.75</td>
</tr>
<tr>
<td>0.50</td>
<td>0.25</td>
<td>0.90</td>
</tr>
<tr>
<td>0.75</td>
<td>0.50</td>
<td>1.00</td>
</tr>
<tr>
<td>1.00</td>
<td>0.75</td>
<td>1.25</td>
</tr>
</tbody>
</table>

mapping: LowerBound, deP, deR, inE, random
Energy-aware strategies on heterogeneous platforms

![Graph showing correlation between energy-energy, energy-time, randomShuffling, time-energy, and time-time for different values of \( \beta_{\text{vol}} = 0.6 \), basicVol or k = 0.2; \( R = 0.95 \).](image)
Energy-aware strategies on heterogeneous platforms

- Processor correlation
  - Ratio to the baseline
- Mapping
  - Lower Bound

\[ \beta_{hi} = 0.6, \text{ basicWork} = 0.3, \ R = 0.8 \]

RR n° 9324
Energy-aware strategies on heterogeneous platforms

Processor correlation

Ratio to the baseline

LowerBound

deP
deR
random

\[ \beta_{b/w} = 0.6, \text{ basicWork} = 0.3, \ R = 0.85 \]

RR n° 9324
Energy-aware strategies on heterogeneous platforms

Correlation ratio to the baseline

β_{b,w} = 0.6, basic workload = 0.3; R = 0.9
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.6; \ \text{basicWork} = 0.3; \ R = 0.95 \]

<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>( \text{Cof}_{\text{task}} = 0.25 )</th>
<th>( \text{Cof}_{\text{task}} = 0.5 )</th>
<th>( \text{Cof}_{\text{task}} = 0.75 )</th>
<th>( \text{Cof}_{\text{task}} = 1 )</th>
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<td>1.0</td>
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Mapping: LowerBound, deP, deR, inE, random

**RR n° 9324**
Energy-aware strategies on heterogeneous platforms

![Graphs showing processor correlation and mapping]
$\beta_{\text{b/w}} = 0.8$; basicWork = 0.1; $\mathcal{R} = 0.85$
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>Ratio to the baseline</th>
<th>mapping</th>
<th>deP</th>
<th>deR</th>
<th>inE</th>
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</table>

β_b/w = 0.8; basicWork = 0.2; R = 0.8

RR n° 9324
$\beta_{\text{bw}} = 0.8$; $\text{basicWork} = 0.2$; $R = 0.85$
Energy-aware strategies on heterogeneous platforms

\[ \beta_{\text{bw}} = 0.8; \beta_{\text{work}} = 0.2; \beta_{\text{R}} = 0.9 \]

\[ \text{cor} = \text{task} = 0.25 \]

\[ \text{cor} = \text{task} = 0.5 \]

\[ \text{cor} = \text{task} = 0.75 \]

\[ \text{cor} = \text{task} = 1 \]

Correlation to the baseline

\[ \text{mapping} = \text{time-energy} \]

\[ \text{mapping} = \text{time-time} \]

\[ \text{mapping} = \text{time-energy} \]

\[ \text{mapping} = \text{time-time} \]
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
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<th>Energy-Energy</th>
<th>Energy-Time</th>
<th>RandomShuffling</th>
<th>Time-Energy</th>
<th>Time-Time</th>
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</tbody>
</table>

Processor correlation

\[
\beta_w = 0.8, \text{ basicWork} = 0.2, R = 0.95
\]

RR n° 9324
Energy-aware strategies on heterogeneous platforms

![Diagram showing correlation between energy and time for different tasks and processor mappings.](image-url)
Energy-aware strategies on heterogeneous platforms

![Graph showing energy-aware strategies on heterogeneous platforms](image-url)
Energy-aware strategies on heterogeneous platforms

Processor correlation

Ratio to the baseline

Lower Bound

deP

deR

inE

random

β

b/w

= 1

basicWork

= 0.1

R

= 0.8

RR n° 9324
\[ \beta_{b/w} = 1; \text{basicWork} = 0.1; \mathcal{R} = 0.85 \]

<table>
<thead>
<tr>
<th>( \text{cor} )</th>
<th>( \text{task} )</th>
<th>( \text{LowerBound} )</th>
<th>( \text{deP} )</th>
<th>( \text{deR} )</th>
<th>( \text{inE} )</th>
<th>( \text{random} )</th>
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Processor correlation vs. Ratio to the baseline for different correlation coefficients and workloads.
Energy-aware strategies on heterogeneous platforms

<table>
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<th>Processor correlation</th>
<th>Ratio to the baseline</th>
<th>Processor correlation</th>
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<tbody>
<tr>
<td>fig1</td>
<td>fig2</td>
<td>fig3</td>
<td>fig4</td>
</tr>
</tbody>
</table>

- **fig1**: Processor correlation = 1; basicWork = 0.1, R = 0.9
- **fig2**: Processor correlation = 0.75; basicWork = 0.1, R = 0.9
- **fig3**: Processor correlation = 0.5; basicWork = 0.1, R = 0.9
- **fig4**: Processor correlation = 0.25; basicWork = 0.1, R = 0.9

RR n° 9324
$\beta_{b/w} = 1$; basicWork = 0.1; $R = 0.95$

![Graph showing energy-aware strategies on heterogeneous platforms](image-url)
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>Correlation</th>
<th>Ratio to the baseline</th>
<th>Processor correlation</th>
<th>LowerBound</th>
<th>RandomShuffling</th>
<th>deP</th>
<th>deR</th>
<th>inE</th>
<th>deP</th>
<th>inE</th>
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<tr>
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<td>0.25</td>
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</tr>
<tr>
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<td>0.50</td>
<td>0.50</td>
<td>0.50</td>
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</tr>
<tr>
<td>time-energy</td>
<td>0.75</td>
<td>0.75</td>
<td>0.75</td>
<td>0.75</td>
<td>0.75</td>
<td>0.75</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>time-time</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td></td>
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</tr>
</tbody>
</table>

\(\beta_{\text{in}} = 1\), \(\text{basicWork} = 0.2\), \(R = 0.85\)
Energy-aware strategies on heterogeneous platforms

![Image of diagrams showing energy-energy, energy-time, randomShuffling, time-energy, and time-time mappings with Processor correlation and Ratio to the baseline.]
Energy-aware strategies on heterogeneous platforms

\[ \beta_{\text{b/w}} = 1; \ basicWork = 0.2; \ R = 0.95 \]

<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>( \text{cor}_{\text{task}} = 0.25 )</th>
<th>( \text{cor}_{\text{task}} = 0.5 )</th>
<th>( \text{cor}_{\text{task}} = 0.75 )</th>
<th>( \text{cor}_{\text{task}} = 1 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ratio to the baseline</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
<td>1.00</td>
</tr>
<tr>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>

**Mapping**
- LowerBound
- \( \text{deP} \)
- \( \text{deR} \)
- \( \text{inE} \)
- random

**Energy-Time**

**Time-Time**

**Random Shuffling**

**Energy-Energy**
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

1.10 1.40 2.50 3.90 5.30

20.80 21.40 23.90 27.80 31.60

1.20 1.80 2.40 3.70 5.00

20.80 21.60 22.90 27.10 31.70

1.30 2.00 2.90 3.70 4.90

20.90 21.60 24.10 27.30 32.30

1.40 2.20 3.40 4.40 5.10

20.90 21.70 26.10 30.90 32.70

Process correlation

LowerBound
dP
deP
deR
random

β = 1; basicWork = 0.3; R = 0.9

ε = 0.25
Energy-aware strategies on heterogeneous platforms
Correlation (Scheduling)

The following section presents ratio of energy consumption using different scheduling strategies under big failure rate, when varying $cor_{proc}$ and $cor_{task}$.
Energy-aware strategies on heterogeneous platforms

\[ \beta_{\text{b/w}} = 0.2; \ \text{basicWork} = 0.1; \ \mathcal{R} = 0.8 \]
Energy-aware strategies on heterogeneous platforms

Processor correlation

Ratio to the baseline

scheduling, lowerbound, energy-energy, energy-time, time-energy, time-time, randomShuffling

\[ \beta_{\text{ideal}} = 0.2; \beta_{\text{bias}} = 0.2; \text{basicWork} = 0.1; \tau = 0.85 \]
Energy-aware strategies on heterogeneous platforms

$\beta_{v/w} = 0.2; \ basicWork = 0.1; \ R = 0.9$

![Diagram showing energy-aware strategies on heterogeneous platforms]
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>Ratio to the baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>deP</td>
<td>0.00</td>
</tr>
<tr>
<td>deR</td>
<td>0.25</td>
</tr>
<tr>
<td>raE</td>
<td>0.50</td>
</tr>
<tr>
<td>random</td>
<td>0.75</td>
</tr>
</tbody>
</table>

$\beta_{\text{de}} = 0.2$, $\beta_{\text{ra}} = 0.1$, $R = 0.95$

$\text{R} = 0.95$

RR n° 9324
\( \beta_{b/w} = 0.2; \ basicWork = 0.2; \ \mathcal{R} = 0.85 \)

<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>( \text{cor}_{\text{task}} = 0.25 )</th>
<th>( \text{cor}_{\text{task}} = 0.5 )</th>
<th>( \text{cor}_{\text{task}} = 0.75 )</th>
<th>( \text{cor}_{\text{task}} = 1 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \beta_{b/w} )</td>
<td>0.23</td>
<td>0.53</td>
<td>0.77</td>
<td>1.02</td>
</tr>
<tr>
<td>( \text{basicWork} )</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
<td>1.00</td>
</tr>
<tr>
<td>( \mathcal{R} )</td>
<td>0.85</td>
<td>0.85</td>
<td>0.85</td>
<td>0.85</td>
</tr>
</tbody>
</table>

**Legend:**
- LowerBound
- energy-energy
- time-energy
- randomShuffling
Energy-aware strategies on heterogeneous platforms

Processor correlation

Ratio to the baseline

LowerBound energy-energy
time-energy
time-time
randomShuffling

$β_{w_0} = 0.2, basicWork = 0.2, R = 0.9$

$\gamma_{w_0} = 0.25$
Energy-aware strategies on heterogeneous platforms

\[ \beta_{\text{bw}} = 0.2; \text{basicWork} = 0.2; R = 0.95 \]
Energy-aware strategies on heterogeneous platforms

![Graphs showing processor correlation and energy-time trade-offs for different cor task values.](Image)

- Processor correlation:
  - cor task = 0.25
  - cor task = 0.5
  - cor task = 0.75
- Ratio to the baseline:
  - deP
  - deR
  - inE
  - random
- Scheduling:
  - LowerBound
  - energy-energy
  - energy-time
  - time-energy
  - randomShuffling

- Processor correlation:
  - cor task = 1
  - cor task = 0.5
  - cor task = 0.75

- Formulas:
  - $\beta_{b/w} = 0.2$; basicWork = 0.3; $R = 0.8$
Energy-aware strategies on heterogeneous platforms

![Graph showing processor correlation ratio to the baseline for different values of \( \beta_{\text{bw}} \) and \( R \).]
Energy-aware strategies on heterogeneous platforms

Processor correlation

Ratio to the baseline

scheduling

LowerBound

energy-energy

time-energy

time-time

random

randomShuffling

β_{b/w} = 0.2; basicWork = 0.3; R = 0.9
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

RR n° 9324
Energy-aware strategies on heterogeneous platforms

\( \beta_{b/w} = 0.4; \text{basicWork} = 0.1; R = 0.85 \)

![Graph showing energy-aware strategies on heterogeneous platforms with different correlation coefficients.](image)

- Correlation coefficients: \( \text{cof}_{\text{task}} = 0.25, 0.5, 0.75, 1 \)
- Processor correlation vs. ratio to the baseline
- Scheduling strategies: LowerBound, energy-time, time-energy, randomShuffling, energy-energy, time-time

Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>Random Shuffling</th>
<th>Lower Bound</th>
<th>Energy-Time</th>
<th>Time-Energy</th>
<th>Random Shuffling</th>
</tr>
</thead>
<tbody>
<tr>
<td>deP</td>
<td>deR</td>
<td>deE</td>
<td>random</td>
<td>Processor correlation</td>
<td></td>
</tr>
<tr>
<td>0.4</td>
<td>0.6</td>
<td>0.8</td>
<td>1.0</td>
<td>Ratio to the baseline</td>
<td></td>
</tr>
<tr>
<td>0.25</td>
<td>0.5</td>
<td>0.75</td>
<td>1.0</td>
<td>Energy-Time</td>
<td></td>
</tr>
<tr>
<td>0.5</td>
<td>0.75</td>
<td>1.0</td>
<td>1.0</td>
<td>Time-Energy</td>
<td></td>
</tr>
<tr>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>Random Shuffling</td>
<td></td>
</tr>
</tbody>
</table>

\( \beta_{0.4} = 0.4; \ \text{basicVolk} = 0.1; \ \text{R} = 0.9 \)

RR n° 9324
Energy-aware strategies on heterogeneous platforms

β_{b/w} = 0.4; basicWork = 0.1; R = 0.95

Processor correlation

Ratio to the baseline

scheduling

LowerBound  energy-time  time-energy  randomShuffling
Energy-aware strategies on heterogeneous platforms

\(\beta_{b/w} = 0.4; \ basicWork = 0.2; \ R = 0.8\)

![Graph showing energy-aware strategies](image_url)

- LowerBound
- energy-time
- time-energy
- randomShuffling

Processor correlation vs. Ratio to the baseline for different correlation tasks and cost functions.
<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>Ratio to the baseline</th>
<th>scheduling</th>
</tr>
</thead>
<tbody>
<tr>
<td>LowerBound energy-energy</td>
<td>time-energy</td>
<td>randomShuffling</td>
</tr>
</tbody>
</table>

### Processor correlation

- **ρ_{0b} = 0.4; basicWork = 0.2; R = 0.9**

### Ratio to the baseline

- 0.00, 0.25, 0.50, 0.75, 1.00

### scheduling

- LowerBound energy-energy
- time-energy
- randomShuffling
### Energy-aware strategies on heterogeneous platforms

The following table illustrates the performance of different scheduling strategies under varying correlation factors. The x-axis represents the ratio of processor power to the baseline, while the y-axis shows the processor correlation. Each bar graph compares the energy-efficiency ratios of different scheduling algorithms, with the baseline set to 1.0.

<table>
<thead>
<tr>
<th>Correlation Factor</th>
<th>Scheduling Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25</td>
<td>deP</td>
</tr>
<tr>
<td>0.5</td>
<td>deR</td>
</tr>
<tr>
<td>0.75</td>
<td>inE</td>
</tr>
<tr>
<td>1.0</td>
<td>random</td>
</tr>
</tbody>
</table>

The graph shows how each strategy performs under different baseline settings, indicating improvements in energy efficiency as the correlation factors increase.
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>Energy-time</th>
<th>Time-energy</th>
<th>Time-time</th>
<th>Scheduling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ratio to the baseline</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cor\textsuperscript{task} = 0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>cor\textsuperscript{task} = 0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>cor\textsuperscript{task} = 0.50</td>
<td>0.50</td>
<td>0.50</td>
<td>0.50</td>
<td>0.50</td>
</tr>
<tr>
<td>cor\textsuperscript{task} = 0.75</td>
<td>0.75</td>
<td>0.75</td>
<td>0.75</td>
<td>0.75</td>
</tr>
<tr>
<td>cor\textsuperscript{task} = 1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>

\( \beta_{\text{b/w}} = 0.4; \ \beta_{\text{b/w} + 0.3} = 0.85 \)
Energy-aware strategies on heterogeneous platforms
\[ \beta_{b/w} = 0.4; \text{ basicWork} = 0.3; R = 0.95 \]

Energy-aware strategies on heterogeneous platforms
\[ \beta_{\text{bw}} = 0.6; \text{basicWork} = 0.1; R = 0.8 \]
Energy-aware strategies on heterogeneous platforms

\( \beta_{b/w} = 0.6; \text{basicWork} = 0.1; \mathcal{R} = 0.9 \)
$\beta_{b/w} = 0.6$; $\text{basicWork} = 0.1$; $R = 0.95$
\( \beta_{b/w} = 0.6; \ basicWork = 0.2; \ R = 0.8 \)

<table>
<thead>
<tr>
<th>CorrTask</th>
<th>Ratio to the baseline</th>
<th>Processor Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25</td>
<td><img src="image1.png" alt="Graph" /></td>
<td><img src="image2.png" alt="Graph" /></td>
</tr>
<tr>
<td>0.50</td>
<td><img src="image3.png" alt="Graph" /></td>
<td><img src="image4.png" alt="Graph" /></td>
</tr>
<tr>
<td>0.75</td>
<td><img src="image5.png" alt="Graph" /></td>
<td><img src="image6.png" alt="Graph" /></td>
</tr>
<tr>
<td>1.00</td>
<td><img src="image7.png" alt="Graph" /></td>
<td><img src="image8.png" alt="Graph" /></td>
</tr>
</tbody>
</table>

**Energy-aware strategies on heterogeneous platforms**

- LowerBound
- energy-time
- time-energy
- randomShuffling

**Lower Bound**

- \( \beta_{b/w} = 0.6 \)
- basicWork = 0.2
- \( R = 0.8 \)
Energy-aware strategies on heterogeneous platforms

Graphs showing processor correlation and ratio to the baseline for different scheduling algorithms and correlation levels.

- Processor correlation
- Ratio to the baseline

Graph parameters:
- \( \beta_{inv} = 0.6; \) basic work = 0.2; \( R = 0.85 \)

Legend:
- LowerBound
- energy-energy
- energy-time
- time-energy
- time-time
- randomShuffling

RR n° 9324
Energy-aware strategies on heterogeneous platforms

β_{b/w} = 0.6; basicWork = 0.2; \mathcal{R} = 0.9

Processor correlation

Ratio to the baseline

\begin{align*}
\text{LowerBound} & \quad \text{energy-time} \\
\text{energy-energy} & \quad \text{time-energy} \\
\text{randomShuffling} &
\end{align*}

 scheduling
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>Ratio to the baseline</th>
<th>scheduling</th>
<th>energy-energy</th>
<th>energy-time</th>
<th>time-energy</th>
<th>time-time</th>
<th>randomShuffling</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \beta_{\text{corr}} = 0.6, \ \text{basicWork} = 0.2, \ R = 0.95 )</td>
<td></td>
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<td>( \text{error} = 0 )</td>
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</tr>
<tr>
<td>( \text{error} = 0.25 )</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>( \text{error} = 0.50 )</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>( \text{error} = 0.75 )</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \text{error} = 1.00 )</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

RR n° 9324
Energy-aware strategies on heterogeneous platforms

Processor correlation

Ratio to the baseline

scheduling

LowerBound

energy-energy

time-energy

time-time

randomShuffling

$\beta_{\text{core}} = 0.6$, basicVcore = 0.3; $R = 0.8$

$\beta_{\text{core}} = 0.3$, basicVcore = 0.3; $R = 0.8$

$\beta_{\text{core}} = 0.1$, basicVcore = 0.3; $R = 0.8$

$\beta_{\text{core}} = 0.0$, basicVcore = 0.3; $R = 0.8$
Energy-aware strategies on heterogeneous platforms

Processor correlation

Ratio to the baseline

Energy-energy

Energy-time

Time-energy

Time-time

scheduling

lowerBound

randomShuffling

Random

β_{0.0}/basicWo r_k = 0.6; basicWo r_k = 0.3; R = 0.85

RR n° 9324
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>Ratio to the baseline</th>
<th>LowerBound</th>
<th>energy-energy</th>
<th>energy-time</th>
<th>time-energy</th>
<th>time-time</th>
<th>randomShuffling</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
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<td>0.00</td>
<td>0.10</td>
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<td>0.10</td>
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<tr>
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<td>0.10</td>
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<td>0.75</td>
<td>0.00</td>
<td>0.10</td>
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<td>0.10</td>
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<tr>
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<td>1.00</td>
<td>0.00</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
</tr>
</tbody>
</table>

\( \beta_{\text{b/w}} = 0.6; \text{basicVerify} = 0.3; R = 0.9 \)
$\beta_{b/w} = 0.6$; $basicWork = 0.3$; $R = 0.95$

<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>$cor_{task} = 0.25$</th>
<th>$cor_{task} = 0.5$</th>
<th>$cor_{task} = 0.75$</th>
<th>$cor_{task} = 1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>0.25</td>
<td>0.75</td>
<td>0.75</td>
<td>0.75</td>
<td>0.75</td>
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<tr>
<td>0.50</td>
<td>0.50</td>
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<td>0.50</td>
<td>0.50</td>
</tr>
<tr>
<td>0.75</td>
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<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>1.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

- LowerBound
- energy-time
- time-energy
- randomShuffling

Energy-aware strategies on heterogeneous platforms
$\beta_{b/w} = 0.8$; $basicWork = 0.1$; $R = 0.8$

<table>
<thead>
<tr>
<th>$cor_{\text{task}}$</th>
<th>0.25</th>
<th>0.50</th>
<th>0.75</th>
<th>1.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.25</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.75</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.00</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Processor correlation

Ratio to the baseline

Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.8; \ basicWork = 0.1; \ R = 0.85 \]

<table>
<thead>
<tr>
<th>(\text{Energy aware} )</th>
<th>(\text{Ratio to the baseline})</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\text{Baseline} )</td>
<td>1.00</td>
</tr>
<tr>
<td>(\text{LowerBound} )</td>
<td>0.80</td>
</tr>
<tr>
<td>(\text{energy-energy} )</td>
<td>0.60</td>
</tr>
<tr>
<td>(\text{energy-time} )</td>
<td>0.50</td>
</tr>
<tr>
<td>(\text{time-energy} )</td>
<td>0.75</td>
</tr>
<tr>
<td>(\text{time-time} )</td>
<td>1.00</td>
</tr>
</tbody>
</table>

- LowerBound: \(\beta_{b/w} \leq 0.8\); \(\text{basicWork} \leq 0.1\); \(R = 0.85\).
Energy-aware strategies on heterogeneous platforms

- \( \beta_{\text{net}} = 0.8 \), basicWork = 0.1; \( R = 0.9 \)
- \( \beta_{\text{net}} = 0.8 \), basicWork = 0.1; \( R = 0.9 \)
- \( \beta_{\text{net}} = 0.8 \), basicWork = 0.1; \( R = 0.9 \)
- \( \beta_{\text{net}} = 0.8 \), basicWork = 0.1; \( R = 0.9 \)

Processor correlation ratio to the baseline

- LowerBound
- LowerBound
- LowerBound
- LowerBound

scheduling

- energy-energy
- energy-time
- time-energy
- randomShuffling

RR n° 9324
Energy-aware strategies on heterogeneous platforms

\( \beta_{b/w} = 0.8; \ \text{basicWork} = 0.1; \ R = 0.95 \)

![Graph showing energy-aware strategies on heterogeneous platforms]
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>Ratio to the baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schedule</td>
<td>Lower Bound</td>
</tr>
<tr>
<td>random</td>
<td>lowerBound</td>
</tr>
</tbody>
</table>

\[ \beta_{\text{switch}} = 0.8, \text{basicVork} = 0.2; R = 0.8 \]

<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>Schedule</th>
<th>Ratio to the baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>random</td>
<td>lowerBound</td>
<td>energy-energy</td>
</tr>
</tbody>
</table>

RR n° 9324
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.8; \ \text{basicWork} = 0.2; \ R = 0.85 \]

<table>
<thead>
<tr>
<th>Ratio to the baseline</th>
<th>Processor correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Processor correlation</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Correlation of Task</th>
<th>LowerBound</th>
<th>energy-time</th>
<th>time-energy</th>
<th>randomShuffling</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{cor}_{\text{task}} = 0 )</td>
<td>( 0.00 )</td>
<td>( 0.25 )</td>
<td>( 0.50 )</td>
<td>( 0.75 )</td>
</tr>
<tr>
<td>( \text{cor}_{\text{task}} = 0.5 )</td>
<td>( 0.00 )</td>
<td>( 0.25 )</td>
<td>( 0.50 )</td>
<td>( 0.75 )</td>
</tr>
<tr>
<td>( \text{cor}_{\text{task}} = 0.75 )</td>
<td>( 0.00 )</td>
<td>( 0.25 )</td>
<td>( 0.50 )</td>
<td>( 0.75 )</td>
</tr>
<tr>
<td>( \text{cor}_{\text{task}} = 1 )</td>
<td>( 0.00 )</td>
<td>( 0.25 )</td>
<td>( 0.50 )</td>
<td>( 0.75 )</td>
</tr>
</tbody>
</table>

**Legend:**
- **Scheduling:**
  - LowerBound
  - energy-time
  - time-energy
  - randomShuffling
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.8; \text{basic Work} = 0.2; R = 0.9 \]

![Graph showing energy-aware strategies on heterogeneous platforms](image_url)
\( \beta_{b/w} = 0.8; \ basicWork = 0.3; \ R = 0.8 \)
Energy-aware strategies on heterogeneous platforms

Processor correlation

Ratio to the baseline

lowerBound

time-energy
time-time
randomShuffling

β_{\text{hw}} = 0.8, \text{ basicWorkR} = 0.3, R = 0.85

RR n° 9324
Energy-aware strategies on heterogeneous platforms

Processor correlation

Ratio to the baseline

scheduling

LowerBound

time-energy

time-energy

randomShuffling

LmaxBound

time-energy

energy-energy

energy-time

energy-time

β w/b = 0.8, basicWerk = 0.3; R = 0.9
\( \beta_{b/w} = 1; \text{basicWork} = 0.1; R = 0.8 \)
Energy-aware strategies on heterogeneous platforms

\begin{center}
\begin{tabular}{|c|c|c|c|c|}
\hline
\textbf{\(\beta_{b/w}\)} & \textbf{\(\beta_{b/w}\)} & \textbf{\(\beta_{b/w}\)} & \textbf{\(\beta_{b/w}\)} \\
\hline
\textbf{baselWork} & \textbf{baselWork} & \textbf{baselWork} & \textbf{baselWork} \\
\hline
\end{tabular}
\end{center}
Energy-aware strategies on heterogeneous platforms

Processor correlation

Ratio to the baseline

scheduling

DeP

deR

inE

random

\( \beta_{\text{bw}} \) = 1, \( \text{basicWork} = 0.1 \), \( R = 0.9 \)

LowerBound

energy-energy

time-energy

energy-time

randomShuffling

RR n° 9324
\( \beta_{b/w} = 1; \ \text{basicWork} = 0.1; \ \mathcal{R} = 0.95 \)

<table>
<thead>
<tr>
<th>Correlation</th>
<th>Schedule</th>
<th>LowerBound</th>
<th>energy-energy</th>
<th>energy-time</th>
<th>time-energy</th>
<th>time-time</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.25</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.50</td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>0.75</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.25</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Processor correlation

Ratio to the baseline

Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

![Graph showing processor correlation ratio to the baseline for different scheduling strategies and correlation values.]
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>Ratio to the baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>deP</td>
<td>0.00</td>
</tr>
<tr>
<td>deR</td>
<td>1.00</td>
</tr>
<tr>
<td>inE</td>
<td>0.00</td>
</tr>
<tr>
<td>random</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Processor correlation:
- deP: 0.00 - 1.00
- deR: 0.00 - 1.00
- inE: 0.00 - 1.00
- random: 0.00 - 1.00

Ratio to the baseline:
- deP: 0.00 - 1.00
- deR: 0.00 - 1.00
- inE: 0.00 - 1.00
- random: 0.00 - 1.00

<table>
<thead>
<tr>
<th>Processor correlation</th>
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</tr>
</thead>
<tbody>
<tr>
<td>deP</td>
<td>0.00</td>
</tr>
<tr>
<td>deR</td>
<td>1.00</td>
</tr>
<tr>
<td>inE</td>
<td>0.00</td>
</tr>
<tr>
<td>random</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Processor correlation:
- deP: 0.00 - 1.00
- deR: 0.00 - 1.00
- inE: 0.00 - 1.00
- random: 0.00 - 1.00

Ratio to the baseline:
- deP: 0.00 - 1.00
- deR: 0.00 - 1.00
- inE: 0.00 - 1.00
- random: 0.00 - 1.00

<table>
<thead>
<tr>
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<tr>
<td>deP</td>
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<td>deR</td>
<td>1.00</td>
</tr>
<tr>
<td>inE</td>
<td>0.00</td>
</tr>
<tr>
<td>random</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Processor correlation:
- deP: 0.00 - 1.00
- deR: 0.00 - 1.00
- inE: 0.00 - 1.00
- random: 0.00 - 1.00

Ratio to the baseline:
- deP: 0.00 - 1.00
- deR: 0.00 - 1.00
- inE: 0.00 - 1.00
- random: 0.00 - 1.00

<table>
<thead>
<tr>
<th>Processor correlation</th>
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</thead>
<tbody>
<tr>
<td>deP</td>
<td>0.00</td>
</tr>
<tr>
<td>deR</td>
<td>1.00</td>
</tr>
<tr>
<td>inE</td>
<td>0.00</td>
</tr>
<tr>
<td>random</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Processor correlation:
- deP: 0.00 - 1.00
- deR: 0.00 - 1.00
- inE: 0.00 - 1.00
- random: 0.00 - 1.00

Ratio to the baseline:
- deP: 0.00 - 1.00
- deR: 0.00 - 1.00
- inE: 0.00 - 1.00
- random: 0.00 - 1.00

\[ \beta_{\text{work}} = 1, \, \text{baseline} = 0.2, \, R = 0.9 \]
**Energy-aware strategies on heterogeneous platforms**

<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>Ratio to the baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core only = 1</td>
<td></td>
</tr>
<tr>
<td>Core only = 0.75</td>
<td></td>
</tr>
<tr>
<td>Core only = 0.5</td>
<td></td>
</tr>
<tr>
<td>Core only = 0.25</td>
<td></td>
</tr>
</tbody>
</table>

**Random Shuffling**

- $\beta_{\text{basic}} = 1$, $\text{basic work} = 0.2$, $R = 0.25$

**Lower Bound**

- $\beta_{\text{basic}} = 1$, $\text{basic work} = 0.2$, $R = 0.25$

---

**RR n° 9324**
Energy-aware strategies on heterogeneous platforms

Processor correlation

\[ \beta_{bu} = 1, \quad \text{baselineWork} = 0.3, \quad R = 0.9 \]

\[ \text{LowerBound} \]

\[ \text{energy-energy} \]

\[ \text{energy-time} \]

\[ \text{time-energy} \]

\[ \text{time-time} \]

\[ \text{randomShuffling} \]

\[ \text{scheduling} \]

\[ \text{energy-energy} \]

\[ \text{energy-time} \]

\[ \text{time-energy} \]

\[ \text{time-time} \]

\[ \beta_{bu} = 1, \quad \text{baselineWork} = 0.3, \quad R = 0.9 \]

\[ \text{energy-energy} \]

\[ \text{energy-time} \]

\[ \text{time-energy} \]

\[ \text{time-time} \]

\[ \text{randomShuffling} \]

\[ \text{scheduling} \]

\[ \text{energy-energy} \]

\[ \text{energy-time} \]

\[ \text{time-energy} \]

\[ \text{time-time} \]

\[ \beta_{bu} = 1, \quad \text{baselineWork} = 0.3, \quad R = 0.9 \]

\[ \text{energy-energy} \]

\[ \text{energy-time} \]

\[ \text{time-energy} \]

\[ \text{time-time} \]

\[ \text{randomShuffling} \]

\[ \text{scheduling} \]

\[ \text{energy-energy} \]

\[ \text{energy-time} \]

\[ \text{time-energy} \]

\[ \text{time-time} \]

\[ \beta_{bu} = 1, \quad \text{baselineWork} = 0.3, \quad R = 0.9 \]

\[ \text{energy-energy} \]

\[ \text{energy-time} \]

\[ \text{time-energy} \]

\[ \text{time-time} \]

\[ \text{randomShuffling} \]

\[ \text{scheduling} \]

\[ \text{energy-energy} \]

\[ \text{energy-time} \]

\[ \text{time-energy} \]

\[ \text{time-time} \]
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 1; \ basicWork = 0.3; \ R = 0.95 \]
basicWork and \( R \) (Mapping)

The following section presents ratio of energy consumption using different mapping strategies under big failure rate, when varying \( basicWork \) and \( R \).
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>CorrProc = 0</th>
<th>CorrProc = 0.25</th>
<th>CorrProc = 0.5</th>
<th>CorrProc = 0.75</th>
<th>CorrProc = 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>R = 0.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.00 0.20 0.40</td>
<td>0.00 0.20 0.40</td>
<td>0.00 0.20 0.40</td>
<td>0.00 0.20 0.40</td>
</tr>
<tr>
<td></td>
<td>0.00 0.20 0.40</td>
<td>0.00 0.20 0.40</td>
<td>0.00 0.20 0.40</td>
<td>0.00 0.20 0.40</td>
</tr>
<tr>
<td></td>
<td>0.00 0.20 0.40</td>
<td>0.00 0.20 0.40</td>
<td>0.00 0.20 0.40</td>
<td>0.00 0.20 0.40</td>
</tr>
<tr>
<td></td>
<td>0.00 0.20 0.40</td>
<td>0.00 0.20 0.40</td>
<td>0.00 0.20 0.40</td>
<td>0.00 0.20 0.40</td>
</tr>
</tbody>
</table>

Basic Work: Ratio to the baseline

CorrProc = 0.25, βb/w = 0.2; Scheduling criteria: time-time

RR n° 9324
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

\[ R = 0.85 \]

\[ R = 0.9 \]

\[ R = 0.95 \]

\[ \text{Basic Work} \]

\[ \text{Scheduling criteria: energy-time} \]

\[ \text{LowerBound} \]

\[ \text{UpperBound} \]

\( \text{cor}_{\text{proc}} = 0 \)

\( \text{cor}_{\text{proc}} = 0.25 \)

\( \text{cor}_{\text{proc}} = 0.5 \)

\( \text{cor}_{\text{proc}} = 0.75 \)

\( \text{cor}_{\text{proc}} = 1 \)
Energy-aware strategies on heterogeneous platforms

\( cor_{\text{task}} = 0.25; \ \beta_{b/w} = 0.2; \) Scheduling criteria: energy-energy

Basic Work: Ratio to the baseline

mapping: LowerBound, deP, deR, inE, random

RR n° 9234
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>$\cos \phi_{\text{proc}}$</th>
<th>$R = 0.95$</th>
<th>$R = 0.9$</th>
<th>$R = 0.85$</th>
<th>$R = 0.8$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.75</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Basic Work: $\cos \phi_{\text{proc}} = 0.25, \beta_{\text{shift}} = 2$; Scheduling criteria: randomShuffling

RR n° 9324
Energy-aware strategies on heterogeneous platforms

corr_{task} = 0.25; \beta_{b/w} = 0.4; Scheduling criteria: time-time
Energy-aware strategies on heterogeneous platforms

0.60
0.70
0.80
20.10
20.20
20.30
20.40
0.60
0.80
1.10
20.20
20.30
20.50
1.10
2.00
2.70
20.50
21.20
22.50
1.30
2.30
3.60
20.90
23.00
26.80
1.30
2.50
3.80
21.70
25.80
31.60
R = 0.85
R = 0.95
task
rr

R = 0.85
R = 0.9
R = 0.95

cor
proc
= 0.25;
β_{bw} = 0.4;
Scheduling criteria: time-energy
RR

Basic Work

LowerBound
deP
deR
inE
random
RR

RR n° 9324
Energy-aware strategies on heterogeneous platforms

$\text{cor}_\text{task} = 0.25; \beta_{b/w} = 0.4$; Scheduling criteria: energy-energy

$R = 0.8$  
$R = 0.85$  
$R = 0.9$  
$R = 0.95$

Basic Work

Ratio to the baseline

mapping
}
Energy-aware strategies on heterogeneous platforms

\[ \text{Cor}_{\text{task}} = 0.25; \quad \beta_{b/w} = 0.4; \quad \text{Scheduling criteria: randomShuffling} \]

**Diagram:**
- Various graphs illustrating the ratio to the baseline for different mapping strategies: LowerBound, deP, deR, inE, random.
- Each graph represents a different value of \( R \) (0.8, 0.85, 0.9, 0.95).
- The x-axis represents the basic work, while the y-axis shows the ratio to the baseline.

**Key Points:**
- Correlation of tasks: \( \text{Cor}_{\text{task}} = 0.25 \).
- Bandwidth factor: \( \beta_{b/w} = 0.4 \).
- Scheduling method: randomShuffling.

These diagrams help visualize the performance and energy efficiency of different mapping strategies under varying conditions.
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 1; \ \beta_{b/w} = 1; \ 	ext{Scheduling criteria: randomShuffling} \]
Energy-aware strategies on heterogeneous platforms

Scheduling criteria: time-time

$\text{cor}_{\text{task}} = 0.25$; $\beta_{b/w} = 0.6$; $\text{R} = 0.8$; $\text{R} = 0.85$; $\text{R} = 0.9$; $\text{R} = 0.95$

Mapping: LowerBound, deP, deR, inE, random
Energy-aware strategies on heterogeneous platforms

\[ R = 0.8 \]

\[ cor_{\text{proc}} = 0 \]

\[ cor_{\text{proc}} = 0.25 \]

\[ cor_{\text{proc}} = 0.5 \]

\[ cor_{\text{proc}} = 0.75 \]

\[ cor_{\text{proc}} = 1 \]

Basic Work

\[ \text{Ratio to the baseline} \]

mapping

\[ \text{deP} \]

\[ \text{deR} \]

\[ \text{inE} \]

\[ \text{random} \]

\[ \text{Scheduling criteria: time-energy} \]

\[ \text{cor}_{\text{task}} = 0.25, \beta_{\text{uw}} = 0.6 \]

\[ R = 0.65 \]

\[ R = 0.8 \]

RR n° 9324
Energy-aware strategies on heterogeneous platforms

- $R = 0.85$
- $R = 0.9$
- $R = 0.95$
- $R = 0.8$
- $R = 0.75$
- $R = 0.7$
- $R = 0.65$
- $R = 0.6$
- $R = 0.55$
- $R = 0.5$
- $R = 0.45$
- $R = 0.4$
- $R = 0.35$
- $R = 0.3$
- $R = 0.25$
- $R = 0.2$
- $R = 0.15$
- $R = 0.1$
- $R = 0.05$

- $\text{cor}_{\text{proc}} = 0$
- $\text{cor}_{\text{proc}} = 0.25$
- $\text{cor}_{\text{proc}} = 0.5$
- $\text{cor}_{\text{proc}} = 0.75$
- $\text{cor}_{\text{proc}} = 1$

- $\text{cor}_{\text{task}} = 0.25$, $\beta_{\text{f}} = 0.6$
- Scheduling criteria: energy-time

Basic Work

$\text{cor}_{\text{proc}} = 0.10$
$\text{cor}_{\text{proc}} = 0.15$
$\text{cor}_{\text{proc}} = 0.20$
$\text{cor}_{\text{proc}} = 0.25$
$\text{cor}_{\text{proc}} = 0.30$

$\text{cor}_{\text{proc}} = 0.35$
$\text{cor}_{\text{proc}} = 0.40$
$\text{cor}_{\text{proc}} = 0.45$
$\text{cor}_{\text{proc}} = 0.50$
$\text{cor}_{\text{proc}} = 0.55$
$\text{cor}_{\text{proc}} = 0.60$

$\text{cor}_{\text{proc}} = 0.65$
$\text{cor}_{\text{proc}} = 0.70$
$\text{cor}_{\text{proc}} = 0.75$
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$\text{cor}_{\text{proc}} = 0.85$
$\text{cor}_{\text{proc}} = 0.90$
$\text{cor}_{\text{proc}} = 0.95$

$\text{cor}_{\text{proc}} = 1.00$

$\text{cor}_{\text{proc}} = 1.10$
$\text{cor}_{\text{proc}} = 1.20$
$\text{cor}_{\text{proc}} = 1.30$
$\text{cor}_{\text{proc}} = 1.40$

$\text{cor}_{\text{proc}} = 1.50$

$\text{cor}_{\text{proc}} = 1.60$
$\text{cor}_{\text{proc}} = 1.70$
$\text{cor}_{\text{proc}} = 1.80$
$\text{cor}_{\text{proc}} = 1.90$

$\text{cor}_{\text{proc}} = 2.00$
$\text{cor}_{\text{proc}} = 2.10$
$\text{cor}_{\text{proc}} = 2.20$
$\text{cor}_{\text{proc}} = 2.30$

$\text{cor}_{\text{proc}} = 2.40$
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$\text{cor}_{\text{proc}} = 2.70$

$\text{cor}_{\text{proc}} = 2.80$
$\text{cor}_{\text{proc}} = 2.90$
$\text{cor}_{\text{proc}} = 3.00$
$\text{cor}_{\text{proc}} = 3.10$

$\text{cor}_{\text{proc}} = 3.20$
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$\text{cor}_{\text{proc}} = 3.40$
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$\text{cor}_{\text{proc}} = 4.80$
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$\text{cor}_{\text{proc}} = 5.00$
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$\text{cor}_{\text{proc}} = 6.60$
$\text{cor}_{\text{proc}} = 6.70$

$\text{cor}_{\text{proc}} = 6.80$
$\text{cor}_{\text{proc}} = 6.90$
$\text{cor}_{\text{proc}} = 7.00$
$\text{cor}_{\text{proc}} = 7.10$

$\text{cor}_{\text{proc}} = 7.20$
$\text{cor}_{\text{proc}} = 7.30$
$\text{cor}_{\text{proc}} = 7.40$
$\text{cor}_{\text{proc}} = 7.50$

$\text{cor}_{\text{proc}} = 7.60$
$\text{cor}_{\text{proc}} = 7.70$
$\text{cor}_{\text{proc}} = 7.80$
$\text{cor}_{\text{proc}} = 7.90$

$\text{cor}_{\text{proc}} = 8.00$
$\text{cor}_{\text{proc}} = 8.10$
$\text{cor}_{\text{proc}} = 8.20$
$\text{cor}_{\text{proc}} = 8.30$

$\text{cor}_{\text{proc}} = 8.40$
$\text{cor}_{\text{proc}} = 8.50$
$\text{cor}_{\text{proc}} = 8.60$
$\text{cor}_{\text{proc}} = 8.70$

$\text{cor}_{\text{proc}} = 8.80$
$\text{cor}_{\text{proc}} = 8.90$
$\text{cor}_{\text{proc}} = 9.00$
$\text{cor}_{\text{proc}} = 9.10$

$\text{cor}_{\text{proc}} = 9.20$
$\text{cor}_{\text{proc}} = 9.30$
$\text{cor}_{\text{proc}} = 9.40$
$\text{cor}_{\text{proc}} = 9.50$

$\text{cor}_{\text{proc}} = 9.60$
$\text{cor}_{\text{proc}} = 9.70$
$\text{cor}_{\text{proc}} = 9.80$
$\text{cor}_{\text{proc}} = 9.90$

$\text{cor}_{\text{proc}} = 10.00$

RR n° 9324
Energy-aware strategies on heterogeneous platforms

![Graph showing energy-aware strategies on heterogeneous platforms](image-url)

- $\text{cor}_{\text{proc}} = 0.25$; $\beta_{\text{br}} = 0.6$; Scheduling criteria: energy-energy
### Energy-aware strategies on heterogeneous platforms

#### Results for different values of \( \text{cor}_{	ext{proc}} \)

<table>
<thead>
<tr>
<th>( \text{cor}_{	ext{proc}} )</th>
<th>Basic Work</th>
<th>( R ) = 0.95</th>
<th>( R ) = 0.85</th>
<th>( R ) = 0.8</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>0.25</td>
<td>0.95</td>
<td>0.95</td>
<td>0.95</td>
<td>0.95</td>
</tr>
<tr>
<td>0.5</td>
<td>0.90</td>
<td>0.90</td>
<td>0.90</td>
<td>0.90</td>
</tr>
<tr>
<td>0.75</td>
<td>0.85</td>
<td>0.85</td>
<td>0.85</td>
<td>0.85</td>
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<tr>
<td>1</td>
<td>0.80</td>
<td>0.80</td>
<td>0.80</td>
<td>0.80</td>
</tr>
</tbody>
</table>

**Note:** The mapping criteria used was a random shuffling strategy. The scheduling criteria were either basic or work leveling. The energy consumption was normalized to the baseline value.

---

**RR n° 9324**
$\text{corr}_{\text{task}} = 0.25$; $\beta_{\text{b/w}} = 0.8$; Scheduling criteria: time-energy
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>$\text{cor}_{\text{true}}$</th>
<th>0.00</th>
<th>0.25</th>
<th>0.50</th>
<th>0.75</th>
<th>1.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R$ = 0.05</td>
<td></td>
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</tr>
<tr>
<td>$R$ = 0.10</td>
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<tr>
<td>$R$ = 0.85</td>
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<td></td>
</tr>
<tr>
<td>$R$ = 0.8</td>
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</tr>
</tbody>
</table>

*Basic Work Ratio to the baseline*

<table>
<thead>
<tr>
<th>$\text{cor}_{\text{true}}$</th>
<th>0.00</th>
<th>0.25</th>
<th>0.50</th>
<th>0.75</th>
<th>1.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R$ = 0.05</td>
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<tr>
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<tr>
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<td></td>
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<tr>
<td>$R$ = 0.8</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

*Mapping Lowerbounds:
- $\text{dep}$
- $\text{dep}$
- $\text{size}$

*Scheduling criteria: energy-time*
Energy-aware strategies on heterogeneous platforms

$\text{corr}_{\text{task}} = 0.25$; $\beta_{b/w} = 0.8$; Scheduling criteria: energy-energy

$\text{RR} \leq 0.9324$
### Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>$\cos_{\text{proc}} = 0$</th>
<th>$\cos_{\text{proc}} = 0.25$</th>
<th>$\cos_{\text{proc}} = 0.5$</th>
<th>$\cos_{\text{proc}} = 0.75$</th>
<th>$\cos_{\text{proc}} = 1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R = 0.05$</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>$R = 0.1$</td>
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<tr>
<td>$R = 0.15$</td>
<td></td>
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<tr>
<td>$R = 0.2$</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>$R = 0.25$</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**Basic Work**

- $\text{cor}_{\text{task}} = 0.25$, $\beta_{\text{btu}} = 0.8$
- Scheduling criteria: randomShuffling

**LowerBound**

- $\text{deP}$
- $\text{deR}$
- $\text{inE}$
- random

** Mapping**

- LowerBound (dp)
- $\text{deP}$, $\text{deR}$, $\text{inE}$, random

**Results**

- $\text{RR} = 0.9324$
<table>
<thead>
<tr>
<th>$\alpha_{p,m} = 0.25, \beta_{u,m} = 1$</th>
<th>$\alpha_{p,m} = 0.5, \beta_{u,m} = 1$</th>
<th>$\alpha_{p,m} = 0.75, \beta_{u,m} = 1$</th>
<th>$\alpha_{p,m} = 1, \beta_{u,m} = 1$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>cor proc = 0</strong>, $R =$ 0.9</td>
<td><strong>cor proc = 0.25</strong>, $R =$ 0.9</td>
<td><strong>cor proc = 0.5</strong>, $R =$ 0.9</td>
<td><strong>cor proc = 0.75</strong>, $R =$ 0.9</td>
</tr>
<tr>
<td>$R =$ 0.85</td>
<td>$R =$ 0.85</td>
<td>$R =$ 0.85</td>
<td>$R =$ 0.85</td>
</tr>
</tbody>
</table>

| $R =$ 0.8 | $R =$ 0.8 | $R =$ 0.8 | $R =$ 0.8 |

**Basic Work**

Ratio to the baseline

**Mapping**

Lower bound, $dP$, $dR$, $uk$, random

$\text{RR n} \equiv 9324$
Energy-aware strategies on heterogeneous platforms

\[ R = 0.85 \]

\[ \text{cor}_{\text{proc}} = 0 \]

\[ \text{cor}_{\text{proc}} = 0.25 \]

\[ \text{cor}_{\text{proc}} = 0.5 \]

\[ \text{cor}_{\text{proc}} = 0.75 \]

\[ \text{cor}_{\text{proc}} = 1 \]

Basic Work

Ratio to the baseline

Mapping: Low-thr. sp. dP, dR, skel, rskel

RR n° 9324
Energy-aware strategies on heterogeneous platforms

\[ R = 0.8 \]

\[ cor_{proc} = 0 \]

\[ cor_{proc} = 0.25 \]

\[ cor_{proc} = 0.5 \]

\[ cor_{proc} = 0.75 \]

\[ cor_{proc} = 1 \]

Basic Work

LowerBound

\[ \beta_{bw} = 1 \]

Scheduling criteria: energy-energy

RR n° 9324
$cor_{task} = 0.25$; $\beta_{b/w} = 1$; Scheduling criteria: randomShuffling

$\mathcal{R} = 0.8$  $\mathcal{R} = 0.85$  $\mathcal{R} = 0.9$  $\mathcal{R} = 0.95$

Ratio to the baseline

Basic Work

mapping: LowerBound  deP  deR  inE  random

Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

cor_{task} = 0.5; \beta_{j,w} = 0.2; Scheduling criteria: time-energy
Energy-aware strategies on heterogeneous platforms

...
$\text{cor}_{\text{task}} = 0.5; \beta_{fw} = 0.2$; Scheduling criteria: randomShuffling
Energy-aware strategies on heterogeneous platforms

cor\text{task} = 0.5; \beta_{j,w} = 0.4; Scheduling criteria: time-energy
$\rho_{\text{task}} = 0.5; \beta_{\text{f/w}} = 0.4; \text{Scheduling criteria: energy-time}$
Energy-aware strategies on heterogeneous platforms

cor\textsubscript{task} = 0.5; \beta_{j,w} = 0.6; Scheduling criteria: time-time
Energy-aware strategies on heterogeneous platforms

RR n° 9324
$cor_{task} = 0.5$; $\beta_{hw} = 0.6$; Scheduling criteria: energy-time
$\text{cor}_{\text{task}} = 0.5$; $\beta_{j,w} = 0.6$; Scheduling criteria: energy-energy
Energy-aware strategies on heterogeneous platforms

\[ \text{corr}_{\text{task}} = 0.5; \; \beta_{\text{f}w} = 0.6; \; \text{Scheduling criteria: randomShuffling} \]
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

![Graph showing energy consumption and task mapping]
Energy-aware strategies on heterogeneous platforms

RR n° 9324
Energy-aware strategies on heterogeneous platforms

![Diagram showing energy-aware strategies on heterogeneous platforms]

Basic Work

Mapping

LowerBound

deP

deR

inE

random

Scheduling criteria: time-time

\( R = 0.85 \)

\( R = 0.8 \)

\( R = 0.9 \)

\( R = 0.95 \)

\( cor_{baseline} = 0 \)

\( cor_{baseline} = 0.25 \)

\( cor_{baseline} = 0.5 \)

\( cor_{baseline} = 0.75 \)

\( cor_{baseline} = 1 \)

\( \beta_{bw} = 0.5 \); \( \beta_{bw} = 1 \); Scheduling criteria: time-time

RR n° 9324
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>$\alpha$</th>
<th>$\beta$</th>
<th>$\gamma$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25</td>
<td>0.75</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Correlation between $\alpha$, $\beta$, and $\gamma$:

- $\alpha = 0.5$, $\beta = 0$, $\gamma = 1$
- Scheduling criteria: time-energy

### Diagram

- Basic Work
- LowerBound
- Random
- $\alpha = 0.5$, $\beta = 0$, $\gamma = 1$
- Scheduling criteria: time-energy

### Notes

- R = 0.95
- R = 0.9
- R = 0.8
- R = 0.75
- R = 0.25
- R = 0.15
- R = 0.10
- R = 0.05

### Results

- $\text{cor} = 0$, $\text{proc} = 0$
- $\text{cor} = 0.25$, $\text{proc} = 0.25$
- $\text{cor} = 0.5$, $\text{proc} = 0.5$
- $\text{cor} = 0.75$, $\text{proc} = 0.75$
- $\text{cor} = 1$, $\text{proc} = 1$

RR n° 9324
$\text{cor}_{\text{task}} = 0.5; \beta_{j,w} = 1; \text{Scheduling criteria: energy-time}$
Energy-aware strategies on heterogeneous platforms

![Graph showing energy-aware strategies on heterogeneous platforms]

- $R = 0.85$
- $\text{cor}_{\text{proc}} = 0.25$, $\beta_0 = 1$
- Scheduling criteria: energy-energy

RR n° 9324
Energy-aware strategies on heterogeneous platforms

$cor_{task} = 0.75; \beta_{b/w} = 0.2; \text{Scheduling criteria time-time}$

![Diagram showing energy-aware strategies on heterogeneous platforms]
Energy-aware strategies on heterogeneous platforms

R = 0.85

Basic Work

R = 0.65

Scheduling criteria: time-energy

R = 0.45

Baseline

R = 0.25

LowerBound

R = 0.05

UpperBound

Scheduling criteria: time-energy

R = 0.8

Baseline

R = 0.6

LowerBound

R = 0.4

UpperBound

Scheduling criteria: time-energy

R = 0.2

Baseline

R = 0.0

UpperBound

Scheduling criteria: time-energy

R = -0.2

Baseline

R = -0.4

LowerBound

R = -0.6

UpperBound

Scheduling criteria: time-energy

R = -0.8

Baseline

R = -1.0

LowerBound

R = -1.2

UpperBound

Scheduling criteria: time-energy

R = -1.4

Baseline

R = -1.6

LowerBound

R = -1.8

UpperBound

Scheduling criteria: time-energy

R = -2.0

Baseline

R = -2.2

LowerBound

R = -2.4

UpperBound

Scheduling criteria: time-energy

R = -2.6

Baseline

R = -2.8

LowerBound

R = -3.0

UpperBound

Scheduling criteria: time-energy

R = -3.4

Baseline

R = -3.6

LowerBound

R = -3.8

UpperBound

Scheduling criteria: time-energy

R = -4.0

Baseline

R = -4.2

LowerBound

R = -4.4

UpperBound

Scheduling criteria: time-energy

R = -4.6

Baseline

R = -4.8

LowerBound

R = -5.0

UpperBound

Scheduling criteria: time-energy
Energy-aware strategies on heterogeneous platforms

### Table

<table>
<thead>
<tr>
<th>( \text{cor}_{\text{proc}} )</th>
<th>0.00</th>
<th>0.25</th>
<th>0.50</th>
<th>0.75</th>
<th>1.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>( R = 0.05 )</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>( R = 0.10 )</td>
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<tr>
<td>( R = 0.15 )</td>
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<tr>
<td>( R = 0.20 )</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

### Diagram

- Basic Work
- \( \text{cor}_{\text{task}} = 0.75 \), \( \beta_{\text{bw}} = 0.2 \)
- Scheduling criteria: energy-energy

### Equation

\[ R = 0.85 \]
cor_{task} = 0.75; \beta_{b/w} = 0.2; Scheduling criteria: randomShuffling
Energy-aware strategies on heterogeneous platforms

\( cor_{task} = 0.75; \beta_{b/w} = 0.4; \) Scheduling criteria: time-time

Basic Work

Ratio to the baseline

mapping: LowerBound \( \rightarrow \) deP \( \rightarrow \) deR \( \rightarrow \) inE \( \rightarrow \) random
<table>
<thead>
<tr>
<th>( \text{cor}_{\text{proc}} = 0 )</th>
<th>( \text{cor}_{\text{proc}} = 0.25 )</th>
<th>( \text{cor}_{\text{proc}} = 0.5 )</th>
<th>( \text{cor}_{\text{proc}} = 0.75 )</th>
<th>( \text{cor}_{\text{proc}} = 1 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( R = 0.95 )</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( R = 0.9 )</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( R = 0.85 )</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( R = 0.8 )</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Basic Work

Ratio to the baseline

mapping:

-LowerBound deP deR inE random

Scheduling criteria: time-energy

\( \text{cor}_{\text{task}} = 0.75; \beta_{\text{aw}} = 0.4 \); \( \beta_{\text{aw}} = 0.4 \).
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.75; \quad \beta_{b/w} = 0.4; \quad \text{Scheduling criteria: energy-time} \]

\[ R = 0.8 \]

\[ R = 0.85 \]

\[ R = 0.9 \]

\[ R = 0.95 \]

for Basic Work

```
cor_{task} = 0.75; \quad \beta_{b/w} = 0.4; \quad \text{Scheduling criteria: energy-time}
```

Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.75; \ \beta_{b/w} = 0.4; \ \text{Scheduling criteria: energy-energy} \]
Energy aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.75; \ \beta_{b/w} = 0.4; \text{ Scheduling criteria: randomShuffling} \]
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.75; \ \beta_{\text{h/w}} = 0.6; \text{Scheduling criteria: time-time} \]
### Energy-aware strategies on heterogeneous platforms

#### Basic Work

<table>
<thead>
<tr>
<th>Setup</th>
<th>$\text{cor}_{\text{pre}} = 0$</th>
<th>$\text{cor}_{\text{pre}} = 0.25$</th>
<th>$\text{cor}_{\text{pre}} = 0.5$</th>
<th>$\text{cor}_{\text{pre}} = 0.75$</th>
<th>$\text{cor}_{\text{pre}} = 1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R = 0.05$</td>
<td><img src="image1" alt="Graph" /></td>
<td><img src="image2" alt="Graph" /></td>
<td><img src="image3" alt="Graph" /></td>
<td><img src="image4" alt="Graph" /></td>
<td><img src="image5" alt="Graph" /></td>
</tr>
<tr>
<td>$R = 0.10$</td>
<td><img src="image6" alt="Graph" /></td>
<td><img src="image7" alt="Graph" /></td>
<td><img src="image8" alt="Graph" /></td>
<td><img src="image9" alt="Graph" /></td>
<td><img src="image10" alt="Graph" /></td>
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<tr>
<td>$R = 0.15$</td>
<td><img src="image11" alt="Graph" /></td>
<td><img src="image12" alt="Graph" /></td>
<td><img src="image13" alt="Graph" /></td>
<td><img src="image14" alt="Graph" /></td>
<td><img src="image15" alt="Graph" /></td>
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<tr>
<td>$R = 0.20$</td>
<td><img src="image16" alt="Graph" /></td>
<td><img src="image17" alt="Graph" /></td>
<td><img src="image18" alt="Graph" /></td>
<td><img src="image19" alt="Graph" /></td>
<td><img src="image20" alt="Graph" /></td>
</tr>
</tbody>
</table>

### Scheduling criteria: energy-time

- $\text{cor}_{\text{pre}} = 0.75, \beta_{\text{sw}} = 0.6$
- $\text{scheduling criteria: energy-time}$

---

RR n° 9324
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>$corr_{pre} = 0$</th>
<th>$corr_{pre} = 0.25$</th>
<th>$corr_{pre} = 0.5$</th>
<th>$corr_{pre} = 0.75$</th>
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<tr>
<td>$R = 0.95$</td>
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</tr>
</tbody>
</table>

Basic Work

$\rho_{task} = 0.75, \beta_{wu} = 0.6, Scheduling~criterion:~energy-energy$
Energy-aware strategies on heterogeneous platforms

cor_{task} = 0.75; \beta_{b/w} = 0.8; Scheduling criteria: time-time
Energy-aware strategies on heterogeneous platforms

\( \text{corr}_{\text{task}} = 0.75; \ \beta_{b/w} = 0.8; \) Scheduling criteria: time-energy

Basic Work

Ratio to the baseline

mapping: LowerBound, deP, deR, inE, random

RR n° 9224
Energy-aware strategies on heterogeneous platforms

---

### Correlation Coefficients

- $\text{corr}_{\text{proc}} = 0$
- $\text{corr}_{\text{proc}} = 0.25$
- $\text{corr}_{\text{proc}} = 0.5$
- $\text{corr}_{\text{proc}} = 0.75$
- $\text{corr}_{\text{proc}} = 1$

### Scheduling Criteria

- Energy-Time

---

### Basic Work

- Mapping
- LowerBound
- deP
- deR
- $\beta_{\text{inE}}$
- $\beta_{\text{onE}}$
- $\beta_{\text{onT}}$

---

### Results

- $R = 0.05$
- $R = 0.1$
- $R = 0.15$

---

### RR

- $n$
Energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{task}} = 0.75; \beta_{b/w} = 0.8; \text{Scheduling criteria: energy-energy} \)

\( R = 0.8 \)
\( R = 0.85 \)
\( R = 0.9 \)
\( R = 0.95 \)

Basic Work

Ratio to the baseline
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
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<th>corr_w</th>
<th>corr_randomShuffling</th>
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<tr>
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<td>0.8</td>
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<tr>
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<td>0.85</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>1</td>
<td>0.85</td>
<td>0.8</td>
<td>0.8</td>
</tr>
</tbody>
</table>

R = 0.95

R = 0.9

R = 0.85

R = 0.8

Basic Work

LowerBound

deP

deR

inE

randomShuffling

Scheduling criteria: randomShuffling

RR n° 9324
Energy-aware strategies on heterogeneous platforms

![Graph showing energy-aware strategies on heterogeneous platforms]

- **$R = 0.9$**
- **$R = 0.85$**
- **$R = 0.8$**

Correlation coefficient $\rho$ and $\beta_0$, $\beta_1$, $\beta_2$:
- $\rho = 0.75$;
- $\beta_0 = 1$;
- $\beta_1$ and $\beta_2$ are determined by the scheduling criteria: time-energy.

**Basic Work**

- $\text{Lower Bound}$
- $\text{deP}$
- $\text{deR}$

- $\text{mapping}$

- $\text{RR}$

**n° 9324**
Energy-aware strategies on heterogeneous platforms

\[ cor_{task} = 0.75; \beta_{b/w} = 1; \text{ Scheduling criteria: energy-time} \]
Energy-aware strategies on heterogeneous platforms

$R = 0.85$

$\text{cor}_{\text{proc}} = 0.75$, $\beta_{\text{w}} = 1$; Scheduling criteria: randomShuffling

RR n° 9324
Energy-aware strategies on heterogeneous platforms

![Graph showing energy-aware strategies on heterogeneous platforms]

- $R = 0.85$
- $R = 0.8$
- $R = 0.75$
- $R = 0.5$
- $R = 0.9$
- $R = 0.95$
- $\text{cor} = 0.10$
- $\text{cor} = 0.15$
- $\text{cor} = 0.20$
- $\text{cor} = 0.25$
- $\text{cor} = 0.30$

Basic Work

Ratio to the baseline

mapping

- Lower Bound
- deP
- deR
- random

$\text{cor}_{\text{task}} = 1$, $\beta_{\text{eq}} = 0.2$, Scheduling criteria: time-time

RR n° 9324
basic work
ratio to the baseline
mapping
LowerBound deP deR inE random

cor task = 1, \beta_{0wu} = 0.2. Scheduling criteria: time-energy

RR n° 9324
Energy-aware strategies on heterogeneous platforms

Basic Work

LowerBound

corr proc = 0
corr proc = 0.25
corr proc = 0.75
corr proc = 1

corr proc = 0

corr proc = 0.25

corr proc = 0.75

corr proc = 1

Mapping: Correlated

corr proc = 0.85

corr proc = 0.9

Scheduling criteria: energy-time

RR n° 9324
Energy-aware strategies on heterogeneous platforms

![Diagram of energy-aware strategies on heterogeneous platforms](image_url)
Energy-aware strategies on heterogeneous platforms

R = 0.8

R = 0.9

R = 0.95

R = 0.75

R = 1

cor_{proc} = 0

cor_{proc} = 0.25

cor_{proc} = 0.5

cor_{proc} = 0.75

cor_{proc} = 1

Task

Mapping

Basic Work

LowerBound

deP

deR

inE

random

β_{b/w} = 0.4

Scheduling criteria: time-time

\text{cor}_{task} = 1; \beta_{b/w} = 0.4

Tasks to the baseline

RR n° 9324
Energy-aware strategies on heterogeneous platforms

\[ R = 0.8 \]

\[ R = 0.85 \]

\[ R = 0.9 \]

\[ R = 0.95 \]

\[ \text{cor}_{\text{task}} = 1; \beta_{\text{w}, \text{w}} = 0.4; \text{Scheduling criterion: time-energy} \]

\[ \text{Basic Work} \]

\[ \text{LowerBound} \]

\[ \text{deP} \]

\[ \text{deR} \]

\[ \text{inE} \]

\[ \text{random} \]
### Energy-aware strategies on heterogeneous platforms

#### Table: Scheduling criteria: energy-energy

<table>
<thead>
<tr>
<th>Scenario</th>
<th>$\text{cor}_{\text{proc}}$ = 0</th>
<th>$\text{cor}_{\text{proc}}$ = 0.25</th>
<th>$\text{cor}_{\text{proc}}$ = 0.5</th>
<th>$\text{cor}_{\text{proc}}$ = 0.75</th>
<th>$\text{cor}_{\text{proc}}$ = 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R = 0.05$</td>
<td>![Graph]</td>
<td>![Graph]</td>
<td>![Graph]</td>
<td>![Graph]</td>
<td>![Graph]</td>
</tr>
<tr>
<td>$R = 0.10$</td>
<td>![Graph]</td>
<td>![Graph]</td>
<td>![Graph]</td>
<td>![Graph]</td>
<td>![Graph]</td>
</tr>
<tr>
<td>$R = 0.45$</td>
<td>![Graph]</td>
<td>![Graph]</td>
<td>![Graph]</td>
<td>![Graph]</td>
<td>![Graph]</td>
</tr>
</tbody>
</table>

#### Figure: Basic Work

- ![Diagram](image)
- ![Diagram](image)
- ![Diagram](image)
- ![Diagram](image)

*Corrections to the baseline:*
- $\text{cor}_{\text{task}} = 1; \beta_{\text{sol}} = 0.4$
- Scheduling criteria: energy-energy

RR n° 9324
Energy-aware strategies on heterogeneous platforms

![Graph showing energy-aware strategies on heterogeneous platforms]

- **$R = 0.85$**
- **$R = 0.9$**
- **$R = 0.95$**

**Scheduling Criteria:** randomShuffling

**Basic Work: Correlation to the baseline**

$\alpha_{\text{task}} = 1; \beta_{\text{compute}} = 0.4$; $\delta_{\text{com}} = 0.4$; Scheduling criteria: randomShuffling

RR n° 9324
Energy-aware strategies on heterogeneous platforms

![Graph showing energy consumption and efficiency for different configurations.

- For $\text{cor}_{\text{proc}} = 0$, the energy consumption is lower with a ratio of 0.8.
- As $\text{cor}_{\text{proc}}$ increases to 0.25, the energy consumption increases, but the ratio remains close to 0.9.
- Further increase to 0.5 results in a significant increase in energy consumption, but the ratio drops to 0.6.
- With $\text{cor}_{\text{proc}} = 0.75$, the energy consumption is high, and the ratio decreases to 0.3.
- At $\text{cor}_{\text{proc}} = 1$, the energy consumption is the highest, and the ratio drops to 0.1.

Scheduling criteria: time-time

- Basic Work
- Mapping
- LowerBound
- $d_{h, \text{ssl}}$
- $d_{h, \text{ssl}}$
- $d_{h, \text{ssl}}$

Correlation Task: $\beta_{\text{b/w}} = 0.6$
Energy-aware strategies on heterogeneous platforms

$\text{cor}_{\text{task}} = 1$; $\beta_{b/w} = 0.6$; Scheduling criteria: time-energy

$\text{cor}_{\text{proc}} = 0.30$; $\beta_{b/w} = 0.9$; Scheduling criteria: time-energy

$\text{cor}_{\text{proc}} = 0.30$; $\beta_{b/w} = 0.6$; Scheduling criteria: time-energy

$\text{cor}_{\text{proc}} = 0.30$; $\beta_{b/w} = 0.9$; Scheduling criteria: time-energy

$\text{cor}_{\text{proc}} = 0.30$; $\beta_{b/w} = 0.6$; Scheduling criteria: time-energy

$\text{cor}_{\text{proc}} = 0.30$; $\beta_{b/w} = 0.9$; Scheduling criteria: time-energy

$\text{cor}_{\text{proc}} = 0.30$; $\beta_{b/w} = 0.6$; Scheduling criteria: time-energy

$\text{cor}_{\text{proc}} = 0.30$; $\beta_{b/w} = 0.9$; Scheduling criteria: time-energy

$\text{cor}_{\text{proc}} = 0.30$; $\beta_{b/w} = 0.6$; Scheduling criteria: time-energy

$\text{cor}_{\text{proc}} = 0.30$; $\beta_{b/w} = 0.9$; Scheduling criteria: time-energy

$\text{cor}_{\text{proc}} = 0.30$; $\beta_{b/w} = 0.6$; Scheduling criteria: time-energy

$\text{cor}_{\text{proc}} = 0.30$; $\beta_{b/w} = 0.9$; Scheduling criteria: time-energy

$\text{cor}_{\text{proc}} = 0.30$; $\beta_{b/w} = 0.6$; Scheduling criteria: time-energy

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$\text{cor}_{\text{proc}} = 0.30$; $\beta_{b/w} = 0.9$; Scheduling criteria: time-energy

$\text{cor}_{\text{proc}} = 0.30$; $\beta_{b/w} = 0.6$; Scheduling criteria: time-energy

$\text{cor}_{\text{proc}} = 0.30$; $\beta_{b/w} = 0.9$; Scheduling criteria: time-energy

$\text{cor}_{\text{proc}} = 0.30$; $\beta_{b/w} = 0.6$; Scheduling criteria: time-energy

$\text{cor}_{\text{proc}} = 0.30$; $\beta_{b/w} = 0.9$; Scheduling criteria: time-energy

$\text{cor}_{\text{proc}} = 0.30$; $\beta_{b/w} = 0.6$; Scheduling criteria: time-energy

$\text{cor}_{\text{proc}} = 0.30$; $\beta_{b/w} = 0.9$; Scheduling criteria: time-energy

$\text{cor}_{\text{proc}} = 0.30$; $\beta_{b/w} = 0.6$; Scheduling criteria: time-energy

$\text{cor}_{\text{proc}} = 0.30$; $\beta_{b/w} = 0.9$; Scheduling criteria: time-energy

$\text{cor}_{\text{proc}} = 0.30$; $\beta_{b/w} = 0.6$; Scheduling criteria: time-energy

$\text{cor}_{\text{proc}} = 0.30$; $\beta_{b/w} = 0.9$; Scheduling criteria: time-energy

$\text{cor}_{\text{proc}} = 0.30$; $\beta_{b/w} = 0.6$; Scheduling criteria: time-energy

$\text{cor}_{\text{proc}} = 0.30$; $\beta_{b/w} = 0.9$; Scheduling criteria: time-energy

$\text{cor}_{\text{proc}} = 0.30$; $\beta_{b/w} = 0.6$; Scheduling criteria: time-energy

$\text{cor}_{\text{proc}} = 0.30$; $\beta_{b/w} = 0.9$; Scheduling criteria: time-energy

$\text{cor}_{\text{proc}} = 0.30$; $\beta_{b/w} = 0.6$; Scheduling criteria: time-energy

$\text{cor}_{\text{proc}} = 0.30$; $\beta_{b/w} = 0.9$; Scheduling criteria: time-energy

$\text{cor}_{\text{proc}} = 0.30$; $\beta_{b/w} = 0.6$; Scheduling criteria: time-energy

$\text{cor}_{\text{proc}} = 0.30$; $\beta_{b/w} = 0.9$; Scheduling criteria: time-energy

$\text{cor}_{\text{proc}} = 0.30$; $\beta_{b/w} = 0.6$; Scheduling criteria: time-energy

$\text{cor}_{\text{proc}} = 0.30$; $\beta_{b/w} = 0.9$; Scheduling criteria: time-energy

$\text{cor}_{\text{proc}} = 0.30$; $\beta_{b/w} = 0.6$; Scheduling criteria: time-energy

$\text{cor}_{\text{proc}} = 0.30$; $\beta_{b/w} = 0.9$; Scheduling criteria: time-energy

$\text{cor}_{\text{proc}} = 0.30$; $\beta_{b/w} = 0.6$; Scheduling criteria: time-energy

$\text{cor}_{\text{proc}} = 0.30$; $\beta_{b/w} = 0.9$; Scheduling criteria: time-energy

$\text{cor}_{\text{proc}} = 0.30$; $\beta_{b/w} = 0.6$; Scheduling criteria: time-energy

$\text{cor}_{\text{proc}} = 0.30$; $\beta_{b/w} = 0.9$; Scheduling criteria: time-energy

$\text{cor}_{\text{proc}} = 0.30$; $\beta_{b/w} = 0.6$; Scheduling criteria: time-energy
Energy-aware strategies on heterogeneous platforms

\begin{figure}
\centering
\includegraphics[width=\textwidth]{energy-aware-strategies}
\caption{Comparison of energy consumption across different correlation factors.}
\end{figure}

\begin{itemize}
\item \textbf{Correlation factor} \( \rho \):
\begin{itemize}
\item \( \rho = 0.85 \)
\item \( \rho = 0.95 \)
\end{itemize}
\item \textbf{Energy-time scheduling criteria}:
\begin{itemize}
\item \( \text{min} = 1 \)
\item \( \beta_{\text{min}} = 0.6 \)
\end{itemize}
\end{itemize}
Energy-aware strategies on heterogeneous platforms

![Graph showing energy-aware strategies on heterogeneous platforms](image-url)

**Basic Work**

**Ratio to the baseline**

**LowerBound**

**deP**

**deR**

**inE**

**random**

**cor**

**task**

**RR n° 9324**
Energy-aware strategies on heterogeneous platforms

\[ R = 0.8 \]

\[ R = 0.9 \]

\[ R = 0.95 \]

\[ \text{Basic Work} \]

\[ \text{Ratio to the baseline} \]

\[ \text{mapping} \]

\[ \text{LowerBound} \]

\[ \text{deP} \]

\[ \text{deR} \]

\[ \text{inE} \]

\[ \text{random} \]

\[ \text{Scheduling criteria: randomShuffling} \]

\[ \text{cor}_{\text{task}} = 1; \beta_{\text{cor}} = 0.6 \]

RR n° 9324
Energy-aware strategies on heterogeneous platforms

0.90 1.10 1.30 20.00 20.20 20.30
1.00 1.40 2.10 20.00 20.10 20.30
1.20 2.20 2.90 20.00 20.10 20.40
1.40 2.50 3.60 20.00 20.00 20.80
1.50 2.80 4.00 20.00 20.00 21.50
0.90 1.00 1.30 20.10 20.30 20.50
1.00 1.40 2.00 20.10 20.40 20.70
1.20 2.20 2.90 20.00 20.40 21.30
1.40 2.60 3.80 20.00 20.50 23.60
1.50 2.90 4.20 20.00 21.10 25.80
0.90 1.00 1.30 21.10 21.50 23.10
1.00 1.40 2.10 21.20 23.20 29.20
1.20 2.20 3.30 21.90 30.50 35.40
1.40 2.80 4.30 23.90 33.40 38.30
1.60 3.10 4.70 25.50 34.80 39.60
0.90 1.00 1.30 21.10 21.50 23.10
1.00 1.40 2.10 21.20 23.20 29.20
1.20 2.20 3.30 21.90 30.50 35.40
1.40 2.80 4.30 23.90 33.40 38.30
1.60 3.10 4.70 25.50 34.80 39.60

R = 0.85

R = 0.9

R = 0.95

R = 0.8

$\text{cor}_{\text{proc}} = 0$  $\text{cor}_{\text{proc}} = 0.25$  $\text{cor}_{\text{proc}} = 0.5$  $\text{cor}_{\text{proc}} = 0.75$  $\text{cor}_{\text{proc}} = 1$

Basic Work

Mapping: Lowenthal et al.  deb  ahR  ale  r alke

$\text{cor}_{\text{task}} = 1; \beta_{\text{la}, \text{w}} = 0.8$, Scheduling criteria: time-time

$\beta_{\text{b/w}} = 0.8$; Scheduling criteria: time-time

RR no 9324
Energy-aware strategies on heterogeneous platforms

\[ R = 0.8 \]

\[ R = 0.9 \]

\[ R = 0.85 \]

\[ R = 0.8 \]

\[ \text{cor}_{\text{task}} = 1; \beta_{\text{wa}} = 0.8; \text{Scheduling criteria: time-energy} \]

Basic Work

\[ \text{Baseline} \]

\[ \text{maping} \]

\[ \text{dLPR} \]

\[ \text{sktech} \]
cor_{task} = 1; \beta_{b/w} = 0.8; Scheduling criteria: energy-energy
Energy-aware strategies on heterogeneous platforms

**Diagram Description:**

- The diagram illustrates the impact of varying parameters on system performance, with each column representing a different setting.
- The x-axis represents the ratio to the baseline, ranging from 0.00 to 1.25.
- The y-axis shows the performance measure, with markers indicating specific data points.
- Different markers and colors indicate varying conditions, such as mapping, correlation, and scheduling criteria.

**Key Parameters:**

- **ρ:** Correlation parameter setting.
- **β:** Weighting parameter for correlation.
- **Scheduling criteria:** Random Shuffling, Random, Preemption, etc.

**Legend:**

- Basic Work
- RR
- Preemption
- Random

**Notes:**

- For specific parameter configurations, there are clear visual distinctions in performance trends.
- The diagram is structured to compare different conditions side by side, allowing for easy analysis of performance implications.

**Technical Details:**

- The diagram is complex, requiring careful examination to interpret accurately.
- It is essential to understand the context of the parameters (ρ, β) to interpret the results correctly.

**Conclusion:**

- The diagram provides a comprehensive view of how different parameter settings affect system performance.
- It is a useful tool for researchers and practitioners looking to optimize energy-aware strategies on heterogeneous platforms.
Energy-aware strategies on heterogeneous platforms

![Graph showing energy-aware strategies on heterogeneous platforms]

- **$R = 0.9$**
- **$R = 0.95$**
- **$R = 0.8$**
- **$R = 0.85$**

**Cor proc**
- 0.10
- 0.15
- 0.20
- 0.25
- 0.30

**Mapping**
- Basic Work
- Scheduling criteria: time-time

**Parameters**
- $\text{cor}_\text{proc} = 0$
- $\text{cor}_\text{proc} = 0.25$
- $\text{cor}_\text{proc} = 0.5$
- $\text{cor}_\text{proc} = 0.75$
- $\text{cor}_\text{proc} = 1$

**Correlation Coefficients**
- $\text{cor} = 0.8$
- $\text{cor} = 0.85$

**Baseline**
- $\beta_{/w} = 1$
- $\beta_{/w} = 1$
- $\beta_{/w} = 1$
- $\beta_{/w} = 1$

**Scheduling Criteria**
- Time-time

**Graphs**
- Comparison of energy-aware strategies under varying correlation coefficients ($\text{cor}_\text{proc}$).
- Analysis of baseline performance and impact on mapping efficiency.

RR n° 9324
Energy-aware strategies on heterogeneous platforms

![Graph showing energy-aware strategies on heterogeneous platforms](image_url)

### Parameters Explained
- \( R = 0.8 \)
- \( R = 0.95 \)
- \( R = 0.9 \)
- \( R = 0.85 \)

### Scheduling Criteria
- \( \gamma_0(w) = 1 \)
- \( \beta_{0,w} = 1 \)

### Results
- Basic Work
- Resource Mapping
- Lower Bound
- Upper Bound

---

RR n° 9324
Energy-aware strategies on heterogeneous platforms

$cor_{task} = 1; \beta_{b/w} = 1$; Scheduling criteria: energy-time

- LowerBound
- deP
- deR
- inE
- random
Energy-aware strategies on heterogeneous platforms

\[ R = 0.85 \]

\[ R = 0.9 \]

\[ R = 0.95 \]

Correlation task: \( \beta_{uw} = 1 \), Scheduling criteria: energy-energy

Basic Work

Ratio to the baseline

Mapping

LowerBound
dP
dR
stk
stk2
basicWork and $\mathcal{R}$ (Scheduling)

The following section presents ratio of energy consumption using different scheduling strategies under big failure rate, when varying basicWork and $\mathcal{R}$. 
$\text{cor}_{\text{task}} = 0.25; \beta_{b/w} = 0.2; \text{Mapping criteria: inE}$
Energy-aware strategies on heterogeneous platforms

cor\textsubscript{task} = 0.25; \beta_{b/w} = 0.2; \text{Mapping criteria: deR}

Ratio to the baseline

Basic Work

scheduling

LowerBound \quad \text{energy-energy} \quad \text{time-energy}

energy-time \quad \text{time-time} \quad \text{randomShuffling}
Energy-aware strategies on heterogeneous platforms

\[ R = 0.8 \]

\[ \text{Basic Work} \]

\[ \text{Ratio to the baseline} \]

\[ \text{scheduling} \]

\[ \text{LowerBound} \]

\[ \text{energy-energy} \]

\[ \text{time-energy} \]

\[ \text{time-time} \]

\[ \text{randomShuffling} \]

\[ \text{cor} \]

\[ \text{task} \]

\[ \text{0.25}; \beta_{w/u} = 0.2; \text{Mapping criteria: deP} \]

\[ n = 9324 \]
\[ \text{cor}_{\text{task}} = 0.25; \; \beta_{b/w} = 0.2; \text{ Mapping criteria: random} \]
Energy-aware strategies on heterogeneous platforms

corr_{task} = 0.25; \beta_{b/w} = 0.4; Mapping criteria: inE

LowerBound  energy-energy  time-time
energy-time  time-energy  randomShuffling
Energy-aware strategies on heterogeneous platforms

![Graph showing energy efficiency and performance trade-offs for different scheduling algorithms and task mapping criteria. The graph includes various markers and lines representing different scenarios and criteria such as energy-time and time-energy trade-offs.](image-url)
$cor_{task} = 0.25; \beta_{b/w} = 0.4; \text{Mapping criteria: random}$

Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

$\text{corr}_{\text{task}} = 0.25$; $\beta_{b/w} = 0.6$; Mapping criteria: inE

Basic Work

Ratio to the baseline

scheduling
- LowerBound
- energy-energy
- energy-time
- time-energy
- randomShuffling

$\text{Basic Work}$

$\text{Ratio to the baseline}$

$\text{cor}_{\text{task}} = 0.25$; $\beta_{b/w} = 0.6$; Mapping criteria: inE
Energy-aware strategies on heterogeneous platforms

\( cor_{task} = 0.25 \); \( \beta_{b/w} = 0.6 \); Mapping criteria: deR

- \( R = 0.8 \)
- \( R = 0.85 \)
- \( R = 0.9 \)
- \( R = 0.95 \)

Ratio to the baseline

Basic Work

LowerBound  energy-time  time-energy  randomShuffling
Energy-aware strategies on heterogeneous platforms

cor\text{task} = 0.25; \beta_{b/w} = 0.6; \text{Mapping criteria: deP}

\begin{align*}
    R &= 0.8, \\
    R &= 0.85, \\
    R &= 0.9, \\
    R &= 0.95
\end{align*}

\begin{align*}
    \text{Ratio to the baseline} &= 0.10, 0.15, 0.20, 0.25, 0.30, 0.35, 0.40, 0.45, 0.50, 0.55, 0.60, 0.65, 0.70, 0.75, 0.80, 0.85, 0.90, 0.95, 1.00
\end{align*}

\begin{align*}
    \text{Basic Work} &= 0.10, 0.15, 0.20, 0.25, 0.30, 0.35, 0.40, 0.45, 0.50, 0.55, 0.60, 0.65, 0.70, 0.75, 0.80, 0.85, 0.90, 0.95, 1.00
\end{align*}

\begin{align*}
    \text{scheduling} &= \text{LowerBound, energy-energy, time-energy, randomShuffling}
\end{align*}
Energy-aware strategies on heterogeneous platforms

\[ R = 0.8 \]

\[ \text{cor}_{\text{task}} = 0.25 \cdot \beta_{\text{wu}} = 0.6; \text{Mapping criteria: random} \]

\[ R = 0.9 \]

\[ \text{cor}_{\text{task}} = 0.25 \cdot \beta_{\text{wu}} = 0.6; \text{Mapping criteria: random} \]

\[ R = 0.95 \]

\[ \text{cor}_{\text{task}} = 0.25 \cdot \beta_{\text{wu}} = 0.6; \text{Mapping criteria: random} \]

\[ R = 1 \]

\[ \text{cor}_{\text{task}} = 0.25 \cdot \beta_{\text{wu}} = 0.6; \text{Mapping criteria: random} \]
Energy-aware strategies on heterogeneous platforms

$R = 0.85$

$R = 0.9$

$R = 0.8$

$cor_{text} = 0.25, \beta_{uu} = 0.8$; Mapping criteria: inE

Basic Work

Ratio to the baseline

scheduling
Energy-aware strategies on heterogeneous platforms

![Graph showing energy-aware strategies with different correlation coefficients and mapping criteria.](image-url)
Energy-aware strategies on heterogeneous platforms

cor\textsubscript{task} = 0.25; \beta_{b/w} = 0.8; Mapping criteria: deP

Ratio to the baseline

Basic Work

scheduling

LowerBound  energy-time  time-energy  randomShuffling
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>( R )</th>
<th>( \text{cor}_{\text{proc}} = 0 )</th>
<th>( \text{cor}_{\text{proc}} = 0.25 )</th>
<th>( \text{cor}_{\text{proc}} = 0.5 )</th>
<th>( \text{cor}_{\text{proc}} = 0.75 )</th>
<th>( \text{cor}_{\text{proc}} = 1 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05</td>
<td>( \beta_{\text{base}} = 0.25 ), ( \beta_{\text{cor}} = 0.8 ), Mapping criteria: random</td>
<td>( \beta_{\text{base}} = 0.25 ), ( \beta_{\text{cor}} = 0.8 ), Mapping criteria: random</td>
<td>( \beta_{\text{base}} = 0.25 ), ( \beta_{\text{cor}} = 0.8 ), Mapping criteria: random</td>
<td>( \beta_{\text{base}} = 0.25 ), ( \beta_{\text{cor}} = 0.8 ), Mapping criteria: random</td>
<td>( \beta_{\text{base}} = 0.25 ), ( \beta_{\text{cor}} = 0.8 ), Mapping criteria: random</td>
</tr>
</tbody>
</table>

Basic Work:
- \( \beta_{\text{base}} = 0.25 \), \( \beta_{\text{cor}} = 0.8 \), Mapping criteria: random

\( R \) = 0.25, 0.5, 0.75, 1

### Notes
- \( \beta_{\text{base}} \) and \( \beta_{\text{cor}} \) are parameters for balancing energy and time.
- Mapping criteria: random

### References
- [118x726]
Energy-aware strategies on heterogeneous platforms

\[ R = 0.8 \]

\[ \text{cor}_{\text{proc}} = 0 \]
\[ \text{cor}_{\text{proc}} = 0.25 \]
\[ \text{cor}_{\text{proc}} = 0.5 \]
\[ \text{cor}_{\text{proc}} = 0.75 \]
\[ \text{cor}_{\text{proc}} = 1 \]

- Basic Work
- Ratio to the baseline
- LowerBound
- RandomShuffling
- Energy-energy
- Energy-time
- Time-energy
- Time-time

\[ \text{cor}_{\text{task}} = 0.25; \beta_{\text{bw}} = 1; \text{Mapping criteria: inE} \]

RR n° 9324
Energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{task}} = 0.25; \ \beta_{b/w} = 1; \text{ Mapping criteria: deR} \)
$cor_{task} = 0.25$; $\beta_{b/w} = 1$; Mapping criteria: deP
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.25; \beta_{b/w} = 1; \text{Mapping criteria: random} \]
Energy-aware strategies on heterogeneous platforms

\[ R = 0.8 \]

\[ \text{cor}_{\text{proc}} = 0 \]

\[ \text{cor}_{\text{proc}} = 0.25 \]

\[ \text{cor}_{\text{proc}} = 0.5 \]

\[ \text{cor}_{\text{proc}} = 0.75 \]

\[ \text{cor}_{\text{proc}} = 1 \]

Basic Work

Ratio to the baseline

scheduling

LowerBound

energy-energy

time-energy

time-time

randomShuffling

\[ \text{cor}_{\text{task}} = 0.5, \beta = 0.2 \]

Mapping criteria: inE

RR n° 9324
Energy-aware strategies on heterogeneous platforms

$R = 0.8$

$R = 0.85$

$R = 0.9$

$R = 0.95$

$\text{cor}_{\text{proc}} = 0$

$\text{cor}_{\text{proc}} = 0.25$

$\text{cor}_{\text{proc}} = 0.5$

$\text{cor}_{\text{proc}} = 0.75$

$\text{cor}_{\text{proc}} = 1$

$\text{cor}_{\text{task}} = 0.5$, $\beta_{0w} = 0.2$. Mapping criteria: deR

Basic Work

Ratio to the baseline

scheduling

LowerBound energy-time energy-energy

time-energy time-time

randomShuffling

$\text{cor}_{\text{proc}}$ = 0.25, $\beta_{0w} = 0.2$. Mapping criteria: deR

$\text{cor}_{\text{task}} = 0.5$

$\text{cor}_{\text{task}} = 0.75$

$\text{cor}_{\text{task}} = 0.9$

$\text{cor}_{\text{task}} = 0.95$

RR n° 9324
Energy-aware strategies on heterogeneous platforms

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<tr>
<th>$\text{cor}_{\text{proc}}$</th>
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<th>0.25</th>
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**Basic Work**

| $\text{cor}_{\text{task}} = 0.5$, $\beta_{\text{MC}} = 0.2$, Mapping criteria: deP |

**Ratio to the baseline**

<table>
<thead>
<tr>
<th>$\text{LowerBound}$</th>
<th>energy-energy</th>
<th>energy-time</th>
<th>time-energy</th>
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<tbody>
<tr>
<td>$\text{randomShuffling}$</td>
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$R \approx 0.85$

$\beta_{\text{MC}} = 0.2$

Mapping criteria: deP

RR n° 9324
$\text{cor}_{\text{task}} = 0.5; \beta_{j,w} = 0.2$; Mapping criteria: random
Energy-aware strategies on heterogeneous platforms

<table>
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<tr>
<th>$\text{cor}_{\text{proc}}$</th>
<th>$R = 0.50$</th>
<th>$R = 0.70$</th>
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**Basic Work**
- Ratio to the baseline

**LowerBound**
- energy-energy
- energy-time
- time-energy
- randomShuffling

**Mapping criteria:**
- $\text{inE} = 0.5, \beta_{0, w} = 0.4$
### Energy-aware strategies on heterogeneous platforms

#### Table 1: Performance Comparison

<table>
<thead>
<tr>
<th>( \text{cor}_{\text{prec}} )</th>
<th>0.00</th>
<th>0.25</th>
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<td>( R ) = 0.20</td>
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</table>

\( \beta_{/w} = 0.5; \beta_{/w} = 0.4; \text{Mapping criteria: deR} \)

#### Diagram

- Basic Work
- Ratio to the baseline
- \( \text{scheduling} \)
- Lower Bound
- \( \text{energy-energy} \)
- \( \text{energy-time} \)
- \( \text{time-energy} \)
- \( \text{time-time} \)
- \( \text{randomShuffling} \)

\( \text{RR n° 9324} \)
Energy-aware strategies on heterogeneous platforms

### Table 1: Performance Comparison

<table>
<thead>
<tr>
<th>Correlation Coefficient ( R )</th>
<th>( \text{Basic Work} )</th>
<th>( \text{Baseline} )</th>
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<td>( 0.30 )</td>
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</table>

### Diagram 1: Graphical Representation

- Correlation Coefficient: \( R = 0 \)
- Correlation Coefficient: \( R = 0.05 \)
- Correlation Coefficient: \( R = 0.10 \)
- Correlation Coefficient: \( R = 0.15 \)
- Correlation Coefficient: \( R = 0.20 \)
- Correlation Coefficient: \( R = 0.25 \)
- Correlation Coefficient: \( R = 0.30 \)

### Graphical Details

- Correlation Coefficient: \( R = 0 \)
- Correlation Coefficient: \( R = 0.05 \)
- Correlation Coefficient: \( R = 0.10 \)
- Correlation Coefficient: \( R = 0.15 \)
- Correlation Coefficient: \( R = 0.20 \)
- Correlation Coefficient: \( R = 0.25 \)
- Correlation Coefficient: \( R = 0.30 \)

### Mapping Criteria

- \( c_{w1} = 0.5 \), \( b_{w1} = 0.4 \)
- Mapping criteria: \( deP \)

### Additional Information

- \( \beta \): \( \beta = 0.4 \)
- \( \alpha \): \( \alpha = 0.5 \)

---

RR n° 9324
Energy-aware strategies on heterogeneous platforms

### Table

<table>
<thead>
<tr>
<th>$\text{corr}_{\text{exec}}$</th>
<th>0</th>
<th>0.25</th>
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**Basic Work**

- Ratio to the baseline
- Scheduling
- LowerBound
- energy-energy
- energy-time
- time-energy
- time-time
- randomShuffling

**Equations**

- $\text{cor}_{\text{task}} = 0.5, \beta_{\text{bw}} = 0.4$
- Mapping criteria: random

**RR n° 9324**
$corr_{task} = 0.5; \beta_{b/w} = 0.6$; Mapping criteria: inE
Energy-aware strategies on heterogeneous platforms

cor\text{task} = 0.5; \beta_{j,w} = 0.6; Mapping criteria: deR

scheduling

LowerBound  energy-time  time-energy  randomShuffling
Energy-aware strategies on heterogeneous platforms

$cor_{task} = 0.5; \beta_{x/w} = 0.6; \text{Mapping criteria: deP}$

![Graph showing energy-aware strategies](image-url)
Energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{task}} = 0.5; \ \beta_{j/w} = 0.6; \) Mapping criteria: random

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- LowerBound
- energy-time
- time-energy
- randomShuffling
Energy-aware strategies on heterogeneous platforms

<table>
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<td>$\text{Ratio to the baseline}$</td>
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$\text{corr}_\text{task} = 0.5, \beta_{\text{lat}} = 0.8$. Mapping criteria: $m \in E$.
\( \text{cor}_{\text{task}} = 0.5; \beta_{b/w} = 0.8; \) Mapping criteria: deR
$cor_{t_{\text{ask}}} = 0.5; \beta_{b/w} = 0.8; \text{Mapping criteria: deP}$
$\text{cor}_{\text{task}} = 0.5; \: \beta_{j,w} = 0.8; \: \text{Mapping criteria: random}$
### Energy-aware strategies on heterogeneous platforms

<table>
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<th>$\text{cor}_{\text{proc}}$</th>
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</table>
Energy-aware strategies on heterogeneous platforms

$R = 0.8$; \( \beta_{\text{bw}} = 1 \); Mapping criteria: deR

RR n° 9324
Energy-aware strategies on heterogeneous platforms

\[ R = 0.8 \]

\[ \text{cor}_{\text{task}} = 0.5, \beta_{\text{sw}} = 1; \text{Mapping criteria: random} \]
$\text{cor}_{\text{task}} = 0.75$; $\beta_{b/w} = 0.2$; Mapping criteria: inE

Energy-aware strategies on heterogeneous platforms
\( \text{cor}_{\text{task}} = 0.75; \; \beta_{b/w} = 0.2; \) Mapping criteria: deR
Energy-aware strategies on heterogeneous platforms

### Figure

The figure illustrates the performance of different scheduling algorithms under various correlation and mapping criteria. The graphs show the ratio to the baseline for different parameters.

- **Parameters**:
  - Correlation between tasks ($\text{corr}_{\text{proc}}$)
  - Mapping criteria ($\text{deP}$)

- **Algorithms**:
  - Basic Work
  - LowerBound

- **Performance Metrics**:
  - Time
  - Energy

The figure includes a legend for the scheduling algorithms and their performance indicators.
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.75; \; \beta_{b/w} = 0.2; \text{ Mapping criteria: random} \]

\[ R = 0.8 \quad R = 0.85 \quad R = 0.9 \quad R = 0.95 \]

Basic Work

Ratio to the baseline

Ratio to the baseline

LowerBound  energy-time  time-energy  time-time  randomShuffling

Evaluating scheduling effectiveness.

cor \_task = 0.75; \; \beta_{b/w} = 0.2; \text{ Mapping criteria: random}
$c_{\text{task}} = 0.75$; $\beta_{\text{b/w}} = 0.4$; Mapping criteria: inE

![Graph showing energy-aware strategies on heterogeneous platforms](image-url)
Energy-aware strategies on heterogeneous platforms

\[ R = 0.8 \]

\[ \text{cor}_{\text{proc}} = 0 \]

\[ \text{cor}_{\text{proc}} = 0.25 \]

\[ \text{cor}_{\text{proc}} = 0.5 \]

\[ \text{cor}_{\text{proc}} = 0.75 \]

\[ \text{cor}_{\text{proc}} = 1 \]

Basic Work

Ratio to the baseline

scheduling

LowerBound

energy-energy

time-energy

time-time

randomShuffling

\[ \text{cor}_{\text{task}} = 0.75, \beta_{\text{mac}} = 0.4 \]

Mapping criteria: deR

RR n° 9324
Energy-aware strategies on heterogeneous platforms

<table>
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<tr>
<th>$\text{cor}_{\text{pre}}$</th>
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$R = 0.85$  
$R = 0.9$  
$R = 0.95$  
$\text{cor}_{\text{proc}} = 0$  
$\text{cor}_{\text{proc}} = 0.25$  
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Basic Work  
Ratio to the baseline  
LowerBound  
energy-energy  
scheduling  
energy-time  
time-energy  
time-time  
randoShuffling  

RR n° 9324
\( \text{cor}_{\text{task}} = 0.75; \ \beta_{b/w} = 0.4; \ \text{Mapping criteria: random} \)
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.75; \ \beta_{b/w} = 0.6; \text{Mapping criteria: inE} \]

\begin{figure}
\centering
\includegraphics[width=\textwidth]{graph.png}
\caption{Graph showing energy consumption under different scheduling strategies.}
\end{figure}
Energy-aware strategies on heterogeneous platforms

\( \rho_{\text{task}} = 0.75; \ \beta_{b/w} = 0.6; \) Mapping criteria: deR

<table>
<thead>
<tr>
<th>( \mathcal{R} )</th>
<th>LowerBound</th>
<th>Energy-energy</th>
<th>Energy-time</th>
<th>Time-energy</th>
<th>RandomShuffling</th>
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Basic Work Ratio to the baseline

scheduling

- LowerBound
- Energy-energy
- Energy-time
- Time-energy
- RandomShuffling
Energy-aware strategies on heterogeneous platforms
$\text{cor}_{\text{task}} = 0.75; \beta_{b/w} = 0.6; \text{Mapping criteria: random}$
Energy-aware strategies on heterogeneous platforms

cor_{task} = 0.75; \beta_{b/w} = 0.8; Mapping criteria: deR
Energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{task}} = 0.75; \; \beta_{b/w} = 1; \) Mapping criteria: inE

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<td>0.30</td>
<td>0.30</td>
<td>0.30</td>
<td>0.30</td>
</tr>
<tr>
<td>0.35</td>
<td>0.35</td>
<td>0.35</td>
<td>0.35</td>
<td>0.35</td>
</tr>
<tr>
<td>0.40</td>
<td>0.40</td>
<td>0.40</td>
<td>0.40</td>
<td>0.40</td>
</tr>
</tbody>
</table>

\( \text{cor}_{\text{proc}} = 0.25 \); \( \text{cor}_{\text{proc}} = 0.5 \); \( \text{cor}_{\text{proc}} = 0.75 \); \( \text{cor}_{\text{proc}} = 1 \)
Energy-aware strategies on heterogeneous platforms

cor_{task} = 0.75; \beta_{b/w} = 1; \text{Mapping criteria: deR}
Energy-aware strategies on heterogeneous platforms

\( \text{corr}_{\text{task}} = 0.75; \ \beta_w = 1; \ \text{Mapping criteria: deP} \)
$\text{cor}_{\text{task}} = 0.75; \beta_{b/w} = 1; \text{Mapping criteria: random}$

![Graph showing energy-aware strategies on heterogeneous platforms]

- LowerBound
- energy-energy
- time-energy
- randomShuffling

Basic Work

Ratio to the baseline
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 1; \; \beta_{b/w} = 0.2; \; \text{Mapping criteria: inE} \]
Energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{task}} = 1; \ \beta_{b/w} = 0.2; \ \text{Mapping criteria: deR} \)
Energy-aware strategies on heterogeneous platforms

\[ corr_{task} = 1; \beta_{b/w} = 0.2; \text{Mapping criteria: deP} \]

<table>
<thead>
<tr>
<th>( R )</th>
<th>( k )</th>
<th>( \text{Basic Work} )</th>
<th>( \text{Ratio to the baseline} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.8</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>0.85</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>0.9</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>0.95</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Correlations:
- \( cor_{task} = 1 \)
- \( \beta_{b/w} = 0.2 \)
- Mapping criteria: deP

Legend:
- LowerBound
- energy-energy
- time-time
- energy-energy
- time-energy
- randomShuffling
Energy-aware strategies on heterogeneous platforms

R = 0.85

\( \text{cor}_{\text{proc}} = 0 \)

\( \text{cor}_{\text{proc}} = 0.25 \)

\( \text{cor}_{\text{proc}} = 0.5 \)

\( \text{cor}_{\text{proc}} = 0.75 \)

\( \text{cor}_{\text{proc}} = 1 \)

Basic Work

Ratio to the baseline

scheduling

Lower Bound

energy-energy

time-energy

time-time

randomShuffling

\( \text{cor}_{\text{task}} = 1; \beta_{\text{uw}} = 0.2; \) Mapping criteria: random

RR n° 9324

RR n° 9324
Energy-aware strategies on heterogeneous platforms

cor_{task} = 1; \beta_{b/w} = 0.4; Mapping criteria: deR

\begin{table}
\begin{tabular}{|c|c|c|c|c|}
\hline
\textbf{R} & 0.8 & 0.85 & 0.9 & 0.95 \\
\hline
\textbf{cor}_{proc} & 0.60 & 0.60 & 0.60 & 0.60 \\
\hline
\textbf{proc} & 0.60 & 0.60 & 0.60 & 0.60 \\
\hline
\textbf{Basic Work} & 0.10 & 0.15 & 0.20 & 0.25 \\
\hline
\textbf{Ratio to the baseline} & 1.00 & 1.00 & 1.00 & 1.00 \\
\hline
\end{tabular}
\end{table}

\begin{figure}
\centering
\includegraphics[width=\textwidth]{chart.png}
\caption{Basic Work vs. Ratio to the baseline for different values of R.}
\end{figure}
consider task $1$; $\beta_{b/w} = 0.4$; Mapping criteria: deP

energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

\[
\begin{align*}
R &= 0.85 \\
\text{Basic Work} &\quad \text{Ratio to the baseline}
\end{align*}
\]
\( cor_{task} = 1; \beta_{b/w} = 0.6; \) Mapping criteria: inE

### Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>Basic Work</th>
<th>Ratio to the baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.10</td>
<td>1.00</td>
</tr>
<tr>
<td>0.25</td>
<td>0.50</td>
</tr>
<tr>
<td>0.75</td>
<td>0.00</td>
</tr>
</tbody>
</table>

**Scheduling**
- LowerBound
- energy-time
- time-time
- energy-energy
- time-energy
- randomShuffling
\(\text{cor}_{\text{task}} = 1; \beta_{b/w} = 0.6; \text{Mapping criteria: deR}\)
Energy-aware strategies on heterogeneous platforms

- \( R = 0.8 \)
- \( R = 0.85 \)
- \( R = 0.9 \)
- \( R = 0.95 \)

\( cor_{task} = 1; \beta_{b/w} = 0.6; \) Mapping criteria: deP

- Basic Work
- Ratio to the baseline

- LowerBound
- energy-energy
- energy-time
- time-energy
- randomShuffling
$cor_{task} = 1; \beta_{b/w} = 0.6;$ Mapping criteria: random

Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

\[ cor_{task} = 1; \beta_{b/w} = 0.8; \text{Mapping criteria: inE} \]

<table>
<thead>
<tr>
<th>Basic Work</th>
<th>Ratio to the baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.10</td>
<td>0.00</td>
</tr>
<tr>
<td>0.15</td>
<td>0.00</td>
</tr>
<tr>
<td>0.20</td>
<td>0.00</td>
</tr>
<tr>
<td>0.25</td>
<td>0.00</td>
</tr>
<tr>
<td>0.30</td>
<td>0.00</td>
</tr>
<tr>
<td>0.35</td>
<td>0.00</td>
</tr>
<tr>
<td>0.40</td>
<td>0.00</td>
</tr>
<tr>
<td>0.45</td>
<td>0.00</td>
</tr>
<tr>
<td>0.50</td>
<td>0.00</td>
</tr>
<tr>
<td>0.55</td>
<td>0.00</td>
</tr>
<tr>
<td>0.60</td>
<td>0.00</td>
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<tr>
<td>0.65</td>
<td>0.00</td>
</tr>
<tr>
<td>0.70</td>
<td>0.00</td>
</tr>
<tr>
<td>0.75</td>
<td>0.00</td>
</tr>
<tr>
<td>0.80</td>
<td>0.00</td>
</tr>
<tr>
<td>0.85</td>
<td>0.00</td>
</tr>
<tr>
<td>0.90</td>
<td>0.00</td>
</tr>
<tr>
<td>0.95</td>
<td>0.00</td>
</tr>
</tbody>
</table>

scheduling: LowerBound, energy-time, time-energy, randomShuffling
$\text{cor}_{\text{task}} = 1; \beta_{b/w} = 0.8; \text{Mapping criteria: deR}$

R = 0.8  
R = 0.85  
R = 0.9  
R = 0.95

Basic Work
Ratio to the baseline

scheduling  
LowerBound  
energy-energy  
time-time  
energy-time  
time-energy  
randoShuffling
Energy-aware strategies on heterogeneous platforms

\[ R = 0.80 \]

\[ R = 0.85 \]

\[ R = 0.90 \]

\[ R = 0.95 \]

\[ \text{cor}_{\text{task}} = 1; \beta_{\text{in}} = 0.8; \text{Mapping criteria: } \text{deP} \]

\[ \text{cor}_{\text{proc}} = 0 \]

\[ \text{cor}_{\text{proc}} = 0.25 \]

\[ \text{cor}_{\text{proc}} = 0.5 \]

\[ \text{cor}_{\text{proc}} = 0.75 \]

\[ \text{cor}_{\text{proc}} = 1 \]

\[ \text{Basic Work} \]

Relative to the baseline
\( cor_{task} = 1; \beta_{b/w} = 0.8; \) Mapping criteria: random

\begin{align*}
R = 0.8 & \quad R = 0.85 & \quad R = 0.9 & \quad R = 0.95 \\
\text{cor}_{\text{proc}} = 0.75 & \quad \text{cor}_{\text{proc}} = 0.5 & \quad \text{cor}_{\text{proc}} = 1.0
\end{align*}
Energy-aware strategies on heterogeneous platforms
\( \text{cor}_{\text{task}} = 1; \beta_{b/w} = 1; \) Mapping criteria: deR

<table>
<thead>
<tr>
<th>R</th>
<th>( \text{cor}_{\text{proc}} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>0.85</td>
<td>0.85</td>
</tr>
<tr>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>0.95</td>
<td>0.95</td>
</tr>
</tbody>
</table>

Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

Zero-Order Basic Work

<table>
<thead>
<tr>
<th>$cor_{pred} = 0$</th>
<th>$cor_{pred} = 0.25$</th>
<th>$cor_{pred} = 0.5$</th>
<th>$cor_{pred} = 0.75$</th>
<th>$cor_{pred} = 1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R = 0.95$</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>$R = 0.9$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$R = 0.85$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$R = 0.8$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$R = 0.75$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mapping criteria: dep

$cor_{task} = 1; \beta_{b/w} = 1; \beta_{b/w} = 1$; $\beta_{b/w} = 1$; $\beta_{b/w} = 1$.
$cor_{task} = 1; \beta_{b/w} = 1; $ Mapping criteria: random
The following section presents ratio of energy consumption using different mapping strategies under small failure rate when varying $\beta_{b/w}$. 

$\beta_{b/w}$ (Mapping)

The following section presents ratio of energy consumption using different mapping strategies under small failure rate when varying $\beta_{b/w}$. 

RR n° 9324
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>energy-energy</th>
<th>energy-time</th>
<th>randomShuffling</th>
<th>time-energy</th>
<th>time-time</th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.10</td>
<td>0.10</td>
<td>-0.10</td>
<td>0.10</td>
<td>0.10</td>
</tr>
<tr>
<td>-0.10</td>
<td>0.10</td>
<td>-0.10</td>
<td>0.10</td>
<td>0.10</td>
</tr>
<tr>
<td>-0.10</td>
<td>0.10</td>
<td>-0.10</td>
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</tr>
<tr>
<td>-0.10</td>
<td>0.10</td>
<td>-0.10</td>
<td>0.10</td>
<td>0.10</td>
</tr>
<tr>
<td>-0.10</td>
<td>0.10</td>
<td>-0.10</td>
<td>0.10</td>
<td>0.10</td>
</tr>
</tbody>
</table>

Correlation values:
- $\rho = 0$
- $\rho = 0.25$
- $\rho = 0.5$
- $\rho = 0.75$
- $\rho = 1$

Mapping to the baseline:
- BasicWork = 0.1; R = 0.9
- BasicWork = 0; R = 0.9

RR n° 9324
$\text{cor}_{\text{task}} = 0; \text{basicWork} = 0.1; \mathcal{R} = 0.92$
$cor_{task} = 0; \ basicWork = 0.1; \ R = 0.94$

<table>
<thead>
<tr>
<th>$cor_{proc}$</th>
<th>$cor_{proc}$</th>
<th>$cor_{proc}$</th>
<th>$cor_{proc}$</th>
<th>$cor_{proc}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.10</td>
<td>0.25</td>
<td>0.5</td>
<td>0.75</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Ratio to the baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta_{b/w}$</td>
</tr>
</tbody>
</table>

- $cor_{task}$
- $basicWork$
- $R$

$R = 0.94$

mapping: LowerBound, $deP$, $deR$, $inE$, random
\( \text{cor}_{\text{task}} = 0; \text{basicWork} = 0.1; \ R = 0.96 \)
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>energy-energy</th>
<th>energy-time</th>
<th>randomShuffling</th>
<th>time-energy</th>
<th>time-time</th>
</tr>
</thead>
<tbody>
<tr>
<td>cor proc = 0.10</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>cor proc = 0.25</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>cor proc = 0.50</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>cor proc = 0.75</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>cor proc = 1.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Ratio to the baseline mapping

rr = 0.98

basicWork = 0.1; R = 0.98
$\text{cor}_{\text{task}} = 0; \text{basicWork} = 0.2; R = 0.9$
Energy-aware strategies on heterogeneous platforms

- $\text{cor}_{\text{task}} = 0; \text{basicWork} = 0.2; R = 0.94$

![Graph showing energy-time ratio for different configurations](image)
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>energy-energy</th>
<th>energy-time</th>
<th>randomShuffling</th>
<th>time-energy</th>
<th>time-time</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
<td>1.00</td>
</tr>
<tr>
<td>0.25</td>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
</tr>
<tr>
<td>0.50</td>
<td>0.25</td>
<td>0.00</td>
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</tr>
<tr>
<td>0.75</td>
<td>0.50</td>
<td>0.25</td>
<td>0.00</td>
<td>0.25</td>
</tr>
<tr>
<td>1.00</td>
<td>0.75</td>
<td>0.50</td>
<td>0.25</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Ratio to the baseline

$\beta_{\text{ratio}} = 0$, $\text{basicWork} = 0.2$, $R = 0.96$

RR n° 9324
\( \text{cor}_{\text{task}} = 0; \text{basicWork} = 0.2; R = 0.98 \)

\begin{figure}[h]
\includegraphics[width=\textwidth]{figure.png}
\end{figure}

\textbf{Energy-aware strategies on heterogeneous platforms}

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|c|c|}
\hline
\text{ratio to the baseline} & \text{\beta/bw} & \text{mapping} & \text{LowerBound} & \text{deP} & \text{deR} & \text{deE} & \text{random} \\
\hline
\hline
\end{tabular}
\end{table}
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th></th>
<th>energy-energy</th>
<th>energy-time</th>
<th>randomShuffling</th>
<th>time-energy</th>
<th>time-time</th>
</tr>
</thead>
<tbody>
<tr>
<td>cor proc</td>
<td>0.0</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
<td>1.00</td>
</tr>
<tr>
<td>R</td>
<td>0.92</td>
<td>0.92</td>
<td>0.92</td>
<td>0.92</td>
<td>0.92</td>
</tr>
</tbody>
</table>

Correlation coefficient between energy and time.
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

cor\_task = 0; basic\_Work = 0.3; R = 0.96
cor_task = 0; basicWork = 0.3; R = 0.98
cor_task = 0.25; basicWork = 0.1; R = 0.9
Energy-aware strategies on heterogeneous platforms
$\text{cor}_{\text{task}} = 0.25; \text{basicWork} = 0.1; \mathcal{R} = 0.94$
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.25; \text{ basicWork} = 0.1; R = 0.96 \]

<table>
<thead>
<tr>
<th>( \text{cor}_{\text{proc}} = 0 )</th>
<th>( \text{cor}_{\text{proc}} = 0.25 )</th>
<th>( \text{cor}_{\text{proc}} = 0.5 )</th>
<th>( \text{cor}_{\text{proc}} = 0.75 )</th>
<th>( \text{cor}_{\text{proc}} = 1 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \beta )</td>
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<td>( 0.25 )</td>
<td>( 0.50 )</td>
<td>( 0.75 )</td>
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<tr>
<td>( \text{basicWork} )</td>
<td>( 0.1 )</td>
<td>( 0.1 )</td>
<td>( 0.1 )</td>
<td>( 0.1 )</td>
</tr>
<tr>
<td>( R )</td>
<td>( 0.96 )</td>
<td>( 0.96 )</td>
<td>( 0.96 )</td>
<td>( 0.96 )</td>
</tr>
</tbody>
</table>

mapping: LowerBound, deP, deR, inE, random
### Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th></th>
<th>energy-energy</th>
<th>energy-time</th>
<th>randomShuffling</th>
<th>time-energy</th>
<th>time-time</th>
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<td>0.10</td>
<td>0.10</td>
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<td>20.00</td>
<td>20.00</td>
</tr>
<tr>
<td>( \text{cor} )</td>
<td>0.10</td>
<td>20.00</td>
<td>20.00</td>
<td>20.00</td>
<td>20.00</td>
</tr>
<tr>
<td>( \text{proc} )</td>
<td>0.10</td>
<td>20.00</td>
<td>20.00</td>
<td>20.00</td>
<td>20.00</td>
</tr>
<tr>
<td>( \text{cor} )</td>
<td>0.25</td>
<td>20.00</td>
<td>20.00</td>
<td>20.00</td>
<td>20.00</td>
</tr>
<tr>
<td>( \text{proc} )</td>
<td>0.25</td>
<td>20.00</td>
<td>20.00</td>
<td>20.00</td>
<td>20.00</td>
</tr>
<tr>
<td>( \text{cor} )</td>
<td>0.50</td>
<td>20.00</td>
<td>20.00</td>
<td>20.00</td>
<td>20.00</td>
</tr>
<tr>
<td>( \text{proc} )</td>
<td>0.50</td>
<td>20.00</td>
<td>20.00</td>
<td>20.00</td>
<td>20.00</td>
</tr>
<tr>
<td>( \text{cor} )</td>
<td>0.75</td>
<td>20.00</td>
<td>20.00</td>
<td>20.00</td>
<td>20.00</td>
</tr>
<tr>
<td>( \text{proc} )</td>
<td>0.75</td>
<td>20.00</td>
<td>20.00</td>
<td>20.00</td>
<td>20.00</td>
</tr>
<tr>
<td>( \text{cor} )</td>
<td>1.00</td>
<td>20.00</td>
<td>20.00</td>
<td>20.00</td>
<td>20.00</td>
</tr>
<tr>
<td>( \text{proc} )</td>
<td>1.00</td>
<td>20.00</td>
<td>20.00</td>
<td>20.00</td>
<td>20.00</td>
</tr>
</tbody>
</table>

### Additional Notes

- \( \text{cor} \) represents the correlation between two variables.
- \( \text{proc} \) represents the processing time.
- Mapping results show the effectiveness of energy-aware strategies across different platforms.

RR n° 9324
Energy-aware strategies on heterogeneous platforms

$cor_{task} = 0.25; \text{basicWork} = 0.2; R = 0.9$

- $cor_{proc} = 0$
- $cor_{proc} = 0.25$
- $cor_{proc} = 0.5$
- $cor_{proc} = 0.75$
- $cor_{proc} = 1$

Ratio to the baseline

Dep

LowerBound

deP

deR

inE

Random

Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

cor_task = 0.25; basicWork = 0.2; R = 0.92

RR n° 9224
$corr_{task} = 0.25; basicWork = 0.2; R = 0.94$
Energy-aware strategies on heterogeneous platforms

cor_{task} = 0.25; basicWork = 0.2; \mathcal{R} = 0.96
Energy-aware strategies on heterogeneous platforms

$cor_{\text{task}} = 0.25; \ basicWork = 0.2; \ R = 0.98$

$cor_{\text{proc}} = 0$

$cor_{\text{proc}} = 0.25$

$cor_{\text{proc}} = 0.5$

$cor_{\text{proc}} = 0.75$

$cor_{\text{proc}} = 1$

Ratio to the baseline

$\beta_{\text{b/w}}$

Mapping: LowerBound, deP, deR, inE, random
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.25; \quad \text{basicWork} = 0.3; \quad R = 0.9 \]

\[ \text{cor}_{\text{proc}} = 0; \quad \text{cor}_{\text{proc}} = 0.25; \quad \text{cor}_{\text{proc}} = 0.5; \quad \text{cor}_{\text{proc}} = 0.75; \quad \text{cor}_{\text{proc}} = 1 \]


cor\text{-}\text{proc} = 0.25; \quad \text{basicWork} = 0.3; \quad R = 0.9

Ratio to the baseline

\[ \beta_{\text{bw}} \]

mapping: LowerBound, deP, deR, inE, random
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

corr_{task} = 0.25; basicWork = 0.3; R = 0.96
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.25; \text{basicWork} = 0.3; \text{R} = 0.98 \]
Energy-aware strategies on heterogeneous platforms

cor_task = 0.5; basicWork = 0.1; R = 0.9

(mapping: LowerBound, deP, deR, inE, random)
\( \text{cor}_{\text{task}} = 0.5; \ basicWork = 0.1; \ \mathcal{R} = 0.92 \)
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

cor_task = 0.5; basicWork = 0.1; R = 0.96
Energy-aware strategies on heterogeneous platforms

RR n° 9324
Energy-aware strategies on heterogeneous platforms

cor\textsubscript{task} = 0.5; basicWork = 0.2; \mathcal{R} = 0.92

\[
\begin{array}{c|c|c|c|c|c}
\hline
\text{cor}_{\text{proc}} &= 0 & \text{cor}_{\text{proc}} &= 0.25 & \text{cor}_{\text{proc}} &= 0.5 \\
\hline
\text{cor}_{\text{proc}} &= 0.75 & \text{cor}_{\text{proc}} &= 1 & \text{cor}_{\text{proc}} &= 1.25 \\
\hline
\end{array}
\]
$\text{cor}_{\text{task}} = 0.5; \text{basicWork} = 0.2; \mathcal{R} = 0.94$
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

cor task = 0.5; basicWork = 0.2; \( R = 0.98 \)

<table>
<thead>
<tr>
<th>cor proc</th>
<th>LowerBound</th>
<th>deP</th>
<th>deR</th>
<th>inE</th>
<th>random</th>
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</table>
$\text{cor}_\text{task} = 0.5; \text{basicWork} = 0.3; R = 0.9$
Energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{task}} = 0.5; \text{basicWork} = 0.3; R = 0.92 \)

![Graph showing energy aware strategies on heterogeneous platforms.](image-url)
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

...
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

corr_task = 0.75; basicWork = 0.1; R = 0.92
cor_{task} = 0.75; basicWork = 0.1; \mathcal{R} = 0.94
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>Energy-energy</th>
<th>Energy-time</th>
<th>RandomShuffling</th>
<th>Time-energy</th>
<th>Time-time</th>
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<tbody>
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<tr>
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<tr>
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</table>

Correlation to the baseline

Ratio to the baseline

Mapping

LowerBound

UpperBound

BasicWork

R = 0.96

Rn° n° 9324
Energy-aware strategies on heterogeneous platforms

![Graph showing energy-time, time-energy, randomShuffling, energy-energy, and time-time performance comparisons.](image-url)
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>Energy-energy</th>
<th>Energy-time</th>
<th>RandomShuffling</th>
<th>Time-energy</th>
<th>Time-time</th>
</tr>
</thead>
<tbody>
<tr>
<td>energy-energy</td>
<td>energy-time</td>
<td>randomShuffling</td>
<td>time-energy</td>
<td>time-time</td>
</tr>
</tbody>
</table>

- Correlation between energy and energy is 0.10
- Correlation between energy and time is 0.10
- Correlation between randomShuffling and energy is 0.10
- Correlation between time-energy and time-time is 0.10

- Correlation between mapping and baselineWork is 0.25; R = 0.9

RR n° 9324
Energy-aware strategies on heterogeneous platforms

\[ \text{ratio to the baseline} \]

<table>
<thead>
<tr>
<th>( \text{corr}_{\text{task}} = 0.75; \text{basicWork} = 0.2; R = 0.92 )</th>
<th>( \text{corr}_{\text{proc}} = 0.0 )</th>
<th>( \text{corr}_{\text{proc}} = 0.25 )</th>
<th>( \text{corr}_{\text{proc}} = 0.5 )</th>
<th>( \text{corr}_{\text{proc}} = 0.75 )</th>
<th>( \text{corr}_{\text{proc}} = 1 )</th>
</tr>
</thead>
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<tr>
<td>( \beta/bw )</td>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
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<td>1.00</td>
</tr>
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<td>0.6</td>
<td>0.8</td>
<td>1.0</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Legend:
- Mapping: LowerBound, deP, deR, inE, random

Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th></th>
<th>energy-energy</th>
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<th>time-time</th>
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<td>0.00</td>
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Energy-aware strategies on heterogeneous platforms

<table>
<thead>
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<th>energy-energy</th>
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<th>time-time</th>
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Ratio to the baseline

LowerBound

BasicWork

emR = 0.2; R = 0.96

RR n° 9324
Energy-aware strategies on heterogeneous platforms

cor\_{task} = 0.75; basicWork = 0.2; R = 0.98

<table>
<thead>
<tr>
<th>cor_{proc}</th>
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cor\_{proc} = 0.5

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cor\_{proc} = 0.75

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cor\_{proc} = 1

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energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

cor_{task} = 0.75; basicWork = 0.3; R = 0.92
Energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{task}} = 0.75; \ \text{basicWork} = 0.3; \ \mathcal{R} = 0.94 \)
Energy-aware strategies on heterogeneous platforms

cor_task = 0.75; basicWork = 0.3; R = 0.96
$\text{cor}_\text{task} = 0.75; \text{basicWork} = 0.3; \mathcal{R} = 0.98$
0.00

0.25

0.50

0.75

1.00

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1.25

0.25

0.50

0.75

1.00

0.00
1.25

0.25

0.8
1.0 0.2
0.4
0.6
0.8
1.0 0.2
0.4

LowerBound

0.6

deP

0.4

20.00
0.10

20.00
0.10

0.2

mapping

20.00
0.10

20.00
0.10

deR

0.8

inE

1.0 0.2

random

0.4
0.6
0.8
1.0 0.2
0.4
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0.8
1.0

time-time

βb/w

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time-energy

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0.10

corproc = 0

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0.10

cortask = 1; basicW ork = 0.1; R = 0.9

20.00
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20.00
0.10

20.00
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0.10

20.00
0.10

20.00
0.10
20.00
0.10

1.25

Ratio to the baseline

20.00
0.10

20.00
0.10

20.00
0.10

randomShuffling

20.00
0.10

20.00
0.10
20.00
0.10

energy-time

20.00
0.10

RR n° 9324
energy-energy

495

Energy-aware strategies on heterogeneous platforms


Energy-aware strategies on heterogeneous platforms

cor_{task} = 1; basicWork = 0.1; R = 0.92
Energy-aware strategies on heterogeneous platforms

cor_task = 1; basicWork = 0.1; R = 0.94
Energy-aware strategies on heterogeneous platforms

cor_{task} = 1; basicWork = 0.1; R = 0.96
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

cor_{task} = 1; basicWork = 0.2; R = 0.9

Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 1; \ \text{basicWork} = 0.2; \ R = 0.92 \]
$\text{cor}_{\text{task}} = 1; \text{basicWork} = 0.2; R = 0.94$
$\text{cor}_{\text{task}} = 1; \text{basicWork} = 0.2; R = 0.96$

Energy-aware strategies on heterogeneous platforms
energy-aware strategies on heterogeneous platforms

cor_task = 1; basicWork = 0.2; \ R = 0.98

Ratio to the baseline

\( \beta_{bw} \)

mapping

LowerBound \ deP \ deR \ inE \ random

Energy-aware strategies on heterogeneous platforms
$cor_{	ext{task}} = 1; \ basicWork = 0.3; \ R = 0.9$

Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>energy-energy</th>
<th>energy-time</th>
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Ratio to the baseline

RR n° 9324
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Energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{proc}} = 0.10 \)

\( \text{cor}_{\text{proc}} = 0.25 \)

\( \text{cor}_{\text{proc}} = 0.50 \)

\( \text{cor}_{\text{proc}} = 0.75 \)

\( \text{cor}_{\text{proc}} = 1.00 \)

\( \text{BasicWork} = 0.3; R = 0.94 \)

\( R_{\text{N}} = 1; \text{BasicWork} = 0.3; R = 0.94 \)

\( R_{\text{N}} = 0; \text{BasicWork} = 0.3; R = 0.94 \)
$\text{cor}_{\text{task}} = 1$; $\text{basicWork} = 0.3$; $R = 0.96$
\( cor_{\text{task}} = 1; \) \( basicWork = 0.3; \) \( R = 0.98 \)

<table>
<thead>
<tr>
<th>( cor_{\text{proc}} )</th>
<th>( \beta )</th>
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Energy-aware strategies on heterogeneous platforms.
\( \beta_{b/w} \) (Scheduling)

The following section presents ratio of energy consumption using different scheduling strategies under small failure rate when varying \( \beta_{b/w} \).
$\text{cor}_\text{task} = 0; \text{basicWork} = 0.1; \mathcal{R} = 0.9$
Energy-aware strategies on heterogeneous platforms

\[ \text{cor} \text{ task} = 0; \text{ basic work} = 0.1; \ R = 0.92 \]

<table>
<thead>
<tr>
<th>\text{cor} \text{ proc}</th>
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<td>\text{Ratio to the baseline}</td>
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<td>scheduling</td>
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\( \beta_{bw} \)
Energy-aware strategies on heterogeneous platforms

<table>
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</table>

Ratio to the baseline

- dsP: Energy-energy
- dsR: Energy-time
- inE: Time-energy
- random: Random Shuffling

RR n° 9324
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

cor_{task} = 0; basicWork = 0.2; R = 0.9

![Graph showing performance metrics for different scenarios]

- cor_{proc} = 0
- cor_{proc} = 0.25
- cor_{proc} = 0.5
- cor_{proc} = 0.75
- cor_{proc} = 1

Ratio to the baseline

- LowerBound
- energy-energy
- time-energy
- randomShuffling
Energy-aware strategies on heterogeneous platforms

cor\_task = 0; basicWork = 0.2; \( R = 0.92 \)

[Diagram showing different scheduling strategies and their ratios to the baseline.]
$\text{cor}_\text{task} = 0$; $\text{basicWork} = 0.2$; $R = 0.94$

Energy-aware strategies on heterogeneous platforms

[Diagram showing various energy and time ratios with different scheduling strategies]
Energy-aware strategies on heterogeneous platforms

\(\text{cor}_{\text{task}} = 0; \text{basicWork} = 0.2; R = 0.96\)

\(\text{cor}_{\text{proc}} = 0\)

\(\text{cor}_{\text{proc}} = 0.25\)

\(\text{cor}_{\text{proc}} = 0.5\)

\(\text{cor}_{\text{proc}} = 0.75\)

\(\text{cor}_{\text{proc}} = 1\)

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\(\text{Ratio to the baseline}\)

scheduling

LowerBound  energy-time  time-time
energy-energy  time-energy  randomShuffling
cor_{task} = 0; basicWork = 0.2; R = 0.98
cor_{\text{task}} = 0; basicWork = 0.3; R = 0.9

Ratio to the baseline

<table>
<thead>
<tr>
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Energy-aware strategies on heterogeneous platforms
cor_{task} = 0; basicWork = 0.3; \mathcal{R} = 0.92

\text{Ratio to the baseline}

\begin{align*}
\text{Corr}_{\text{proc}} & = 0 \\
\text{Corr}_{\text{proc}} & = 0.25 \\
\text{Corr}_{\text{proc}} & = 0.5 \\
\text{Corr}_{\text{proc}} & = 0.75 \\
\text{Corr}_{\text{proc}} & = 1
\end{align*}

\text{Scheduling}

- LowerBound
- energy-time
- time-energy
- randomShuffling
\( \text{cor}_{\text{task}} = 0; \text{basicWork} = 0.3; R = 0.96 \)

<table>
<thead>
<tr>
<th>( \text{cor}_{\text{proc}} )</th>
<th>Scheduling</th>
<th>LowerBound</th>
<th>energy-energy</th>
<th>energy-time</th>
<th>time-energy</th>
<th>randomShuffling</th>
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</table>

\( \beta_{bw} \) Ratio to the baseline

Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
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<th>deR</th>
<th>inE</th>
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Ratio to the baseline

<table>
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<th>0.75</th>
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<td>0.50</td>
<td>0.75</td>
</tr>
</tbody>
</table>

β | 0.00 | 0.25 | 0.50 | 0.75 |

scheduling | energy | energy | energy | energy |

randomShuffling | time | time | time | time |
Energy-aware strategies on heterogeneous platforms

- cor\textsubscript{task} = 0.25; basicWork = 0.1; R = 0.9

- cor\textsubscript{proc} = 0

- cor\textsubscript{proc} = 0.25

- cor\textsubscript{proc} = 0.5

- cor\textsubscript{proc} = 0.75

- cor\textsubscript{proc} = 1

Ratio to the baseline

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<td>energy-energy</td>
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</table>
cor\textsubscript{task} = 0.25; basic\textit{Work} = 0.1; R = 0.92
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.25; \text{basicWork} = 0.1; \mathcal{R} = 0.94 \]
Energy-aware strategies on heterogeneous platforms

cor\(_{\text{task}} = 0.25; \) basicWork = 0.1; R = 0.96

<table>
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<tr>
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<tr>
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scheduling: LowerBound, energy-time, time-energy, randomShuffling

Energy-aware strategies on heterogeneous platforms

RR n 6321
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.25; \text{basicWork} = 0.1; R = 0.98 \]

<table>
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- LowerBound
- energy-energy
- time-energy
- randomShuffling

\[ \beta_{b/w} \]

Ratio to the baseline

Energy-efficiency scheduling

530
Energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{task}} = 0.25; \text{basicWork} = 0.2; R = 0.9 \)
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.25; \text{basicWork} = 0.2; R = 0.92 \]
Energy-aware strategies on heterogeneous platforms

cor\textsubscript{task} = 0.25; cor\textsubscript{proc} = 0.5; R = 0.94

cor\textsubscript{proc} = 0; 0.25; 0.5; 0.75; 1.0
cor_{task} = 0.25; basicWork = 0.2; R = 0.96

\[\text{Ratio to the baseline}\]

<table>
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\[\beta_{bw}\]

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scheduling

- LowerBound
- energy-time
- time-time
- energy-energy
- time-energy
- randomShuffling
cor\text{task} = 0.25; \text{basicWork} = 0.2; \mathcal{R} = 0.98
\( \text{cor}_{\text{task}} = 0.25; \ \text{basicWork} = 0.3; \ R = 0.9 \)

![Graph showing energy-aware strategies on heterogeneous platforms](image-url)
Energy-aware strategies on heterogeneous platforms

cor_task = 0.25; basicWork = 0.3; R = 0.92
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.25; \text{basicWork} = 0.3; R = 0.94 \]

\begin{align*}
\text{cor}_{\text{proc}} &= 0.00, 0.25, 0.50, 0.75, 1.00 \\
\text{β}_{\text{b/w}} &\text{ Ratio to the baseline}
\end{align*}
Energy-aware strategies on heterogeneous platforms

cor_{task} = 0.25; basicWork = 0.3; R = 0.96

cor_{proc} = 0

cor_{proc} = 0.25

cor_{proc} = 0.5

cor_{proc} = 0.75

cor_{proc} = 1
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.25; \text{basicWork} = 0.3; R = 0.98 \]

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</tbody>
</table>

Ratio to the baseline

- LowerBound
- energy-energy
- energy-time
- time-energy
- randomShuffling

scheduling

Energy-aware strategies on heterogeneous platforms

540
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.5; \text{basicWork} = 0.1; \mathcal{R} = 0.9 \]

<table>
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</tbody>
</table>

\(
\begin{array}{c}
\beta_{bw} \\
\end{array}
\)
Energy-aware strategies on heterogeneous platforms

\( \text{cor}_\text{task} = 0.5; \ \text{basicWork} = 0.1; \ \mathcal{R} = 0.92 \)
Energy-aware strategies on heterogeneous platforms

cor\textsuperscript{task} = 0.5; basicWork = 0.1; \mathcal{R} = 0.94
Energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{task}} = 0.5; \text{basicWork} = 0.1; \mathcal{R} = 0.98 \)
\( \text{cor}_{\text{task}} = 0.5; \text{basicWork} = 0.2; \mathcal{R} = 0.9 \)
Energy-aware strategies on heterogeneous platforms

cor_{task} = 0.5; basicWork = 0.2; \mathcal{R} = 0.92
Energy-aware strategies on heterogeneous platforms

![Graph showing performance metrics across different platforms and configurations.

*Note: The graph is not fully transcribed in the text; it displays various metrics and results related to energy efficiency and task execution times.]*
Energy-aware strategies on heterogeneous platforms

- \( \text{corr}_{\text{proc}} = 0 \)
- \( \text{corr}_{\text{proc}} = 0.25 \)
- \( \text{corr}_{\text{proc}} = 0.5 \)
- \( \text{corr}_{\text{proc}} = 0.75 \)
- \( \text{corr}_{\text{proc}} = 1 \)

Ratio to the baseline scheduling

LowerBound, energy-energy, time-energy, randomShuffling
Energy-aware strategies on heterogeneous platforms

![Chart showing energy consumption and time comparison]
Energy-aware strategies on heterogeneous platforms
$\text{cor}_{\text{task}} = 0.5$; basicWork = 0.3; $R = 0.92$
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

![Graphical representation of energy-aware strategies on heterogeneous platforms]
Correlation between different scheduling strategies and their impact on energy consumption. The graphs illustrate the ratio to the baseline for various correlation parameters and scheduling methods. The parameters include tasks with basic work (`basicWork = 0.3`) and correlation between tasks (`cor_task = 0.5`). The ratio is plotted against the beta parameter (`β`) for different scheduling methods: lower bound, energy-time, time-energy, and random shuffling. The results show how changes in correlation and beta affect the energy efficiency of the systems.
Energy-aware strategies on heterogeneous platforms

cor_{task} = 0.75; basicWork = 0.1; R = 0.9
$\text{cor}_{\text{task}} = 0.75; \text{basicWork} = 0.1; R = 0.92$
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>corproc</th>
<th>deP</th>
<th>deR</th>
<th>inE</th>
<th>random</th>
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<td>0.50</td>
<td>0.75</td>
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<tr>
<td>0.5</td>
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<tr>
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<td>0.00</td>
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<td>0.50</td>
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cor task = 0.75; basicWork = 0.1; R = 0.84

RR n° 9324
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>Schedule</th>
<th>deP</th>
<th>deR</th>
<th>inE</th>
<th>random</th>
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<tr>
<td>$\text{cor}_{\text{proc}} = 0$</td>
<td><img src="image1" alt="Graph" /></td>
<td><img src="image2" alt="Graph" /></td>
<td><img src="image3" alt="Graph" /></td>
<td><img src="image4" alt="Graph" /></td>
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<td>$\text{cor}_{\text{proc}} = 0.25$</td>
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<td><img src="image6" alt="Graph" /></td>
<td><img src="image7" alt="Graph" /></td>
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<td><img src="image12" alt="Graph" /></td>
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<tr>
<td>$\text{cor}_{\text{proc}} = 0.75$</td>
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<td><img src="image14" alt="Graph" /></td>
<td><img src="image15" alt="Graph" /></td>
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- $\beta_{\text{Actor}}$: 0.75, $\text{basicWork} = 0.1$, $R = 0.96$
- $\beta_{\text{Actor}}$: 0.25, $\text{basicWork} = 0.1$, $R = 0.96$
- $\beta_{\text{Actor}}$: 0.0, $\text{basicWork} = 0.1$, $R = 0.96$

RR n° 9324
Energy-aware strategies on heterogeneous platforms

\(cor_{task} = 0.75; basicWork = 0.1; R = 0.98\)
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>$\text{cor}_{\text{proc}}$</th>
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<th>$\text{doR}$</th>
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Ratio to the baseline scheduling.
Energy-aware strategies on heterogeneous platforms

cor\(_{\text{task}}\) = 0.75; basicWork = 0.2; \(R = 0.92\)

cor\(_{\text{proc}}\) = 0

cor\(_{\text{proc}}\) = 0.25

cor\(_{\text{proc}}\) = 0.5

cor\(_{\text{proc}}\) = 0.75

cor\(_{\text{proc}}\) = 1

\[\text{Ratio to the baseline}\]

<table>
<thead>
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<th>cor(_{\text{proc}})</th>
<th>cor(_{\text{proc}}) = 0</th>
<th>cor(_{\text{proc}}) = 0.25</th>
<th>cor(_{\text{proc}}) = 0.5</th>
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\[\text{LowerBound}\]

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\[\text{energy-energy}\]

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\[\text{energy-time}\]

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\[\text{time-energy}\]

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<td>1.50</td>
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</table>

\[\text{time-time}\]

<table>
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\[\text{random}\]

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</table>
Energy-aware strategies on heterogeneous platforms

corr_task = 0.75; basicWork = 0.2; R = 0.94

Ratio to the baseline

<table>
<thead>
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<tr>
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</tr>
</tbody>
</table>

scheduling
LowerBound + energy-time + time-energy + randomShuffling
\( \text{cor}_{\text{task}} = 0.75; \text{basic work} = 0.2; \mathcal{R} = 0.96 \)

<table>
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<tr>
<th>( \text{cor}_{\text{proc}} )</th>
<th>( \text{Ratio to the baseline} )</th>
</tr>
</thead>
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<tr>
<td>1.00</td>
<td>1.25</td>
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</table>

Graphs showing the performance of different scheduling strategies with varying correlation values between tasks and processors.
$\text{cor}_{\text{task}} = 0.75$; $\text{basicWork} = 0.2$; $R = 0.98$
cor_{task} = 0.75; basicWork = 0.3; R = 0.9

Energy-aware strategies on heterogeneous platforms
cor_{task} = 0.75; basicWork = 0.3; R = 0.92

<table>
<thead>
<tr>
<th>cor_{proc}</th>
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<td>0.75</td>
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</table>

β/σ

scheduling

LowerBound  energy-time  time-time
energy-energy  time-energy  randomShuffling

Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

cor\textsubscript{task} = 0.75; basic\textsubscript{Work} = 0.3; \mathcal{R} = 0.94
Energy-aware strategies on heterogeneous platforms
$\text{corr}_{\text{task}} = 0.75; \text{basicWork} = 0.3; R = 0.98$

Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

\[ cor_{\text{task}} = 1; \; basicWork = 0.1; \; R = 0.9 \]

<table>
<thead>
<tr>
<th>Correlation Task</th>
<th>Correlation Proc</th>
<th>Ratio to the baseline</th>
</tr>
</thead>
<tbody>
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<td>( cor_{\text{proc}} = 0 )</td>
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<td>( cor_{\text{proc}} = 0.25 )</td>
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<tr>
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<td>( cor_{\text{proc}} = 0.5 )</td>
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</tr>
<tr>
<td>( cor_{\text{proc}} = 0.75 )</td>
<td>( cor_{\text{proc}} = 0.75 )</td>
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<tr>
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<td>( cor_{\text{proc}} = 1 )</td>
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\[ \beta_{b/w} \]

\[ \text{LowerBound} \; \; \text{energy-time} \; \; \text{time-energy} \; \; \text{randomShuffling} \]
Energy-aware strategies on heterogeneous platforms

cor_{task} = 1; basicWork = 0.1; R = 0.92
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>cplr</th>
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<th>deR</th>
<th>inE</th>
<th>random</th>
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Ratio to the baseline

- LowerBound
- energy-energy
- energy-time
- time-energy
- randomShuffling

β<sub>b/w</sub> = 1; basicWork = 0.1; R = 0.94

RR n° 9324
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

**Correlation Coefficient (cor):**
- cor task = 1; basicWork = 0.1; R = 0.98

**Correlation Coefficient (cor proc):**
- cor proc = 0
- cor proc = 0.25
- cor proc = 0.5
- cor proc = 0.75
- cor proc = 1

**Ratio to the baseline:***
- LowerBound
- energy-time
- time-energy
- time-energy
- randomShuffling
Energy-aware strategies on heterogeneous platforms

cor\_task = 1; basicWork = 0.2; R = 0.9
Energy-aware strategies on heterogeneous platforms

\( cor_{task} = 1; \) basicWork = 0.2; \( R = 0.92 \)
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms
$cor_{task} = 1$; $basicWork = 0.2$; $R = 0.98$
Energy-aware strategies on heterogeneous platforms

cor\_task = 1; basicWork = 0.3; R = 0.9
$cor_{task} = 1; \ \text{basicWork} = 0.3; \ \mathcal{R} = 0.92$
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 1; \text{basicWork} = 0.3; R = 0.94 \]

\[ \text{cor}_{\text{proc}} = 0 \]

\[ \text{cor}_{\text{proc}} = 0.25 \]

\[ \text{cor}_{\text{proc}} = 0.5 \]

\[ \text{cor}_{\text{proc}} = 0.75 \]

\[ \text{cor}_{\text{proc}} = 1 \]
Energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{task}} = 1; \text{basicWork} = 0.3; \ R = 0.96 \)
$cor_{\text{task}} = 1; \ basicWork = 0.3; \ R = 0.98$

Ratio to the baseline

<table>
<thead>
<tr>
<th>$cor_{\text{proc}}$</th>
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<tr>
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<tr>
<td>1.25</td>
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</tbody>
</table>

$\beta_{b/w}$

scheduling

LowerBound | energy-time | time-time
energy-energy | time-energy | randomShuffling
Correlation (Mapping)

The following section presents ratio of energy consumption using different mapping strategies under small failure rate, when varying $cor_{proc}$ and $cor_{task}$. 
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.2; \ basicWork = 0.1; \ R = 0.9 \]
Energy-aware strategies on heterogeneous platforms

Correlation

Processor correlation

Ratio to the baseline

\( \beta_{\text{corr}} = 0.2; \text{ basicWork} - h = 0.1; \text{ R} = 0.92 \)

\( \text{ b/w} \)
\( \beta_{b/w} = 0.2; \quad \text{basicWork} = 0.1; \quad R = 0.94 \)
Energy-aware strategies on heterogeneous platforms.

\[ \beta_{b/w} = 0.2; \ \text{basicWork} = 0.1; \ \mathcal{R} = 0.96 \]

\[ \text{cor} \text{task} = 0 \]
\[ \text{cor} \text{task} = 0.25 \]
\[ \text{cor} \text{task} = 0.5 \]
\[ \text{cor} \text{task} = 0.75 \]
\[ \text{cor} \text{task} = 1 \]

Ratio to the baseline

Processor correlation

mapping

LowerBound, deP, deR, inE, random

Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.2; \ \text{basicWork} = 0.1; \ \mathcal{R} = 0.98 \]

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<tr>
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<td><img src="image" alt="Random graph" /></td>
</tr>
</tbody>
</table>

mapping:  LowerBound, deP, deR, inE, random
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.2; \; basicWork = 0.2; \; R = 0.9 \]
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.2; \text{basicWork} = 0.2; \mathcal{R} = 0.92 \]
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
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<th>Energy-time</th>
<th>RandomShuffling</th>
<th>Time-energy</th>
<th>Time-time</th>
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<tr>
<td>BasicWork = 0.2; b/w = 0.2</td>
<td>BasicWork = 0.2</td>
<td>BasicWork = 0.2; b/w = 0.2</td>
<td>BasicWork = 0.2; b/w = 0.2</td>
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Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

\[
\beta_{b/w} = 0.2; \text{basicWork} = 0.2; \ R = 0.98
\]
Energy-aware strategies on heterogeneous platforms

\[ \beta_{\text{raw}} = 0.2; \ \text{basicW} \in [0.3, \ R = 0.9] \]

\[ \text{Processor correlation} \]

\[ \text{Ratio to the baseline} \]

\[ \text{deP} \]

\[ \text{deR} \]

\[ \text{inE} \]

\[ \text{random} \]

\[ \text{mapping} \]

\[ \text{lower bounds} \]

\[ \text{upper bounds} \]

RR n° 9324
Energy-aware strategies on heterogeneous platforms

<table>
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</tr>
<tr>
<td>0.5</td>
<td>time-energy</td>
<td>0.75</td>
</tr>
<tr>
<td>0.6</td>
<td>time-time</td>
<td>1.00</td>
</tr>
</tbody>
</table>

RR n° 9324
\[ \beta_{b/w} = 0.2; \text{basicWork} = 0.3; R = 0.94 \]

<table>
<thead>
<tr>
<th>mapping</th>
<th>LowerBound</th>
<th>deP</th>
<th>deR</th>
<th>inE</th>
<th>random</th>
</tr>
</thead>
</table>

| \( \text{cor}_{\text{task}} = 0 \) | \( \text{cor}_{\text{task}} = 0.25 \) | \( \text{cor}_{\text{task}} = 0.5 \) | \( \text{cor}_{\text{task}} = 0.75 \) | \( \text{cor}_{\text{task}} = 1 \) |
|-----------|-------------|-----|-----|-----|--------|

Energy-aware strategies on heterogeneous platforms
<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>energy-energy</th>
<th>energy-time</th>
<th>randomShuffling</th>
<th>time-energy</th>
<th>time-time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ratio to the baseline</td>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
<td>1.00</td>
</tr>
</tbody>
</table>

RR n° 9324
Energy-aware strategies on heterogeneous platforms

The diagram shows the correlation of energy to time across different mapping strategies. The x-axis represents the ratio of baseline, and the y-axis shows the processor correlation. The mapping strategies include energy-energy, energy-time, randomShuffling, time-energy, and time-time, each with varying correlation coefficients. The graphs illustrate how energy consumption changes with different correlation values.
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.4; \text{basicWork} = 0.1; \ R = 0.9 \]
$\beta_{b/w} = 0.4$; basicWork $= 0.1$; $R = 0.92$
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

\[
\begin{array}{cccc}
\text{energy-energy} & \text{energy-time} & \text{randomShuffling} & \text{time-energy} \\
\text{energy-time} & \text{time-energy} & \text{randomShuffling} & \text{time-time} \\
\text{randomShuffling} & \text{time-energy} & \text{randomShuffling} & \text{time-time} \\
\text{time-energy} & \text{time-time} & \text{randomShuffling} & \text{time-time} \\
\end{array}
\]
Energy-aware strategies on heterogeneous platforms

$\beta_{0.4} = 0.4; \beta_{0.2} = 0.2; R = 0.9$

Processor correlation

Mapping

LowerBound

deP
deR
inE
randomShuffling
time-energy
time-time
energy-energy
energy-time
randomShuffling
Energy-aware strategies on heterogeneous platforms

Processor correlation

Ratio to the baseline

LowerBound deP deR inE random

β_w = 0.4, baselineW= 0.2; R = 0.92

RR n° 9324
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.4; \ \text{basicWork} = 0.2; \ \mathcal{R} = 0.94 \]
Energy-aware strategies on heterogeneous platforms

\[
\begin{array}{c|c|c|c|c|c}
\text{Processor correlation} & \text{Ratio to the baseline} & \text{Lower Bound} & \text{deP} & \text{deR} & \text{RandomShuffling} \\
\hline
\text{energy-energy} & 0.10 & 0.10 & 0.10 & 0.10 & 0.10 \\
\text{energy-time} & 0.10 & 0.10 & 0.10 & 0.10 & 0.10 \\
\text{randomShuffling} & 0.10 & 0.10 & 0.10 & 0.10 & 0.10 \\
\text{time-energy} & 0.10 & 0.10 & 0.10 & 0.10 & 0.10 \\
\text{time-time} & 0.10 & 0.10 & 0.10 & 0.10 & 0.10 \\
\end{array}
\]

\[
\begin{array}{c|c|c|c}
\text{energy-energy} & 0.10 & 0.10 & 0.10 \\
\text{energy-time} & 0.10 & 0.10 & 0.10 \\
\text{randomShuffling} & 0.10 & 0.10 & 0.10 \\
\text{time-energy} & 0.10 & 0.10 & 0.10 \\
\text{time-time} & 0.10 & 0.10 & 0.10 \\
\end{array}
\]

\[
\begin{array}{c|c|c|c}
\text{energy-energy} & 0.10 & 0.10 & 0.10 \\
\text{energy-time} & 0.10 & 0.10 & 0.10 \\
\text{randomShuffling} & 0.10 & 0.10 & 0.10 \\
\text{time-energy} & 0.10 & 0.10 & 0.10 \\
\text{time-time} & 0.10 & 0.10 & 0.10 \\
\end{array}
\]

\[
\begin{array}{c|c|c|c}
\text{energy-energy} & 0.10 & 0.10 & 0.10 \\
\text{energy-time} & 0.10 & 0.10 & 0.10 \\
\text{randomShuffling} & 0.10 & 0.10 & 0.10 \\
\text{time-energy} & 0.10 & 0.10 & 0.10 \\
\text{time-time} & 0.10 & 0.10 & 0.10 \\
\end{array}
\]

\[
\begin{array}{c|c|c|c}
\text{energy-energy} & 0.10 & 0.10 & 0.10 \\
\text{energy-time} & 0.10 & 0.10 & 0.10 \\
\text{randomShuffling} & 0.10 & 0.10 & 0.10 \\
\text{time-energy} & 0.10 & 0.10 & 0.10 \\
\text{time-time} & 0.10 & 0.10 & 0.10 \\
\end{array}
\]

\[
\begin{array}{c|c|c|c}
\text{energy-energy} & 0.10 & 0.10 & 0.10 \\
\text{energy-time} & 0.10 & 0.10 & 0.10 \\
\text{randomShuffling} & 0.10 & 0.10 & 0.10 \\
\text{time-energy} & 0.10 & 0.10 & 0.10 \\
\text{time-time} & 0.10 & 0.10 & 0.10 \\
\end{array}
\]

\[
\begin{array}{c|c|c|c}
\text{energy-energy} & 0.10 & 0.10 & 0.10 \\
\text{energy-time} & 0.10 & 0.10 & 0.10 \\
\text{randomShuffling} & 0.10 & 0.10 & 0.10 \\
\text{time-energy} & 0.10 & 0.10 & 0.10 \\
\text{time-time} & 0.10 & 0.10 & 0.10 \\
\end{array}
\]

\[
\begin{array}{c|c|c|c}
\text{energy-energy} & 0.10 & 0.10 & 0.10 \\
\text{energy-time} & 0.10 & 0.10 & 0.10 \\
\text{randomShuffling} & 0.10 & 0.10 & 0.10 \\
\text{time-energy} & 0.10 & 0.10 & 0.10 \\
\text{time-time} & 0.10 & 0.10 & 0.10 \\
\end{array}
\]

RR n° 9324
Energy-aware strategies on heterogeneous platforms
$\beta_{b/w} = 0.4; \text{basicWork} = 0.3; R = 0.9$

Processor correlation

Ratio to the baseline

mapping LowerBound deP deR inE random
$\beta_{b/w} = 0.4$; $\text{basicWork} = 0.3$; $R = 0.92$.
Energy-aware strategies on heterogeneous platforms

![Graph showing energy and time-energy correlations with different correlation values and mapping strategies.](image)

- Processor correlation
- Ratio to the baseline
- Basic Work to basic Work
- Lower Bound
- deP
- deR
- inE
- randomShuffling
- Random

- $\beta_{b/w} = 0.4$, basic Work to basic Work = 0.3, $R = 0.94$
- $R_n = 0.9324$

RR n° 9324
\[ \beta_{b/w} = 0.4; \text{basicWork} = 0.3; R = 0.96 \]

<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>Ratio to the baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>0.50</td>
<td>0.50</td>
</tr>
<tr>
<td>0.75</td>
<td>0.75</td>
</tr>
<tr>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>1.25</td>
<td>1.25</td>
</tr>
</tbody>
</table>

**Mapping**
- LowerBound
- deP
- deR
- inE
- random

Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>energy-energy</th>
<th>energy-time</th>
<th>randomShuffling</th>
<th>time-energy</th>
<th>time-time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correlation</td>
<td>1</td>
<td>1</td>
<td>0.5</td>
<td>0</td>
<td>0.75</td>
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<tr>
<td>Correlation</td>
<td>0.5</td>
<td>0.25</td>
<td>0.5</td>
<td>0</td>
<td>0.75</td>
</tr>
<tr>
<td>Correlation</td>
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<td>0.125</td>
<td>0.5</td>
<td>0</td>
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<tr>
<td>Correlation</td>
<td>0</td>
<td>0</td>
<td>0.5</td>
<td>0</td>
<td>0.75</td>
</tr>
</tbody>
</table>

βR = 0.6, basicWork = 0.1; R = 0.9

Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

$\beta_{b/w} = 0.6$; $\\text{basicWork} = 0.1$; $R = 0.92$

$cor_{task} = 0$

$cor_{task} = 0.25$

$cor_{task} = 0.5$

$cor_{task} = 0.75$

$cor_{task} = 1$

Ratio to the baseline

Processor correlation

mapping

LowerBound  dP  deR  inE  random

RR n° 9224
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>Correlation Type</th>
<th>Ratio to the Baseline</th>
<th>Processor Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>energy-energy</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>energy-time</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>randomShuffling</td>
<td>0.50</td>
<td>0.50</td>
</tr>
<tr>
<td>time-energy</td>
<td>0.75</td>
<td>0.75</td>
</tr>
<tr>
<td>time-time</td>
<td>1.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>

- mapping
- corr
- task

β_Eo = 0.6, basicW/c_k = 0.1, R = 0.96
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.6; \text{basicWork} = 0.2; \ R = 0.9 \]

<table>
<thead>
<tr>
<th>correlation</th>
<th>ratio to the baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.0</td>
</tr>
<tr>
<td>0.25</td>
<td>1.5</td>
</tr>
<tr>
<td>0.5</td>
<td>2.0</td>
</tr>
<tr>
<td>0.75</td>
<td>2.5</td>
</tr>
<tr>
<td>1</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Processor correlation

mapping: LowerBound, deP, deR, imE, random
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>Energy-energy</th>
<th>Energy-time</th>
<th>RandomShuffling</th>
<th>Time-energy</th>
<th>Time-time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Processor correlation</td>
<td>Ratio to the baseline</td>
<td>LowerBound</td>
<td>( \beta_{b/w} = 0.6 )</td>
<td>basicWork</td>
</tr>
</tbody>
</table>

\[ \text{Baseline} \quad \text{BasicWork} \quad \text{Randomization} \]
\( \beta_{b/w} = 0.6; \text{basicWork} = 0.2; \mathcal{R} = 0.94 \)
Energy-aware strategies on heterogeneous platforms

\[ \text{Processor correlation} \]

\[ \text{Ratio to the baseline} \]

\[ \beta_{\text{mem}} = 0.6 \text{, basicWork/energy} = 0.2 \text{, } R = 0.96 \]

\[ \text{mapping: LowerBound, deP, deR, inE, random} \]

RR n° 9324
Energy-aware strategies on heterogeneous platforms

Processor correlation

Ratio to the baseline

Lower Bound

deP

deR

random

\( \beta_{b/w} = 0.6, \ basicW = 0.2; \ R = 0.98 \)

RR n° 9324
Energy-aware strategies on heterogeneous platforms

\[ R = 0.25 \]

\[ \beta_{0,0} = 0.6; \text{basicW} \times h = 0.3; R = 0.92 \]
Energy-aware strategies on heterogeneous platforms

\( \beta_{b/w} = 0.6; \ basicWork = 0.3; \ R = 0.94 \)
Energy-aware strategies on heterogeneous platforms

Correlation
- Energy-energy
- Energy-time
- RandomShuffling
- Time-energy
- Time-time

β = 0.6, basicWork = 0.3, R = 0.96
Energy-aware strategies on heterogeneous platforms

0.10 0.25 0.50 0.75 1.00

energy-energy  energy-time  randomShuffling  time-energy  time-time

Processor correlation

Ratio to the baseline

mappings

LowerBound  deP  deR  inE  random

β_W  =  0.6, basicWork  =  0.3;  R  =  0.98

RR n° 9324
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.8; \text{basicWork} = 0.1; \mathcal{R} = 0.92 \]
\( \beta_{b/w} = 0.8 \); \( basicWork = 0.1 \); \( R = 0.94 \)
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.8; \text{basicWork} = 0.1; R = 0.96 \]

[Graph showing processor correlation vs. ratio to the baseline for different correlation values.]
$\beta_{b/w} = 0.8; basicWork = 0.1; R = 0.98$

Processor correlation

Ratio to the baseline

Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

![Graphs showing energy and time correlation for different mapping strategies and processor correlations.](image)

- **Processing correlation**
- **Processor to baseline mapping**
- **Correlation between energy and time**
- **Random Shuffling**

- **Baseline Work:** 
  - $\beta_{b/w} = 0.8$
  - $\text{basicW} = 0.2$
  - $\text{R} = 0.9$

- **Error on:**
  - $\text{energy-energy}$
  - $\text{energy-time}$
  - $\text{randomShuffling}$
  - $\text{time-energy}$
  - $\text{time-time}$

- **Mapping:**
  - LowerBound
  - $\text{deP}$
  - $\text{deR}$
  - $\text{inE}$

RR n° 9324
Energy-aware strategies on heterogeneous platforms

Processor correlation

Ratio to the baseline

\[ \beta_{b/w} = 0.8; \text{ basicW/req} = 0.2; R = 0.94 \]

\[ \beta_{b/w} = 0.8; \text{ basicW/req} = 0.2; R = 0.94 \]

\[ \beta_{b/w} = 0.8; \text{ basicW/req} = 0.2; R = 0.94 \]

\[ \beta_{b/w} = 0.8; \text{ basicW/req} = 0.2; R = 0.94 \]
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.8; \ basicWork = 0.2; \ R = 0.96 \]

\[ \text{cor}_{\text{task}} = 0.00 \]
\[ \text{cor}_{\text{task}} = 0.25 \]
\[ \text{cor}_{\text{task}} = 0.50 \]
\[ \text{cor}_{\text{task}} = 0.75 \]
\[ \text{cor}_{\text{task}} = 1.00 \]

\[ \text{Ratio to the baseline} \]

\[ \text{Processor correlation} \]

\[ \beta_{b/w} = 0.8; \ basicWork = 0.2; \ R = 0.96 \]

\[ \text{cor}_{\text{task}} = 0.00 \]
\[ \text{cor}_{\text{task}} = 0.25 \]
\[ \text{cor}_{\text{task}} = 0.50 \]
\[ \text{cor}_{\text{task}} = 0.75 \]
\[ \text{cor}_{\text{task}} = 1.00 \]

\[ \text{Ratio to the baseline} \]

\[ \text{Processor correlation} \]
Energy-aware strategies on heterogeneous platforms
$\beta_{b/w} = 0.8; \text{ basicWork} = 0.3; R = 0.92$

![Graph showing energy-aware strategies on heterogeneous platforms](image-url)
Energy-aware strategies on heterogeneous platforms

Processor correlation

Ratio to the baseline

$\beta_{ \text{b/w} } = 0.8$, basicWork = 0.3; $R = 0.94$

RR n° 9324
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>energy-energy</th>
<th>energy-time</th>
<th>randomShuffling</th>
<th>time-energy</th>
<th>time-time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correlation</td>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
<td>1.00</td>
</tr>
<tr>
<td>Baseline</td>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
<td>1.00</td>
</tr>
</tbody>
</table>

β \(b/w\) = 0.8; basicWork = 0.3; R = 0.96

RR n° 9324
\[ \beta_{b/w} = 0.8; \ \text{basicWork} = 0.3; \ \mathcal{R} = 0.98 \]

![Graph showing processor correlation with different mapping algorithms and correlation levels.](image-url)
Energy-aware strategies on heterogeneous platforms

**Diagram Description**

- The diagram compares different energy- and time-based strategies on heterogeneous platforms.
- The x-axis represents the ratio to the baseline, ranging from 0.00 to 1.25.
- The y-axis indicates the processor correlation, ranging from 0.00 to 1.00.
- Different mapping strategies are compared:
  - energy-energy
  - energy-time
  - randomShuffling
  - time-energy
  - time-time
- Each strategy is represented by a line color and marker, allowing for easy comparison.

**Key Observations**

- The energy-energy strategy shows a correlation close to the baseline for all ratios.
- The time-time strategy has a higher correlation than the energy-energy strategy for lower ratios.
- The randomShuffling strategy has the lowest correlation across all ratios.

**Note**

- The diagram is designed to visually compare the effectiveness of different energy-aware strategies under varying conditions.

RR n° 9324
Energy-aware strategies on heterogeneous platforms

\[ \beta_{\text{in}} = 1; \quad \text{basicWork} = 0.1; \quad R = 0.92 \]
### Energy-aware strategies on heterogeneous platforms

#### Energy-Energy

<table>
<thead>
<tr>
<th>Correlation</th>
<th>Baseline</th>
<th>Workload</th>
<th>Mapping</th>
<th>Processor Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>cor_total = 1</td>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
</tr>
<tr>
<td>cor_total = 0.75</td>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
</tr>
<tr>
<td>cor_total = 0.50</td>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
</tr>
<tr>
<td>cor_total = 0.25</td>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
</tr>
<tr>
<td>cor_total = 0</td>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
</tr>
</tbody>
</table>

#### Energy-Time

<table>
<thead>
<tr>
<th>Correlation</th>
<th>Baseline</th>
<th>Workload</th>
<th>Mapping</th>
<th>Processor Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>cor_total = 1</td>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
</tr>
<tr>
<td>cor_total = 0.75</td>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
</tr>
<tr>
<td>cor_total = 0.50</td>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
</tr>
<tr>
<td>cor_total = 0.25</td>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
</tr>
<tr>
<td>cor_total = 0</td>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
</tr>
</tbody>
</table>

#### Random Shuffling

<table>
<thead>
<tr>
<th>Correlation</th>
<th>Baseline</th>
<th>Workload</th>
<th>Mapping</th>
<th>Processor Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>cor_total = 1</td>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
</tr>
<tr>
<td>cor_total = 0.75</td>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
</tr>
<tr>
<td>cor_total = 0.50</td>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
</tr>
<tr>
<td>cor_total = 0.25</td>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
</tr>
<tr>
<td>cor_total = 0</td>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
</tr>
</tbody>
</table>

#### Time-Energy

<table>
<thead>
<tr>
<th>Correlation</th>
<th>Baseline</th>
<th>Workload</th>
<th>Mapping</th>
<th>Processor Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>cor_total = 1</td>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
</tr>
<tr>
<td>cor_total = 0.75</td>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
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<tr>
<td>cor_total = 0.50</td>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
</tr>
<tr>
<td>cor_total = 0.25</td>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
</tr>
<tr>
<td>cor_total = 0</td>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
</tr>
</tbody>
</table>

#### Time-Time

<table>
<thead>
<tr>
<th>Correlation</th>
<th>Baseline</th>
<th>Workload</th>
<th>Mapping</th>
<th>Processor Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>cor_total = 1</td>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
</tr>
<tr>
<td>cor_total = 0.75</td>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
</tr>
<tr>
<td>cor_total = 0.50</td>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
</tr>
<tr>
<td>cor_total = 0.25</td>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
</tr>
<tr>
<td>cor_total = 0</td>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
</tr>
</tbody>
</table>

**Processing correlation** between different strategies and the baseline is shown in the figure.
Energy-aware strategies on heterogeneous platforms

$\beta_{b/w} = 1$; basicWork = 0.1; $R = 0.96$
### Energy-aware strategies on heterogeneous platforms

#### Energy-aware mapping

<table>
<thead>
<tr>
<th>Correlation Type</th>
<th>Ratio to the Baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Correlation</strong></td>
<td><strong>Mapping</strong></td>
</tr>
<tr>
<td>Correlation 0.1</td>
<td>Correlation 0.25</td>
</tr>
<tr>
<td>Correlation 0.5</td>
<td>Correlation 0.75</td>
</tr>
<tr>
<td>Correlation 1.0</td>
<td>Correlation 1.25</td>
</tr>
</tbody>
</table>

#### Processor Correlation

- LowerBound = 1, basicWork = 0.1, R = 0.98
- RR n° 9324
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>energy-energy</th>
<th>energy-time</th>
<th>randomShuffling</th>
<th>time-energy</th>
<th>time-time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>0.75</td>
<td>0.25</td>
<td>0</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>0.5</td>
<td>0.5</td>
<td>0</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>0.25</td>
<td>0.75</td>
<td>0</td>
<td>0.25</td>
<td>0.75</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Processor correlation

Ratio to the baseline

\( \beta_{in} = 1; \) basicWork = 0.2; \( R = 0.9 \)

RR no. 9324
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 1; \text{basicWork} = 0.2; \mathcal{R} = 0.92 \]

<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>Ratio to the baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>0.50</td>
<td>0.50</td>
</tr>
<tr>
<td>0.75</td>
<td>0.75</td>
</tr>
<tr>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>1.25</td>
<td>1.25</td>
</tr>
</tbody>
</table>

Legend:
- **LowerBound**
- **deP**
- **deR**
- **inE**
- **random**

Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

...
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

Processor correlation

Ratio to the baseline

\[ \alpha_{\text{b/w}} = \frac{1}{2}, \quad \text{basicWork} = 0.6, \quad R = 0.38 \]

\[ \beta_{\text{b/w}} = 0, \quad \text{basicWork} = 0.6, \quad R = 0.38 \]

\[ \beta_{\text{b/w}} = 1, \quad \text{basicWork} = 0.6, \quad R = 0.38 \]

\[ \beta_{\text{b/w}} = 0, \quad \text{basicWork} = 0.6, \quad R = 0.38 \]

\[ \beta_{\text{b/w}} = 1, \quad \text{basicWork} = 0.6, \quad R = 0.38 \]

\[ \beta_{\text{b/w}} = 0, \quad \text{basicWork} = 0.6, \quad R = 0.38 \]

\[ \beta_{\text{b/w}} = 1, \quad \text{basicWork} = 0.6, \quad R = 0.38 \]

\[ \beta_{\text{b/w}} = 0, \quad \text{basicWork} = 0.6, \quad R = 0.38 \]

\[ \beta_{\text{b/w}} = 1, \quad \text{basicWork} = 0.6, \quad R = 0.38 \]

\[ \beta_{\text{b/w}} = 0, \quad \text{basicWork} = 0.6, \quad R = 0.38 \]

\[ \beta_{\text{b/w}} = 1, \quad \text{basicWork} = 0.6, \quad R = 0.38 \]
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 1; \ \text{basicWork} = 0.3; \ R = 0.92 \]

- \( \text{cor}_{\text{task}} = 0 \)
- \( \text{cor}_{\text{task}} = 0.25 \)
- \( \text{cor}_{\text{task}} = 0.5 \)
- \( \text{cor}_{\text{task}} = 0.75 \)
- \( \text{cor}_{\text{task}} = 1 \)

Mapping: LowerBound, deP, deR, inE, random

RR n° 924
Energy aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>Energy-energy</th>
<th>Energy-time</th>
<th>RandomShuffling</th>
<th>Time-energy</th>
<th>Time-time</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta_{W_{0}} = 1$, $\text{basicWork} = 0.3$, $R = 0.34$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_{W_{0}} = 1$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_{W_{0}} = 1$, $\text{basicWork} = 0.3$, $R = 0.34$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RR n° 9324
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

\[ \text{Processor correlation} \]

\[ \text{Ratio to the baseline} \]

\[ \beta_{\text{bw}} = 1; \text{basicWork} = 0.3; R = 0.98 \]

\[ \beta_{\text{bw}} = 1; \text{basicWork} = 0.3; R = 0.98 \]

\[ \beta_{\text{bw}} = 1; \text{basicWork} = 0.3; R = 0.98 \]

\[ \beta_{\text{bw}} = 1; \text{basicWork} = 0.3; R = 0.98 \]
Correlation (Scheduling)

The following section presents ratio of energy consumption using different scheduling strategies under small failure rate, when varying $cor_{\text{proc}}$ and $cor_{\text{task}}$. 
Energy-aware strategies on heterogeneous platforms

ratkα = 0 ; basicWork = 0.1 ; R = 0.9

\[ \beta_{\text{in}} = 0.2 ; \text{basicWork} = 0.1 ; R = 0.9 \]
Energy-aware strategies on heterogeneous platforms
\( \beta_{b/w} = 0.2; \) basicWork = 0.1; \( R = 0.94 \)
Energy-aware strategies on heterogeneous platforms

Processor correlation

Ratio to the baseline

scheduling

LowerBound

energy-energy

time-energy

time-time

randomShuffling

$β_{b/w} = 0.2$, basicWork = 0.1, $R = 0.96$

RR n° 9324
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.2; \text{ basicWork} = 0.1; \ R = 0.98 \]

<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>LowerBound</th>
<th>energy-time</th>
<th>time-energy</th>
<th>randomShuffling</th>
</tr>
</thead>
<tbody>
<tr>
<td>cor_task = 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cor_task = 0.25</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cor_task = 0.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cor_task = 0.75</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cor_task = 1</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Energy-aware strategies on heterogeneous platforms

RR n° 5234

Energy-aware strategies on heterogeneous platforms

647
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.2; \ basisWork = 0.2; \ R = 0.92 \]
Energy-aware strategies on heterogeneous platforms

\[ \beta_{\text{w0}} = 0.2; \beta_{\text{wU}} = 0.2; R = 0.94 \]
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.2; \; basicWork = 0.2; \; R = 0.96 \]
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.2; \text{ basicWork} = 0.2; R = 0.98 \]
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/\text{ic}} = 0.2; \quad \text{basicWork} = 0.3; \quad R = 0.9 \]
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>Energy-time</th>
<th>Time-energy</th>
<th>Energy-energy</th>
<th>Random Shuffling</th>
</tr>
</thead>
<tbody>
<tr>
<td>deP</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>deR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>iaE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>random</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ \beta_{\text{de}} = 0.2; \ beta_{\text{deR}} = 0.3; R = 0.92 \]
Energy-aware strategies on heterogeneous platforms

\[ \beta_{bw} = 0.2; \text{basicWork} = 0.3; R = 0.94 \]
Energy-aware strategies on heterogeneous platforms

\[ \beta_{\text{b/w}} = 0.2; \text{basicWork} = 0.3; R = 0.96 \]

![Graph showing energy-time, energy-energy, and time-energy scheduling across different processor correlation and correlation task values.]
\( \beta_{b/w} = 0.2; \ basicWork = 0.3; \ R = 0.98 \)

Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

\[ \beta_{\text{bw}} = 0.4; \ \text{basicWork} = 0.1; \ \mathcal{R} = 0.9 \]
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.4; \text{basicWork} = 0.1; \ R = 0.92 \]
Energy-aware strategies on heterogeneous platforms

$\beta_{b/w} = 0.4$; $basicWork = 0.1$; $R = 0.94$

Processor correlation

Ratio to the baseline

LowerBound: $\beta_{b/w} = 0.4$; $basicWork = 0.1$; $R = 0.94$
Energy-aware strategies on heterogeneous platforms

\[ \beta_{\text{bw}} = 0.4; \text{basicWork} = 0.1; R = 0.98 \]
$\beta_{b/w} = 0.4$; $basicWork = 0.2$; $R = 0.9$

![Graph showing energy-time and time-energy performance](image-url)

**Energy-aware strategies on heterogeneous platforms**
Energy-aware strategies on heterogeneous platforms

\( \beta_{b/w} = 0.4; \quad basicWork = 0.2; \quad R = 0.92 \)
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.4; \text{basicWork} = 0.2; R = 0.96 \]

Processor correlation

Ratio to the baseline

Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

$\beta_{b/w} = 0.4; \text{ basicWork} = 0.2; R = 0.98$
Energy-aware strategies on heterogeneous platforms

Processor correlation

Ratio to the baseline scheduling

Lower Bound  energy-energy  time-energy  time-time  randomShuffling

\[ \beta_{b/w} = 0.4; \text{basicWork} = 0.3; R = 0.9 \]

RR n° 9324
Energy-aware strategies on heterogeneous platforms

\[ \beta_{\text{cpu}} = 0.4; \text{basicWork} = 0.3; R = 0.94 \]
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.4; \ basicWork = 0.3; \ R = 0.96 \]
\( \beta_{b/w} = 0.4; \ basicWork = 0.3; \ R = 0.98 \)
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.6; \ basicWork = 0.1; \ R = 0.92 \]

<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>Ratio to the baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>0.25</td>
<td>1.25</td>
</tr>
<tr>
<td>0.50</td>
<td>1.50</td>
</tr>
<tr>
<td>0.75</td>
<td>1.75</td>
</tr>
<tr>
<td>1.00</td>
<td>2.00</td>
</tr>
</tbody>
</table>

- LowerBound
- energy-time
- time-energy
- randomShuffling

---

Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

Processor correlation

Ratio to the baseline

scheduling

LowerBound

energy-energy

time-energy

time-time

randomShuffling

β_{b/w} = 0.6; basicWk = 0.1; R = 0.94

RR n° 9324
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.6; \ basicWork = 0.1; \ R = 0.96 \]
Energy-aware strategies on heterogeneous platforms

\( \beta_{\text{b/w}} = 0.6; \text{basicWork} = 0.1; R = 0.98 \)

Processor correlation

Ratio to the baseline

scheduling

LowerBound

energy-time
time-energy

energy-energy
time-time

randomShuffling
Energy-aware strategies on heterogeneous platforms

$\beta_{b/w} = 0.6; \text{basicWork} = 0.2; \mathcal{R} = 0.9$
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>Ratio to the baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>deP</td>
<td>BasicW + e = 0.6; R = 0.92</td>
</tr>
<tr>
<td>deR</td>
<td>BasicW + e = 0.6; R = 0.92</td>
</tr>
<tr>
<td>inE</td>
<td>BasicW + e = 0.6; R = 0.92</td>
</tr>
<tr>
<td>random</td>
<td>BasicW + e = 0.6; R = 0.92</td>
</tr>
</tbody>
</table>

rr n° 9324
Energy-aware strategies on heterogeneous platforms

$\beta_{b/w} = 0.6$; basicWork = 0.2; $R = 0.94$

![Graph showing energy-aware strategies on heterogeneous platforms](image)
Energy-aware strategies on heterogeneous platforms

Processor correlation

Ratio to the baseline

Random shuffling

Lower Bound

Energy-energy

Energy-time

Time-energy

Time-time

β_{ho} = 0.6; basicW or k = 0.2; R = 0.96

RR n° 9324
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>Ratio to the baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>deP</td>
<td>deR</td>
</tr>
<tr>
<td>Correlation</td>
<td>Correlation</td>
</tr>
<tr>
<td>Correlation n = 1</td>
<td>Correlation n = 0.75</td>
</tr>
<tr>
<td>Correlation n = 0.25</td>
<td>Correlation n = 0.5</td>
</tr>
</tbody>
</table>

Processor correlation

\[ \beta_{b/w} = 0.6, \beta_{basicW} = 0.2; R = 0.98 \]

β_{b/w} = 0.6; basicW or e = 0.2; R = 0.98.
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.6; \text{basic Work} = 0.3; \mathcal{R} = 0.9 \]
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.6; \ \text{basicWork} = 0.3; \ R = 0.92 \]
Energy-aware strategies on heterogeneous platforms

\( \beta_{b/w} = 0.6; \ basicWork = 0.3; \ R = 0.94 \)

![Graph showing processor correlation and ratio to the baseline for different scheduling methods.]
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.6; \quad \text{basicWork} = 0.3; \quad R = 0.96 \]

<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>0.00</th>
<th>0.25</th>
<th>0.50</th>
<th>0.75</th>
<th>1.00</th>
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</thead>
<tbody>
<tr>
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<tr>
<td>Cor task = 0.5</td>
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</tr>
<tr>
<td>Cor task = 0.75</td>
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<tr>
<td>Cor task = 1.0</td>
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</tbody>
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Ratio to the baseline

<table>
<thead>
<tr>
<th>Scheduling</th>
<th>LowerBound</th>
<th>energy-time</th>
<th>time-energy</th>
<th>randomShuffling</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
<td>1.00</td>
</tr>
<tr>
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<td>0.50</td>
<td>0.75</td>
<td>1.00</td>
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<tr>
<td>0.20</td>
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<td>0.50</td>
<td>0.75</td>
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<tr>
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<td>0.75</td>
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<td>0.40</td>
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<td>0.50</td>
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</tr>
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<td>0.75</td>
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<td>0.75</td>
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<td>1.00</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
<td>1.00</td>
</tr>
</tbody>
</table>
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.8; \ \text{basicWork} = 0.1; \ \mathcal{R} = 0.9 \]
$\beta_{b/w} = 0.8$; basicWork = 0.1; $R = 0.92$
Energy-aware strategies on heterogeneous platforms

\[ \beta_{\text{bw}} = 0.8; \text{basicWork} = 0.1; R = 0.94 \]
\( \beta_{b/w} = 0.8; \) basicWork = 0.1; \( R = 0.96 \)

Processor correlation

Ratio to the baseline

Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

\[ \beta_{\text{b/w}} = 0.8; \text{basicWork} = 0.1; R = 0.98 \]

<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>cor = 0</th>
<th>cor = 0.25</th>
<th>cor = 0.5</th>
<th>cor = 0.75</th>
<th>cor = 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ratio to the baseline</td>
<td><img src="image1.png" alt="Graph" /></td>
<td><img src="image2.png" alt="Graph" /></td>
<td><img src="image3.png" alt="Graph" /></td>
<td><img src="image4.png" alt="Graph" /></td>
<td><img src="image5.png" alt="Graph" /></td>
</tr>
</tbody>
</table>

scheduling

- LowerBound
- energy-time
- time-energy
- randomShuffling

energy-efficiency

- energy-energy
- time-energy
- randomShuffling
Energy-aware strategies on heterogeneous platforms

\[ \beta_{\text{b/w}} = 0.8; \; \text{basicWork} = 0.2; \; R = 0.9 \]
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.8; \ basicWork = 0.2; \ R = 0.92 \]
Energy-aware strategies on heterogeneous platforms

![Diagram of Processor correlation and Ratio to the baseline for different scheduling algorithms and processor correlation values]
Energy-aware strategies on heterogeneous platforms

\[ \beta_{\text{b/w}} = 0.8; \text{basicWork} = 0.2; \mathcal{R} = 0.96 \]

[Graph showing processor correlation vs. scheduling ratio]
Energy-aware strategies on heterogeneous platforms

Processor correlation

Ratio to the baseline

LowerBound

energy-energy
time-energy
time-time
randomShuffling

\[ \beta_{\text{avg}} = 0.8, \text{basicWork} = 0.2; R = 0.98 \]

\[ R^2 = 0.9324 \]
Energy-aware strategies on heterogeneous platforms

\( \beta_{b/w} = 0.8; \ basicWork = 0.3; \ R = 0.9 \)
\[ \beta_{b/w} = 0.8; \ \text{basicWork} = 0.3; \ R = 0.92 \]

\[ \text{cor}_{\text{task}} = 0 \]

\[ \text{cor}_{\text{task}} = 0.25 \]

\[ \text{cor}_{\text{task}} = 0.5 \]

\[ \text{cor}_{\text{task}} = 0.75 \]

\[ \text{cor}_{\text{task}} = 1 \]

Processor correlation

Ratio to the baseline

Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

\[ \beta_{\text{b/w}} = 0.8; \ basicWork = 0.3; \ R = 0.94 \]
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.8; \text{ basicWork} = 0.3; R = 0.98 \]
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 1; \ basicWork = 0.1; \ R = 0.9 \]
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 1; \, \text{basicWork} = 0.1; \, R = 0.92 \]

Processor correlation

Ratio to the baseline

scheduling

LowerBound  energy-energy  time-time

energy-energy  time-energy  randomShuffling
Energy-aware strategies on heterogeneous platforms

\[ \beta_{\text{b/w}} = 1; \text{basicWork} = 0.1; \mathcal{R} = 0.94 \]

\[
\begin{array}{c|c|c|c|c|c}
\text{cor}_{\text{task}} & 0 & 0.25 & 0.5 & 0.75 & 1.0 \\
\hline
\text{Ratio to the baseline} & \text{LowerBound} & \text{energy-energy} & \text{time-energy} & \text{time-time} & \text{randomShuffling}
\end{array}
\]
Energy-aware strategies on heterogeneous platforms

![Graph showing Processor correlation and Ratio to the baseline for different scenarios and correlation levels.](image)

- **Graph Legend:**
  - LowerBound: energy-energy
  - UpperBound: energy-time
  - RandomShuffling: time-energy

- **Graph Details:**
  - Processor correlation levels: 0.00, 0.25, 0.50, 0.75, 1.00

- **Scenario Descriptions:**
  - \( \beta_{\text{bw}} = 1 \), \( \text{basisWork} = 0.1 \), \( R = 0.36 \)

---

**RR n° 9324**
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 1; \text{basicWork} = 0.2; \mathcal{R} = 0.9 \]
Energy-aware strategies on heterogeneous platforms

\( \beta_{b/w} = 1; \) basicWork = 0.2; \( R = 0.92 \)
Energy-aware strategies on heterogeneous platforms

$\beta_{b/w} = 1; \text{basicWork} = 0.2; \mathcal{R} = 0.94$

<table>
<thead>
<tr>
<th>cor task</th>
<th>LowerBound</th>
<th>energy-energy</th>
<th>time-energy</th>
<th>randomShuffling</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>0.25</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
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<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>0.75</td>
<td>0.00</td>
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<td>0.00</td>
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</tr>
<tr>
<td>1.00</td>
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<td>0.00</td>
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</tr>
<tr>
<td>1.25</td>
<td>0.00</td>
<td>0.00</td>
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<td>0.00</td>
</tr>
</tbody>
</table>

Processor correlation

Ratio to the baseline

LowerBound | energy-energy | time-energy | randomShuffling
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 1; \ \text{basicWork} = 0.2; \ \mathcal{R} = 0.96 \]
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 1; \ basicWork = 0.2; \ \mathcal{R} = 0.98 \]
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 1; \ basicWork = 0.3; \ R = 0.9 \]
Energy-aware strategies on heterogeneous platforms

$\beta_{\text{bw}} = 1; \text{basicWork} = 0.3; \mathcal{R} = 0.92$

![Graph showing processor correlation results](image)
\[ \beta_{\text{basicWork}} = 1; \ \text{basicWork} = 0.3; \ R = 0.94 \]
Energy-aware strategies on heterogeneous platforms

\( \beta_{b/w} = 1; \ basicWork = 0.3; \ R = 0.96 \)
Energy-aware strategies on heterogeneous platforms
basicWork and $\mathcal{R}$ (Mapping)

The following section presents ratio of energy consumption using different mapping strategies under small failure rate, when varying $\text{basicWork}$ and $\mathcal{R}$. 
Energy-aware strategies on heterogeneous platforms

$c_{\text{task}} = 0$; $\beta_{b/w} = 0.2$; Scheduling criteria: time-time

<table>
<thead>
<tr>
<th>$R$</th>
<th>0.9</th>
<th>0.92</th>
<th>0.94</th>
<th>0.96</th>
<th>0.98</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta_{b/w}$</td>
<td>0.10</td>
<td>0.15</td>
<td>0.20</td>
<td>0.25</td>
<td>0.30</td>
</tr>
</tbody>
</table>

- Basic Work
- Ratio to the baseline
- $\text{LowerBound}$
- $\text{deP}$
- $\text{deR}$
- $\text{inE}$
- $\text{random}$

Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

R = 0.00
R = 0.46
R = 0.88

Basic Work
Correlation: time-energy

\( \alpha = 0; \beta_{\text{trunc}} = 0.2 \). Scheduling criteria: time-energy

\( \alpha = 0.25 \) and \( \beta_{\text{trunc}} = 0.2 \). Scheduling criteria: time-energy

\( \alpha = 0.5 \) and \( \beta_{\text{trunc}} = 0.2 \). Scheduling criteria: time-energy

\( \alpha = 0.75 \) and \( \beta_{\text{trunc}} = 0.2 \). Scheduling criteria: time-energy

\( \alpha = 1 \) and \( \beta_{\text{trunc}} = 0.2 \). Scheduling criteria: time-energy

RR n° 9324
Energy-aware strategies on heterogeneous platforms

\[ R = 0.9 \]

\[ R = 0.92 \]

\[ R = 0.94 \]

\[ R = 0.96 \]

\[ R = 0.98 \]

Basic Work

\[ \text{Ratio to the baseline} \]

\[ \text{LowerBound} \]

\[ \text{deP} \]

\[ \text{deR} \]

\[ \text{inE} \]

\[ \text{random} \]

\[ \text{cor} \]

\[ \text{task} \]

\[ \beta_{\text{b/w}} = 0.2 \]

\[ \text{Scheduling criteria: energy-time} \]

\[ \text{cor}_{\text{prac}} = 0 \]

\[ \text{cor}_{\text{prac}} = 0.25 \]

\[ \text{cor}_{\text{prac}} = 0.5 \]

\[ \text{cor}_{\text{prac}} = 0.75 \]

\[ \text{cor}_{\text{prac}} = 1 \]

\[ \text{Radius to the baseline} \]
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

![Graph showing energy-aware strategies on heterogeneous platforms]
cor_{task} = 0; \beta_{b/w} = 0.4; \text{ Scheduling criteria: time-time}
$\text{cor}_{\text{task}} = 0$; $\beta_{b/w} = 0.4$; Scheduling criteria: time-energy
Energy-aware strategies on heterogeneous platforms

\[ R = 0.9 \]

\[ R = 0.92 \]

\[ R = 0.94 \]

\[ R = 0.96 \]

\[ \text{cor}_{	ext{proc}} = 0 \]

\[ \text{cor}_{	ext{proc}} = 0.25 \]

\[ \text{cor}_{	ext{proc}} = 0.5 \]

\[ \text{cor}_{	ext{proc}} = 0.75 \]

\[ \text{cor}_{	ext{proc}} = 1 \]

\[ \text{cor}_{	ext{task}} = 0; \beta = 0.4 \].

\[ \beta = 0.4 \].

\[ \text{Scheduling criteria: energy-time} \]

\[ \text{Basic Work} \]

\[ \text{LowestCost} \]

\[ \text{colP} \]

\[ \text{colR} \]

\[ \text{colE} \]

\[ \text{Task} \]

RR no 9324
Energy-aware strategies on heterogeneous platforms

cor\(_{\text{task}} = 0\); \(\beta_{h/w} = 0.4\); Scheduling criteria: energy-energy

<table>
<thead>
<tr>
<th>(\mathcal{R} = 0.9)</th>
<th>(\mathcal{R} = 0.92)</th>
<th>(\mathcal{R} = 0.94)</th>
<th>(\mathcal{R} = 0.96)</th>
<th>(\mathcal{R} = 0.98)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\text{cor}<em>{\text{proc}} = 0).25 (\text{cor}</em>{\text{proc}} = 0).5 (\text{cor}_{\text{proc}} = 1)| |</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\text{mapping})</td>
<td>(\text{LowerBound})</td>
<td>(\text{deP})</td>
<td>(\text{deR})</td>
<td>(\text{inE})</td>
</tr>
</tbody>
</table>

Basic Work

Ratio to the baseline

0.10 0.15 0.20 0.25 0.30 0.10 0.15 0.20 0.25 0.30 0.10 0.15 0.20 0.25 0.30 0.10 0.15 0.20 0.25 0.30 0.10 0.15 0.20 0.25 0.30 0.10 0.15 0.20 0.25 0.30 0.10 0.15 0.20 0.25 0.30 0.10 0.15 0.20 0.25 0.30 0.10 0.15 0.20 0.25 0.30 0.10
### Energy-aware strategies on heterogeneous platforms

**Table:**

<table>
<thead>
<tr>
<th>$\cos_{prac}$</th>
<th>0</th>
<th>0.25</th>
<th>0.5</th>
<th>0.75</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R$</td>
<td>0.98</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>$R$</td>
<td>0.96</td>
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<tr>
<td>$R$</td>
<td>0.94</td>
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<td></td>
</tr>
<tr>
<td>$R$</td>
<td>0.92</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$R$</td>
<td>0.90</td>
<td></td>
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</tr>
</tbody>
</table>

**Graph:**

- **Basic Work:**
  - $\alpha_{k,b}$ = 0; $\beta_{b,a} = 0.4$

**Legend:**

- Mapping
- LowerBound
- dP
- dR
- $a b c$
- random

**Axes:**

- Y-axis: $[0.00, 0.25, 0.50, 0.75, 1.00]$
- X-axis: $[0.00, 0.25, 0.50, 0.75, 1.00]$
Energy-aware strategies on heterogeneous platforms

corr \_task = 0.75; \beta_{b/w} = 1; \text{Scheduling criteria: randomShuffling}
Energy-aware strategies on heterogeneous platforms

\[ R = 0.9 \]
\[ cor_{proc} = 0 \]
\[ cor_{proc} = 0.25 \]
\[ cor_{proc} = 0.5 \]
\[ cor_{proc} = 0.75 \]
\[ cor_{proc} = 1 \]

\[ R = 0.96 \]
\[ R = 0.94 \]
\[ R = 0.92 \]
\[ R = 0.9 \]

Basic Work

Ratio to the baseline

Mapping

LowerBound

deP

deR

inE

random

\[ cor_{task} = 1; \beta_{b/w} = 0.2 \]

Scheduling criteria: time-time

RR

°

\[ 9324 \]
Energy-aware strategies on heterogeneous platforms

\[ R = 0.98 \]

\[ R = 0.92 \]

\[ R = 0.94 \]

\[ R = 0.96 \]

\[ \text{cor}_{\text{task}} = 1; \beta_{\text{w}} = 0.2. \quad \text{Scheduling criteria: time-energy} \]

\[ \text{Basic Work} \]

\[ \text{LowerBound} \]

\[ \text{dep} \]

\[ \text{dep} \]

\[ \text{random} \]

\[ \text{mapping} \]
Energy-aware strategies on heterogeneous platforms

\[ R = 0.9 \]

\[ R = 0.92 \]

\[ R = 0.94 \]

\[ R = 0.96 \]

\[ \text{cor} \] \text{proc} = 0.25 \]

\[ \text{cor} \] \text{proc} = 0.5 \]

\[ \text{cor} \] \text{proc} = 0.75 \]

\[ \text{cor} \] \text{proc} = 1 \]

Basic Work

\[ \beta_{bw} = 0.2 \]

Scheduling criteria: energy-time

\[ \text{cor} \] \text{task} = 1 \]

\[ \text{cor} \] \text{task} = 0 \]

\[ \text{cor} \] \text{task} = 0.2 \]

\[ \text{cor} \] \text{task} = 0.4 \]

\[ \text{cor} \] \text{task} = 0.6 \]

\[ \text{cor} \] \text{task} = 0.8 \]

\[ \text{cor} \] \text{task} = 1 \]
Energy-aware strategies on heterogeneous platforms

\[ R = 0.9 \]

\[ R = 0.92 \]

\[ R = 0.94 \]

\[ R = 0.96 \]

\[ R = 0.98 \]

\[ \text{cor proc} = 0 \]

\[ \text{cor proc} = 0.25 \]

\[ \text{cor proc} = 0.5 \]

\[ \text{cor proc} = 0.75 \]

\[ \text{cor proc} = 1 \]
cor_{task} = 1; \beta_{b/w} = 0.2; Scheduling criteria: randomShuffling
Energy-aware strategies on heterogeneous platforms

\[ R = 0.98 \]

\[ R = 0.96 \]

\[ R = 0.94 \]

\[ R = 0.92 \]

\[ R = 0.90 \]

\[ \text{cor}_{\text{proc}} = 0 \]

\[ \text{cor}_{\text{proc}} = 0.25 \]

\[ \text{cor}_{\text{proc}} = 0.5 \]

\[ \text{cor}_{\text{proc}} = 0.75 \]

\[ \text{cor}_{\text{proc}} = 1 \]

\[ \text{cor}_{\text{task}} = 1; \beta_{j,u} = 0.4; \text{Scheduling criteria: time-time} \]

Basic Work

\[ \text{LowerBound} \]

\[ \text{deP} \]

\[ \text{deR} \]

\[ \text{inE} \]

\[ \text{random} \]

\[ \beta_{b/w} = 0.4 \]
Energy-aware strategies on heterogeneous platforms

\[ R = 0.9 \]

\[ \text{cor}_\text{proc} = 0.95 \]

\[ \text{cor}_\text{proc} = 0.75 \]

\[ \text{cor}_\text{proc} = 0.5 \]

\[ \text{cor}_\text{proc} = 0.25 \]

\[ \text{cor}_\text{proc} = 0.0 \]

\[ \text{cor}_\text{proc} = 1 \]

Basic Work

Radix to base

Mapping

Low/High, static, dynamic, dR, dP, dE, random

\[ \text{mapping} \]

\[ \text{Basic Work} \]

\[ \text{Radix to base} \]

\[ \text{Scheduling criteria: time-energy} \]

\[ \beta_{\text{w}} = 0.4 \]

\[ \text{cor}_\text{task} = 1 \]

\[ \beta_{\text{w}} = 0.4 \]

\[ \text{Scheduling criteria: time-energy} \]

RR n° 9324
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>$cor_{max} = 0$</th>
<th>$cor_{max} = 0.25$</th>
<th>$cor_{max} = 0.5$</th>
<th>$cor_{max} = 0.75$</th>
<th>$cor_{max} = 1$</th>
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<tbody>
<tr>
<td>$R = 0.98$</td>
<td></td>
<td></td>
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<tr>
<td>$R = 0.96$</td>
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<tr>
<td>$R = 0.92$</td>
<td></td>
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<td></td>
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<tr>
<td>$R = 0.90$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Basic Work:**

- $cor_{task} = 1$, $\beta_{b/w} = 0.4$
- Scheduling criteria: energy-energy

**Lowfame:**

- $cor_{task} = 1$, $\beta_{b/w} = 0.4$
- Scheduling criteria: energy-energy

**Light:**

- $cor_{task} = 1$, $\beta_{b/w} = 0.4$
- Scheduling criteria: energy-energy

**delP:**

- $cor_{task} = 1$, $\beta_{b/w} = 0.4$
- Scheduling criteria: energy-energy

**delP:**

- $cor_{task} = 1$, $\beta_{b/w} = 0.4$
- Scheduling criteria: energy-energy

** Backend:**

- $cor_{task} = 1$, $\beta_{b/w} = 0.4$
- Scheduling criteria: energy-energy

** Backend:**

- $cor_{task} = 1$, $\beta_{b/w} = 0.4$
- Scheduling criteria: energy-energy
cor_{task} = 0; \beta_{b/w} = 0.6; Scheduling criteria: time-time
Energy-aware strategies on heterogeneous platforms

![Graphical representation of energy-aware strategies on heterogeneous platforms]

*Correlation to the baseline:*
- \( R = 0.98 \)
- \( R = 0.96 \)
- \( R = 0.94 \)
- \( R = 0.92 \)
- \( R = 0.90 \)

*Mapping strategies:*
- Basic Work
- Scheduling criteria: randomShuffling
  - \( \alpha = 1 \), \( \beta_{i,j} = 0.4 \)

*Scheduling parameters:*
- \( \beta_{i,j} = 0.4 \), \( b/w = 0.4 \)
Energy-aware strategies on heterogeneous platforms

\begin{align*}
  R &= 0.98 \\
  R &= 0.96 \\
  R &= 0.94 \\
  R &= 0.92 \\
  R &= 0.90
\end{align*}

Basic Work

\begin{align*}
  \text{Mapping} & \quad \text{LowerBound} \\
  \text{deP} & \quad \text{deR} \\
  \text{random} & \quad \text{Scheduling criteria: time-time}
\end{align*}

\text{cor} \quad \text{task} = 1; \beta_{0, u} = 0.6. \text{ Scheduling criteria: time-time}
\( c_{\text{task}} = 1; \beta_{b/w} = 0.6; \) Scheduling criteria: time-energy

<table>
<thead>
<tr>
<th>( \mathcal{R} )</th>
<th>( n )</th>
<th>( \mathcal{N} )</th>
<th>( \text{cor} )</th>
<th>( \text{proc} )</th>
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<tr>
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</tr>
</tbody>
</table>

Basic Work

<table>
<thead>
<tr>
<th>( \text{Ratio to the baseline} )</th>
<th>( \mathcal{R} )</th>
<th>( \mathcal{N} )</th>
<th>( \text{cor} )</th>
<th>( \text{proc} )</th>
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<tr>
<td>0.10</td>
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</tbody>
</table>

**Mapping:** LowerBound, deP, deR, inE, random

Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{task}} = 1; \ \beta_{b/w} = 0.6; \ \text{Scheduling criteria: energy-energy} \)
Energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{task}} = 1; \beta_{\text{bw}} = 0.6; \) Scheduling criteria: randomShuffling

\begin{table}[h]
\begin{tabular}{|c|c|c|c|c|}
\hline
\text{Rate to the baseline} & \text{LowerBound} & \text{deP} & \text{deR} & \text{inE} & \text{random} \\
\hline
\hline
\end{tabular}
\end{table}
$cor_{task} = 1; \beta_{bw} = 0.8$; Scheduling criteria: time-time
Energy-aware strategies on heterogeneous platforms

R = 0.98

R = 0.96

R = 0.94

R = 0.92

R = 0.9

Basic Work

Mapping

Lower bounds

dR

dP

eE

naken

\( \text{cor}_{\text{task}} = 1; \beta_{j,u} = 0.8 \), Scheduling criteria: time-energy

RR n° 9324
Energy-aware strategies on heterogeneous platforms

$c_{\text{task}} = 1$; $\beta_{b/w} = 0.8$; Scheduling criteria: energy-time

Basic Work

<table>
<thead>
<tr>
<th>Basic Work</th>
<th>R = 0.9</th>
<th>R = 0.92</th>
<th>R = 0.94</th>
<th>R = 0.96</th>
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<td>0.40</td>
<td>0.40</td>
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</tr>
</tbody>
</table>

mapping: LowerBound - deP - deE - Random

Energy-aware strategies on heterogeneous platforms
cor_{task} = 1; \beta_{b/w} = 0.8; Scheduling criteria: energy-energy

Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>$\rho_{FPE} = 0$</th>
<th>$\rho_{FPE} = 0.025$</th>
<th>$\rho_{FPE} = 0.05$</th>
<th>$\rho_{FPE} = 0.075$</th>
<th>$\rho_{FPE} = 0.1$</th>
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</thead>
<tbody>
<tr>
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<tr>
<td>$R = 0.06$</td>
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<tr>
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</table>

Basic Work ratio to the baseline mapping

Lower Bound

deP deR inE random

Scheduling criteria: time-energy

$\rho_{FPE} = 0; \beta_{D}^{} = 0.06$. Scheduling criteria: time-energy
Energy-aware strategies on heterogeneous platforms

\[ cor_{task} = 1; \beta_{b/w} = 0.8; \text{Scheduling criteria: randomShuffling} \]

<table>
<thead>
<tr>
<th>( N )</th>
<th>( \beta_{b/w} )</th>
<th>( cor_{proc} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.9</td>
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<tr>
<td>0.92</td>
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Basic Work

Ratio to the baseline

 mapping: LowerBound, deP, deR, inE, random
Energy-aware strategies on heterogeneous platforms

\[ R = 0.9 \]

\[ R = 0.92 \]

\[ R = 0.94 \]

\[ R = 0.96 \]

\[ \text{Basic Work} \]

\[ \text{Correlation task} = 1; \beta_0, \omega = 1. \]

Scheduling criteria: time-time
cor_{task} = 1; \beta_{b/w} = 1; Scheduling criteria: time-energy
Energy-aware strategies on heterogeneous platforms

cor\_task = 1; \beta_{b/w} = 1; Scheduling criteria: energy-time

Basic Work

Ratio to the baseline

mapping LowerBound dP dR inE random

RR n° 9221

Energy-aware strategies on heterogeneous platforms

774
Energy-aware strategies on heterogeneous platforms

\[ R = 0.96 \]

\[ R = 0.94 \]

\[ R = 0.92 \]

\[ R = 0.90 \]

\[ \text{cor} \text{.} \text{proc} = 0 \]
\[ \text{cor} \text{.} \text{proc} = 0.25 \]
\[ \text{cor} \text{.} \text{proc} = 0.5 \]
\[ \text{cor} \text{.} \text{proc} = 0.75 \]
\[ \text{cor} \text{.} \text{proc} = 1 \]

Basic Work

Ratio to the baseline

mapping

LowerBound

deP

deR

inE

random

\[ \text{cor} \text{.} \text{task} = 1; \beta_{\text{b/w}} = 1; \] Scheduling criteria: energy-energy

 RR n° 9324
cor_{task} = 0; \beta_{b/w} = 0.6; \text{Scheduling criteria: energy-time}

<table>
<thead>
<tr>
<th>$\mathbf{R}$</th>
<th>$\mathbf{N}$</th>
<th>$\mathbf{R}$</th>
<th>$\mathbf{N}$</th>
<th>$\mathbf{R}$</th>
<th>$\mathbf{N}$</th>
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<table>
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<th>0.75</th>
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<tr>
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</tbody>
</table>

Mapping:  
- LowerBound  
- deP  
- deR  
- inE  
- random

Energy-aware strategies on heterogeneous platforms
R = 0.90

Basic Work

corr = 0; \beta_{uw} = 0.6. Scheduling criteria: energy-energy

RR n° 9324
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

cor\textsubscript{task} = 0; \beta_{b/w} = 0.8; Scheduling criteria: time-time
Energy-aware strategies on heterogeneous platforms

\[ R = 0.9 \]

\[ \text{cor}_{\text{proc}} = 0 \]

\[ \text{cor}_{\text{proc}} = 0.25 \]

\[ \text{cor}_{\text{proc}} = 0.5 \]

\[ \text{cor}_{\text{proc}} = 0.75 \]

\[ \text{cor}_{\text{proc}} = 1 \]

Basic Work

\[ \frac{\text{ratio to the baseline}}{\text{mapping}} \]

\[ \text{cor}_{\text{task}} = 0; \beta_{b/w} = 0.8 \]

\[ \text{Scheduling criteria: time-energy} \]

RR n° 9324
Energy-aware strategies on heterogeneous platforms

- $R = 0.98$
- $R = 0.96$
- $R = 0.94$
- $R = 0.92$
- $R = 0.90$

- corr: 0.0, \beta_{bw} = 0.8. Scheduling criteria: energy-time

Basic Work
- LowerBound
- deP
- deR
- inE
- random

RR n° 9324
cor_{task} = 0; \beta_{b/w} = 0.8; \text{Scheduling criteria: energy-energy}
$\text{cor}_{\text{task}} = 0$; $\beta_{b/w} = 0.8$; Scheduling criteria: randomShuffling

Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>cor_{prev} = 0</th>
<th>cor_{prev} = 0.25</th>
<th>cor_{prev} = 0.5</th>
<th>cor_{prev} = 0.75</th>
<th>cor_{prev} = 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>R = 0.98</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R = 0.96</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>R = 0.94</td>
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</tr>
<tr>
<td>R = 0.92</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>R = 0.9</td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[
\text{cor}_{\text{proc}} = 0.10, 0.15, 0.20, 0.25, 0.30, 0.35, 0.40, 0.45, 0.50, 0.55, 0.60, 0.65, 0.70, 0.75, 0.80, 0.85, 0.90, 0.95, 1.00
\]

Basic Work

Ratio to the baseline

**Scheduling criteria:** time-time

**cor**_{task} = 0; \beta_{sw} = 1.

RR n° 9324
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>$\text{cor}_{\text{prev}}$</th>
<th>$R = 0.98$</th>
<th>$R = 0.96$</th>
<th>$R = 0.94$</th>
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<tr>
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<td>$\beta_0$</td>
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<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>$\text{Scheduling criteria: energy-time}$</td>
<td>Basic Work</td>
<td>LowerBound</td>
<td>deP</td>
<td>deR</td>
<td>inE</td>
</tr>
<tr>
<td>$\text{Mapping}$</td>
<td>baseline</td>
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<td>baseline</td>
<td>baseline</td>
<td>baseline</td>
</tr>
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</table>

RR n° 9324
Energy-aware strategies on heterogeneous platforms

R = 0.90
R = 0.92
R = 0.94
R = 0.96
R = 0.98

cor proc = 1
R cor proc = 0.75
R cor proc = 0.5
R cor proc = 0.25
R cor proc = 0

Basic Work
LowerBound
def
rand


corr_m = 0; \beta_{0w} = 1. Scheduling criteria: energy-energy

RR n° 9324
$cor_{task} = 0; \beta_{b/w} = 1; \text{Scheduling criteria: randomShuffling}$
\( \text{cor}_{\text{task}} = 0.25; \ \beta_{b/w} = 0.2; \) Scheduling criteria: time-time

![Graph showing energy-aware strategies on heterogeneous platforms]
Energy-aware strategies on heterogeneous platforms

cor\text{task} = 0.25; \beta_{b/w} = 0.2; Scheduling criteria: time-energy

\begin{figure}
\centering
\includegraphics[width=\textwidth]{figure}
\caption{Comparison of different mapping strategies.}
\end{figure}
\( cor_{task} = 0.25; \beta_{b/w} = 0.2; \) Scheduling criteria: energy-time
cor_{task} = 0.25; \beta_{b/w} = 0.2; Scheduling criteria: energy-energy
Energy-aware strategies on heterogeneous platforms

Basic Work

Ratio to the baseline

Low bound deP: deR: inE: random

cor task = 0.25; β_w = 0.2; Scheduling criteria: randomShuffling

RR n°9324
Energy-aware strategies on heterogeneous platforms

<table>
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<tr>
<th>$cor_{pre} = 0$</th>
<th>$cor_{pre} = 0.25$</th>
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<th>$cor_{pre} = 0.75$</th>
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<td>$R = 0.94$</td>
<td>$R = 0.92$</td>
<td>$R = 0.90$</td>
</tr>
</tbody>
</table>

**Task execution time**

- $cor_{task} = 0.25$, $\beta_{uw} = 0.4$

Scheduling criteria: time-time

<table>
<thead>
<tr>
<th>Basic Work</th>
<th>LowerBound</th>
<th>deP</th>
<th>deR</th>
<th>inE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>$0.25$</td>
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</table>

RR n° 9324
Energy-aware strategies on heterogeneous platforms

cor\_task = 0.25; \beta_{b/w} = 0.4; Scheduling criteria: energy-time

<table>
<thead>
<tr>
<th>R = 0.9</th>
<th>R = 0.92</th>
<th>R = 0.94</th>
<th>R = 0.96</th>
<th>R = 0.98</th>
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<td>[ \text{cor} \text{proc} = 0.15 ]</td>
<td>[ \text{cor} \text{proc} = 0.20 ]</td>
<td>[ \text{cor} \text{proc} = 0.25 ]</td>
<td>[ \text{cor} \text{proc} = 0.30 ]</td>
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</tbody>
</table>

Basic Work | \[ \text{Ratio to the baseline} \] | \[ \text{LowerBound} \] | \[ \text{deP} \] | \[ \text{deR} \] | \[ \text{deE} \] | \[ \text{random} \] |
<table>
<thead>
<tr>
<th></th>
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</tr>
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<tbody>
<tr>
<td>0.10</td>
<td>0.15</td>
<td>0.20</td>
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<tr>
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<td>0.25</td>
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<tr>
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<td>0.15</td>
<td>0.20</td>
<td>0.25</td>
<td>0.30</td>
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<tr>
<td>0.10</td>
<td>0.15</td>
<td>0.20</td>
<td>0.25</td>
<td>0.30</td>
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</tbody>
</table>

Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

\[ R = 0.98 \]

\[ \text{cor}_{\text{proc}} = 0 \]

\[ \text{cor}_{\text{proc}} = 0.25 \]

\[ \text{cor}_{\text{proc}} = 0.5 \]

\[ \text{cor}_{\text{proc}} = 0.75 \]

\[ \text{cor}_{\text{proc}} = 1 \]

\[ R = 0.96 \]

\[ R = 0.94 \]

\[ R = 0.92 \]

\[ R = 0.90 \]

\[ \text{cor}_{\text{task}} = 0.25 \]

\[ \beta_{\text{eff}} = 0.4 \]

Scheduling criteria: energy-energy

Basic Work

\[ \text{deP} \]

\[ \text{deR} \]

\[ \text{inE} \]

\[ \text{random} \]

\[ \text{LowerBound} \]

\[ \text{cor}_{\text{proc}} \]

\[ \text{cor}_{\text{task}} \]

\[ \text{mapping} \]
Energy-aware strategies on heterogeneous platforms

<table>
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</table>

Scheduling criteria: randomShuffling, Basic Work

RR n° 9324
Energy-aware strategies on heterogeneous platforms

corr_{task} = 0.25; \beta_{t/w} = 0.6; Scheduling criteria: time-time

Ratio to the baseline

Basic Work

0.10 0.15 0.20 0.25 0.30 0.10 0.15 0.20 0.25 0.30 0.10 0.15 0.20 0.25 0.30 0.10 0.15 0.20 0.25 0.30

mapping LowerBound deP deR inE random
\( \text{cor}_{\text{task}} = 0.25; \ \beta_{b/w} = 0.6; \) Scheduling criteria: time-energy

Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

cor_{task} = 0.25; \beta_{b/w} = 0.6; Scheduling criteria: energy-time

Basic Work

Ratio to the baseline

mapping

LowerBound deP deR inE random
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.25; \beta_{b/w} = 0.6; \text{Scheduling criteria: energy-energy} \]

<table>
<thead>
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<th>Correlation</th>
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<th>0.94</th>
<th>0.96</th>
<th>0.98</th>
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<tbody>
<tr>
<td>Basic Work</td>
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<td>0.15</td>
<td>0.20</td>
<td>0.25</td>
<td>0.30</td>
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</table>

**Ratio to the baseline**

- LowerBound
- deP
- deR
- inE
- random

Energy-aware strategies on heterogeneous platforms

803
$cor_{task} = 0.25; \beta_{b/w} = 0.6; $ Scheduling criteria: randomShuffling

<table>
<thead>
<tr>
<th>$R$</th>
<th>$cor_{proc}$</th>
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<tr>
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<tr>
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</table>

Energy-aware strategies on heterogeneous platforms
cor_task = 0.25; \beta_{b/w} = 0.8; Scheduling criteria: time-time
cor_{task} = 0.25; \beta_{bw} = 0.8; \text{Scheduling criteria: time-energy}

Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

$cor_{task} = 0.25$; $\beta_{b/w} = 0.8$; Scheduling criteria: energy-time
Energy-aware strategies on heterogeneous platforms

\[ R = 0.9, \ R' = 0.92, \ R'' = 0.94, \ R''' = 0.96, \ R'''' = 0.98 \]

cor = 0.25; \ \beta_{\text{inE}} = 0.8; \ \text{Scheduling criteria: energy-energy}

Basic Work

Correlation.

Lower Bound: 0.75; \ \text{Mapping: 0.5, 0.25; \ \text{Baseline: 0.0, 0.25, 0.5, 0.75, 1.0}}

RR n° 9324
cor = 0.25; $\beta b/w = 0.8$; Scheduling criteria: randomShuffling
Energy-aware strategies on heterogeneous platforms

cor\_task = 0.25; \beta_{b/w} = 1; Scheduling criteria: time-time
$\text{cor}_\text{task} = 0.25; \beta_{b/w} = 1$; Scheduling criteria: time-energy
$cor_{\text{task}} = 0.25; \beta_{b/w} = 1$; Scheduling criteria: energy-time

**Energy-aware strategies on heterogeneous platforms**

**Basic Work**

**Ratio to the baseline**

**Mapping**

- LowerBound
- deP
- deR
- inE
- random
**Energy-aware strategies on heterogeneous platforms**

<table>
<thead>
<tr>
<th>$corr_{\text{proc}}$</th>
<th>$corr_{\text{task}}$</th>
<th>$corr_{\text{energy}}$</th>
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<tbody>
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<tr>
<td>1.00</td>
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</table>

**Scheduling criteria:** energy-energy

**Basic Work:**

- $\beta_{b/w} = 1$
- $\beta_{\text{fu}} = 0.25$

**LowerBound:**

- $\delta_{\text{fu}} = 0.05$
- $\delta_{\text{nu}} = 0.05$

**UpperBound:**

- $\delta_{\text{fu}} = 0.05$
- $\delta_{\text{nu}} = 0.05$
Energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{task}} = 0.25; \ \beta_{b/w} = 1; \ \text{Scheduling criteria: randomShuffling} \)

**R** = 0.9; **R** = 0.92; **R** = 0.94; **R** = 0.96; **R** = 0.98

**Basic Work**

**Mapping**

- LowerBound
- deP
- deR
- inE
- random

814
$cor_{task} = 0.5; \beta_{j,w} = 0.2$; Scheduling criteria: time-time
Energy-aware strategies on heterogeneous platforms

corr_{task} = 0.5; \beta_{bw} = 0.2; Scheduling criteria: time-energy

"coreBoost = 0.5; \beta_{bw} = 0.2; Scheduling criteria: time-energy"
Energy-aware strategies on heterogeneous platforms

corr_{task} = 0.5; \beta_{h/w} = 0.2; Scheduling criteria: energy-time

mapping — LowerBound — deP — deR — inE — random
cor proc = 0.00; Scheduling criteria: energy-energy

corr = 0.25; βb/w = 0.5; βw = 0.2; Scheduling criteria: energy-energy

RR n° 9324
\( cor_{\text{task}} = 0.5; \beta_{j,w} = 0.2; \) Scheduling criteria: randomShuffling
Energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{task}} = 0.5; \ \beta_{\text{bw}} = 0.4; \text{Scheduling criteria: time-time} \)

<table>
<thead>
<tr>
<th>R</th>
<th>( \text{cor}_{\text{proc}} )</th>
<th>LowerBound</th>
<th>deP</th>
<th>deR</th>
<th>inE</th>
<th>random</th>
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<tr>
<td>0.94</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>0.96</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>0.98</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Basic Work

| Basic Work | 0.10 | 0.15 | 0.20 | 0.25 | 0.30 | 0.35 | 0.40 | 0.45 | 0.50 | 0.55 | 0.60 | 0.65 | 0.70 | 0.75 | 0.80 | 0.85 | 0.90 | 0.95 | 1.00 |
|------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| 0.0       | 0.10 | 0.15 | 0.20 | 0.25 | 0.30 | 0.35 | 0.40 | 0.45 | 0.50 | 0.55 | 0.60 | 0.65 | 0.70 | 0.75 | 0.80 | 0.85 | 0.90 | 0.95 | 1.00 |
| 0.1       | 0.10 | 0.15 | 0.20 | 0.25 | 0.30 | 0.35 | 0.40 | 0.45 | 0.50 | 0.55 | 0.60 | 0.65 | 0.70 | 0.75 | 0.80 | 0.85 | 0.90 | 0.95 | 1.00 |
| 0.2       | 0.10 | 0.15 | 0.20 | 0.25 | 0.30 | 0.35 | 0.40 | 0.45 | 0.50 | 0.55 | 0.60 | 0.65 | 0.70 | 0.75 | 0.80 | 0.85 | 0.90 | 0.95 | 1.00 |
| 0.3       | 0.10 | 0.15 | 0.20 | 0.25 | 0.30 | 0.35 | 0.40 | 0.45 | 0.50 | 0.55 | 0.60 | 0.65 | 0.70 | 0.75 | 0.80 | 0.85 | 0.90 | 0.95 | 1.00 |
| 0.4       | 0.10 | 0.15 | 0.20 | 0.25 | 0.30 | 0.35 | 0.40 | 0.45 | 0.50 | 0.55 | 0.60 | 0.65 | 0.70 | 0.75 | 0.80 | 0.85 | 0.90 | 0.95 | 1.00 |
| 0.5       | 0.10 | 0.15 | 0.20 | 0.25 | 0.30 | 0.35 | 0.40 | 0.45 | 0.50 | 0.55 | 0.60 | 0.65 | 0.70 | 0.75 | 0.80 | 0.85 | 0.90 | 0.95 | 1.00 |

Mapping: LowerBound, deP, deR, inE, random
Energy-aware strategies on heterogeneous platforms

cor_{task} = 0.5; \beta_{t/w} = 0.4; Scheduling criteria: time-energy

<table>
<thead>
<tr>
<th>Basic Work</th>
<th>Ratio to the baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.10</td>
<td>0.00</td>
</tr>
<tr>
<td>0.15</td>
<td>0.05</td>
</tr>
<tr>
<td>0.20</td>
<td>0.10</td>
</tr>
<tr>
<td>0.25</td>
<td>0.15</td>
</tr>
<tr>
<td>0.30</td>
<td>0.20</td>
</tr>
<tr>
<td>0.35</td>
<td>0.25</td>
</tr>
<tr>
<td>0.40</td>
<td>0.30</td>
</tr>
<tr>
<td>0.45</td>
<td>0.35</td>
</tr>
<tr>
<td>0.50</td>
<td>0.40</td>
</tr>
<tr>
<td>0.55</td>
<td>0.45</td>
</tr>
<tr>
<td>0.60</td>
<td>0.50</td>
</tr>
<tr>
<td>0.65</td>
<td>0.55</td>
</tr>
<tr>
<td>0.70</td>
<td>0.60</td>
</tr>
<tr>
<td>0.75</td>
<td>0.65</td>
</tr>
<tr>
<td>0.80</td>
<td>0.70</td>
</tr>
<tr>
<td>0.85</td>
<td>0.75</td>
</tr>
<tr>
<td>0.90</td>
<td>0.80</td>
</tr>
<tr>
<td>0.95</td>
<td>0.85</td>
</tr>
<tr>
<td>1.00</td>
<td>0.90</td>
</tr>
</tbody>
</table>

mapping: LowerBound, deP, deR, inE, random
Energy-aware strategies on heterogeneous platforms

corr_{task} = 0.5; \beta_{j/w} = 0.4; Scheduling criteria: energy-time
Energy-aware strategies on heterogeneous platforms

cor\text{task} = 0.5; \beta_{j,w} = 0.4; Scheduling criteria: energy-energy

\begin{tikzpicture}
\begin{axis}[
    title={R = 0.9},
    xlabel={Basic Work},
    ylabel={Ratio to the baseline},
    legend style={at={(0.5,0.97)},anchor=north}
]
\addplot[only marks,mark size=1pt,mark options={draw=black,fill=black}] table {data1.dat};
\addplot[only marks,mark size=1pt,mark options={draw=black,fill=black}] table {data2.dat};
\addplot[only marks,mark size=1pt,mark options={draw=black,fill=black}] table {data3.dat};
\addplot[only marks,mark size=1pt,mark options={draw=black,fill=black}] table {data4.dat};
\addlegendentry{LowerBound}
\end{axis}
\end{tikzpicture}

\begin{tikzpicture}
\begin{axis}[
    title={R = 0.92},
    xlabel={Basic Work},
    ylabel={Ratio to the baseline},
    legend style={at={(0.5,0.97)},anchor=north}
]
\addplot[only marks,mark size=1pt,mark options={draw=black,fill=black}] table {data1.dat};
\addplot[only marks,mark size=1pt,mark options={draw=black,fill=black}] table {data2.dat};
\addplot[only marks,mark size=1pt,mark options={draw=black,fill=black}] table {data3.dat};
\addplot[only marks,mark size=1pt,mark options={draw=black,fill=black}] table {data4.dat};
\addlegendentry{LowerBound}
\end{axis}
\end{tikzpicture}

\begin{tikzpicture}
\begin{axis}[
    title={R = 0.94},
    xlabel={Basic Work},
    ylabel={Ratio to the baseline},
    legend style={at={(0.5,0.97)},anchor=north}
]
\addplot[only marks,mark size=1pt,mark options={draw=black,fill=black}] table {data1.dat};
\addplot[only marks,mark size=1pt,mark options={draw=black,fill=black}] table {data2.dat};
\addplot[only marks,mark size=1pt,mark options={draw=black,fill=black}] table {data3.dat};
\addplot[only marks,mark size=1pt,mark options={draw=black,fill=black}] table {data4.dat};
\addlegendentry{LowerBound}
\end{axis}
\end{tikzpicture}

\begin{tikzpicture}
\begin{axis}[
    title={R = 0.96},
    xlabel={Basic Work},
    ylabel={Ratio to the baseline},
    legend style={at={(0.5,0.97)},anchor=north}
]
\addplot[only marks,mark size=1pt,mark options={draw=black,fill=black}] table {data1.dat};
\addplot[only marks,mark size=1pt,mark options={draw=black,fill=black}] table {data2.dat};
\addplot[only marks,mark size=1pt,mark options={draw=black,fill=black}] table {data3.dat};
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\end{axis}
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\begin{tikzpicture}
\begin{axis}[
    title={R = 0.98},
    xlabel={Basic Work},
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]
\addplot[only marks,mark size=1pt,mark options={draw=black,fill=black}] table {data1.dat};
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\addplot[only marks,mark size=1pt,mark options={draw=black,fill=black}] table {data3.dat};
\addplot[only marks,mark size=1pt,mark options={draw=black,fill=black}] table {data4.dat};
\addlegendentry{LowerBound}
\end{axis}
\end{tikzpicture}
Energy-aware strategies on heterogeneous platforms

- $\text{cor}_{\text{task}} = 0.5$; $\beta_{\text{cpu}} = 0.4$; Scheduling criteria: randomShuffling

<table>
<thead>
<tr>
<th>$\mathcal{R}$</th>
<th>$\text{deP}$</th>
<th>$\text{deR}$</th>
<th>$\text{inE}$</th>
<th>random</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
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<tr>
<td>0.92</td>
<td>0.92</td>
<td>0.92</td>
<td>0.92</td>
<td>0.92</td>
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<tr>
<td>0.94</td>
<td>0.94</td>
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<td>0.96</td>
<td>0.96</td>
<td>0.96</td>
<td>0.96</td>
<td>0.96</td>
</tr>
</tbody>
</table>

- $\text{cor}_{\text{proc}} = 0.25$; $\text{cor}_{\text{proc}} = 0.5$; $\text{cor}_{\text{proc}} = 0.75$

- $\mathbf{R}$ score:
  - $\mathbf{R} = 0.10$
  - $\mathbf{R} = 0.15$
  - $\mathbf{R} = 0.20$
  - $\mathbf{R} = 0.25$
  - $\mathbf{R} = 0.30$

- Basic Work & Ratio to the baseline

- Mapping: LowerBound, deP, deR, inE, random
**Energy-aware strategies on heterogeneous platforms**

<table>
<thead>
<tr>
<th>$\text{corr}_{\text{proc}}$</th>
<th>$R = 0.98$</th>
<th>$R = 0.96$</th>
<th>$R = 0.94$</th>
<th>$R = 0.92$</th>
<th>$R = 0.9$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{corr}_{\text{task}}$</td>
<td>0.5; $\beta_w = 0.6$; Scheduling criteria: time-time</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\text{Basic Work}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\text{LowerBound}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\text{deP}$</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>$\text{deR}$</td>
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</tr>
<tr>
<td>$\text{random}$</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

### RR n° 9324
cor_task = 0.5; β_w = 0.6; Scheduling criteria: time-energy.
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

cor\textsubscript{task} = 0.5; \beta_{b/w} = 0.6; Scheduling criteria: energy-energy

Basic Work

Ratio to the baseline

mapping

LowerBound  deP  deR  inE  random
Energy-aware strategies on heterogeneous platforms

$R = 0.98$

$R = 0.96$

$R = 0.94$

$R = 0.92$

$R = 0.90$

$\text{cor}_{\text{proc}} = 0$; $\beta_{w} = 0.6$; Scheduling criteria: randomShuffling

Basic Work
Energy-aware strategies on heterogeneous platforms

\( c_{\text{task}} = 0.5; \beta_{p,w} = 0.8; \) Scheduling criteria: time-time
Energy-aware strategies on heterogeneous platforms

c_{o}r_{task} = 0.5; \beta_{l/w} = 0.8; Scheduling criteria: time-energy

<table>
<thead>
<tr>
<th>N</th>
<th>Mapping</th>
<th>LowerBound</th>
<th>deP</th>
<th>deR</th>
<th>inE</th>
<th>random</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.9</td>
<td>LowerBound</td>
<td>deP</td>
<td>deR</td>
<td>inE</td>
<td>random</td>
<td></td>
</tr>
<tr>
<td>0.92</td>
<td>LowerBound</td>
<td>deP</td>
<td>deR</td>
<td>inE</td>
<td>random</td>
<td></td>
</tr>
<tr>
<td>0.94</td>
<td>LowerBound</td>
<td>deP</td>
<td>deR</td>
<td>inE</td>
<td>random</td>
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<tr>
<td>0.96</td>
<td>LowerBound</td>
<td>deP</td>
<td>deR</td>
<td>inE</td>
<td>random</td>
<td></td>
</tr>
<tr>
<td>0.98</td>
<td>LowerBound</td>
<td>deP</td>
<td>deR</td>
<td>inE</td>
<td>random</td>
<td></td>
</tr>
</tbody>
</table>
$cor_{task} = 0.5; \beta_{j/w} = 0.8; \text{ Scheduling criteria: energy-time}$

Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

\[ R = 0.9 \]

\[ \beta_{b/w} = 0.8 \]

Scheduling criteria: energy-energy

Basic Work

Mapping

Lower bounds

dE

dR

sake

radii to the baseline
Energy-aware strategies on heterogeneous platforms

\[ R = 0.9 \]

\[ \alpha = 0.5, \beta_0 = 0.8 \]

Scheduling criteria: randomShuffling

Basic Work

- LowerBound
- dP
- dR
- Scheduling criterion

mapping

RR n° 9324
Energy-aware strategies on heterogeneous platforms

$cor_{task} = 0.5; \beta_{b/w} = 1$; Scheduling criteria: time-time

Basic Work

Ratio to the baseline

Mapping: LowerBound, doP, doR, inE, random
Energy-aware strategies on heterogeneous platforms

Basic Work

Ratio to the baseline

Mapping

LowerBound

deP

deR

inE

random

Scheduling criteria: time-energy

$\alpha = 0.5; \beta_{b/w} = 1$

$\gamma_{cor} = 0.00; 0.25; 0.50; 0.75; 1.00$

$\gamma_{task} = 0.00; 0.25; 0.50; 0.75; 1.00$

RR n° 9324
Energy-aware strategies on heterogeneous platforms

corr_{task} = 0.5; \beta_{j,w} = 1; Scheduling criteria: energy-time

![Graph showing energy-aware strategies on heterogeneous platforms](image-url)
cor_{task} = 0.5; \beta_{j/u} = 1; Scheduling criteria: energy-energy
cor_{task} = 0.5; \beta_{b/w} = 1; \text{Scheduling criteria: randomShuffling}

RR n° 9324
$\text{cor}_{\text{task}} = 0.75; \beta_{b/w} = 0.2; \text{Scheduling criteria: time-time}$
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.75; \beta_{b/w} = 0.2; \text{Scheduling criteria: time-energy} \]

<table>
<thead>
<tr>
<th>( R = 0.9 )</th>
<th>( R = 0.92 )</th>
<th>( R = 0.94 )</th>
<th>( R = 0.96 )</th>
<th>( R = 0.98 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic Work</td>
<td>Ratio to the baseline</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.00</td>
<td>0.10</td>
<td>0.15</td>
<td>0.20</td>
<td>0.25</td>
</tr>
<tr>
<td>0.00</td>
<td>0.00</td>
<td>0.25</td>
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<tr>
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<td>0.00</td>
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<td>0.25</td>
<td>0.50</td>
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<tr>
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<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.25</td>
</tr>
</tbody>
</table>

mapping: LowerBound, deP, deR, inE, random
cor\text{task} = 0.75; \beta_{b/w} = 0.2; \text{Scheduling criteria: energy-time}
$cor_{task} = 0.75; \beta_{b/w} = 0.2; $ Scheduling criteria: energy-energy

<table>
<thead>
<tr>
<th>$R$</th>
<th>$cor_{proc}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.9</td>
<td>0.10</td>
</tr>
<tr>
<td>0.92</td>
<td>0.10</td>
</tr>
<tr>
<td>0.94</td>
<td>0.10</td>
</tr>
<tr>
<td>0.96</td>
<td>0.10</td>
</tr>
<tr>
<td>0.98</td>
<td>0.10</td>
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</tbody>
</table>

Basic Work: Ratio to the baseline

Scheduling criteria: energy-energy

mapping: LowerBound, deP, deR, inE, random
Energy-aware strategies on heterogeneous platforms

cor\textsubscript{\textit{task}} = 0.75; \beta_{b/w} = 0.2; Scheduling criteria: randomShuffling

R = 0.9

\begin{align*}
\text{Basic Work} & \quad \text{Ratio to the baseline} \\
0.10 & \quad 0.15 & \quad 0.20 & \quad 0.25 & \quad 0.30 & \quad 0.10 & \quad 0.15 & \quad 0.20 & \quad 0.25 & \quad 0.30 \\
0.00 & \quad 0.25 & \quad 0.50 & \quad 0.75 & \quad 1.00 & \quad 1.00 & \quad 1.00 & \quad 1.00 & \quad 1.00 & \quad 1.00 \\
\end{align*}

mapping - LowerBound - deP - deR - inE - random

RR n = 9324
Energy-aware strategies on heterogeneous platforms

\[ R = 0.98 \]

\[ R = 0.96 \]

\[ R = 0.94 \]

\[ R = 0.92 \]

\[ \text{cor} \text{ proc} = 0.10 \]

\[ \text{cor} \text{ proc} = 0.15 \]

\[ \text{cor} \text{ proc} = 0.20 \]

\[ \text{cor} \text{ proc} = 0.25 \]

\[ \text{cor} \text{ proc} = 0.30 \]

Basic Work

\[ \text{cor} \text{ task} = 0.75; \beta_{\text{uw}} = 0.4 \]

Scheduling criteria: time-time

RR n° 9324
$\text{cor}_\text{task} = 0.75; \beta_{b/w} = 0.4$; Scheduling criteria: time-energy
$\text{cor}_{\text{task}} = 0.75; \beta_{b/w} = 0.4; \text{Scheduling criteria: energy-time}$
$\text{cor}_{\text{task}} = 0.75$; $\beta_{b/w} = 0.4$; Scheduling criteria: energy-energy

**Basic Work Ratio to the baseline**

<table>
<thead>
<tr>
<th>$\mathcal{R}$ = 0.9</th>
<th>$\mathcal{R}$ = 0.92</th>
<th>$\mathcal{R}$ = 0.94</th>
<th>$\mathcal{R}$ = 0.96</th>
<th>$\mathcal{R}$ = 0.98</th>
</tr>
</thead>
</table>

**Scheduling criteria:** energy-energy
Energy-aware strategies on heterogeneous platforms

R = 0.98
R = 0.96
R = 0.94
R = 0.92
R = 0.9

\( \text{cor}_{\text{proc}} = 0 \)
\( \text{cor}_{\text{proc}} = 0.25 \)
\( \text{cor}_{\text{proc}} = 0.5 \)
\( \text{cor}_{\text{proc}} = 0.75 \)
\( \text{cor}_{\text{proc}} = 1 \)

Basic Work
\( \text{cor}_{\text{proc}} = 0.75, \beta_{\text{wu}} = 0.4 \); Scheduling criteria: randomShuffling
\( \beta_{\text{wu}} = 0.4 \); Scheduling criteria: randomShuffling

RR n° 9324
$\text{cor}_{\text{task}} = 0.75; \, \beta_{b/w} = 0.6; \, \text{Scheduling criteria: time-time}$
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.75; \ \beta_{b/w} = 0.6; \text{Scheduling criteria: time-energy} \]
Energy-aware strategies on heterogeneous platforms

---

**Basic Work**  
Ratio to the baseline

**Mapping**  
Cor_mapping = 0.75, β_task = 0.6; Scheduling criteria: energy-time

---

RR n° 9324
$cor_{task} = 0.75; \beta_{b/w} = 0.6; $ Scheduling criteria: energy-energy
Energy-aware strategies on heterogeneous platforms

![Graph showing energy-aware strategies on heterogeneous platforms]

- Basic Work
- Mapping
- LowerBound
- deP
- deR
- inE
- random
- randomShuffling

- cos_corr = 0.75; $\beta_{uw} = 0.6$; Scheduling criteria: randomShuffling

RR n° 9324
Energy-aware strategies on heterogeneous platforms

cor\textsubscript{task} = 0.75; \beta_{b/w} = 0.8; Scheduling criteria: time-time

cor = 0.9

\begin{center}
\begin{tabular}{|c|c|c|c|c|}
\hline
Basic Work & \multicolumn{4}{|c|}{Ratio to the baseline} \\
\hline
& 0.10 & 0.15 & 0.20 & 0.25 \\
\hline
0.00 & 0.00 & 0.00 & 0.00 & 0.00 \\
0.25 & 0.25 & 0.25 & 0.25 & 0.25 \\
0.50 & 0.50 & 0.50 & 0.50 & 0.50 \\
0.75 & 0.75 & 0.75 & 0.75 & 0.75 \\
1.00 & 1.00 & 1.00 & 1.00 & 1.00 \\
1.25 & 1.25 & 1.25 & 1.25 & 1.25 \\
\hline
\end{tabular}
\end{center}

mapping: LowerBound, deP, deR, inE, random
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

$c_{\text{task}} = 0.75$; $\beta_{b/w} = 0.8$; Scheduling criteria: energy-energy

Basic Work

Ratio to the baseline

Mapper: LowerBound, deP, deR, inE, random
Energy-aware strategies on heterogeneous platforms

\[ R = 0.9, \quad \text{cor} \quad \text{task} = 0.95; \quad \beta_{\text{cor}} = 0.8; \quad \text{Scheduling criteria: randomShuffling} \]
Energy-aware strategies on heterogeneous platforms

corr_{task} = 0.75; \beta_{b/w} = 1; Scheduling criteria: time-time

Basic Work

Ratio to the baseline

Mapping: LowerBound, dP, dR, inE, random
Energy-aware strategies on heterogeneous platforms

\[ R = 0.9 \]

\[ \text{Basic Work} \]

\[ \text{Ratio to the baseline} \]

\[ \text{LowerBound} \]

\[ \text{deP} \]

\[ \text{deR} \]

\[ \text{inE} \]

\[ \text{random} \]

\[ \text{cor} \]

\[ \text{task} \]

\[ \beta_{uw} = 0.75; \beta_{uw} = 1; \] Scheduling criteria: time-energy

\[ \text{cor} = 0.75; \beta_{uw} = 1; \] Scheduling criteria: time-energy

\[ \text{cor} = 0.9; \beta_{uw} = 1; \] Scheduling criteria: time-energy

\[ \text{cor} = 0.0; \beta_{uw} = 1; \] Scheduling criteria: time-energy

\[ \text{cor} = 0.25; \beta_{uw} = 1; \] Scheduling criteria: time-energy

\[ \text{cor} = 0.5; \beta_{uw} = 1; \] Scheduling criteria: time-energy

\[ \text{cor} = 0.75; \beta_{uw} = 1; \] Scheduling criteria: time-energy

\[ \text{cor} = 1; \beta_{uw} = 1; \] Scheduling criteria: time-energy

\[ \text{IQ} \]

\[ \text{sw} \]

\[ \text{task} \]
Energy-aware strategies on heterogeneous platforms

\[ R = 0.98 \]

\[ R = 0.92 \]

\[ R = 0.90 \]

\[ R = 0.88 \]

\[ \text{cor} \text{proc} = 0 \]

\[ \text{cor} \text{proc} = 0.25 \]

\[ \text{cor} \text{proc} = 0.5 \]

\[ \text{cor} \text{proc} = 0.75 \]

\[ \text{cor} \text{proc} = 1 \]

\[ \text{mapping} = \text{Lowest} \]

\[ \text{cor} \text{task} = 0.75; \beta_\text{w} = 1; \text{Scheduling criteria: energy-time} \]

Basic Work

\[ \text{cor} \text{proc} = 0 \]

\[ \text{cor} \text{proc} = 0.25 \]

\[ \text{cor} \text{proc} = 0.5 \]

\[ \text{cor} \text{proc} = 0.75 \]

\[ \text{cor} \text{proc} = 1 \]

\[ \text{cor} \text{proc} = 0 \]

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Energy-aware strategies on heterogeneous platforms

\( cor_{\text{task}} = 0.75; \ \beta_{b/w} = 1; \ Scheduling\ criteria: \ energy-energy \)
**basicWork** and $\mathcal{R}$ (Scheduling)

The following section presents ratio of energy consumption using different scheduling strategies under small failure rate, when varying *basicWork* and $\mathcal{R}$. 
cor_{task} = 0; β_{b/w} = 0.2; Mapping criteria: inE

Basic Work

R \equiv 0.9\quad R \equiv 0.92\quad R \equiv 0.94\quad R \equiv 0.96\quad R \equiv 0.98

Ratio to the baseline

LowerBound \quad energy-energy \quad energy-time \quad time-energy \quad time-time

randomShuffling
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0; \ \beta_{\text{b/w}} = 0.2; \ \text{Mapping criteria: deR} \]
Energy-aware strategies on heterogeneous platforms

\[ cor_{\text{task}} = 0; \beta_{\text{b/w}} = 0.2; \text{Mapping criteria: deP} \]

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<tr>
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RR n° 5241

Energy-aware strategies on heterogeneous platforms

847
Energy-aware strategies on heterogeneous platforms

cor_task = 0; \beta_{b/w} = 0.4; Mapping criteria: inE

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Energy-aware strategies on heterogeneous platforms

cor_{task} = 0; \beta_{b/w} = 0.4; Mapping criteria: deR

Basic Work

Ratio to the baseline

scheduling LowerBound energy-time time-energy randomShuffling
Energy-aware strategies on heterogeneous platforms

cor_task = 0; \beta_{b/w} = 0.4; Mapping criteria: deP
Energy-aware strategies on heterogeneous platforms
\[ \text{cor}_{\text{task}} = 0; \beta_{b/w} = 0.6; \text{Mapping criteria: inE} \]

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<td>energy-time</td>
<td>time-energy</td>
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Energy-aware strategies on heterogeneous platforms
$cor_{task} = 0; \beta_{b/w} = 0.6; $ Mapping criteria: deR

Energy-aware strategies on heterogeneous platforms
energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{task}} = 1; \beta_{b/w} = 1; \text{Mapping criteria: random} \)

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Energy-aware strategies on heterogeneous platforms

\[ R = 0.9 \]

\[ cor_{pren} = 0 \]

\[ cor_{pren} = 0.25 \]

\[ cor_{pren} = 0.5 \]

\[ cor_{pren} = 0.75 \]

\[ cor_{pren} = 1 \]

Basic Work

Ratio to the baseline

scheduling

LowerBound

time-energy

time-time

energy-energy

energy-time

\[ cor_{task} = 0; \beta_{0_{uw}} = 0.6; \] Mapping criteria: deP

\[ cor_{task} = 0; \beta_{0_{uw}} = 0.6; \] Mapping criteria: deP

\[ cor_{task} = 0; \beta_{0_{uw}} = 0.6; \] Mapping criteria: deP

\[ cor_{task} = 0; \beta_{0_{uw}} = 0.6; \] Mapping criteria: deP

\[ cor_{task} = 0; \beta_{0_{uw}} = 0.6; \] Mapping criteria: deP

RR n° 9324
Energy-aware strategies on heterogeneous platforms

corr \text{task} = 0; \beta_{b/w} = 0.6; Mapping criteria: random

Basic Work Ratio to the baseline

R = 0.9

R = 0.92

R = 0.94

R = 0.96

R = 0.98

\text{scheduling}
Energy-aware strategies on heterogeneous platforms

\[ R = 0.9 \]

\[ \text{Basic Work} \]

Ratio to the baseline

- LowerBound
- energy-energy
- energy-time
- time-energy
- randomShuffling

\[ \text{Mapping criteria: inE} \]

\[ \text{cor}_{\text{task}} = 0; \beta_{\text{bw}} = 0.8; \]
Energy-aware strategies on heterogeneous platforms

\[ R = 0.9 \]

\[ R = 0.92 \]

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\[ R = 0.96 \]

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\[ \text{cor}_{\text{task}} = 0; \; \beta_{b/w} = 0.8; \; \text{Mapping criteria: deR} \]

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</table>

\[ \text{scheduling} \]

\[ \text{cor}_{\text{proc}} = 0.25; \; \text{cor}_{\text{proc}} = 0.5; \; \text{cor}_{\text{proc}} = 0.75; \; \text{cor}_{\text{proc}} = 1.0 \]

\[ \text{LowerBound} \]

\[ \text{energy-time} \]

\[ \text{time-energy} \]

\[ \text{randomShuffling} \]
cor_{task} = 0; \beta_{b/w} = 0.8; Mapping criteria: deP

<table>
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Energy-aware strategies on heterogeneous platforms
$c_{\text{task}} = 0; \beta_{b/w} = 0.8; $ Mapping criteria: random

$\mathcal{R} = 0.9; \mathcal{R} = 0.92; \mathcal{R} = 0.94; \mathcal{R} = 0.96; \mathcal{R} = 0.98$

Basic Work

Ratio to the baseline

Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

\[ R = 0.9 \]

\[ R = 0.92 \]

\[ R = 0.94 \]

\[ R = 0.96 \]

\[ R = 0.98 \]

\( cor_{task} = 0; \beta_{b/w} = 1; \) Mapping criteria: inE

### Schedule

<table>
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<th>energy-time</th>
<th>time-energy</th>
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### Correlation

- Task: 0
- Between: 1

### Mapping Criteria

- inE
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0; \beta_{b/w} = 1; \text{Mapping criteria: deR} \]

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<th>( K )</th>
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**Basic Work**

- LowerBound
- energy-energy
- time-energy
- randomShuffling

**Graphs**

- Energy vs. Work
- Time vs. Work
$c_{\text{task}} = 0; \beta_{b/w} = 1; \text{Mapping criteria: deP}$
Energy-aware strategies on heterogeneous platforms

$R = 0.9$; $\beta_{b/w} = 1$; Mapping criteria: random

Ratio to the baseline

Basic Work
energy-aware strategies on heterogeneous platforms

\( \text{corr}_{\text{task}} = 0.25; \ \beta_{b/w} = 0.2; \ \text{Mapping criteria: inE} \)
$cor_{task} = 0.25$; $\beta_{b/w} = 0.2$; Mapping criteria: deR
Energy-aware strategies on heterogeneous platforms
$\text{Cor}_{\text{task}} = 0.25$; $\beta_{b/w} = 0.2$; Mapping criteria: random
Energy-aware strategies on heterogeneous platforms

cor_{task} = 0.25; \beta_{b/w} = 0.4; Mapping criteria: inE
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.25; \beta_{b/w} = 0.4; \text{Mapping criteria: deR} \]

\[ R = 0.9, R = 0.92, R = 0.94, R = 0.96, R = 0.98 \]

Ratio to the baseline

Basic Work

scheduling LowerBound energy-time time-energy energy-energy randomShuffling
$\text{cor}_{\text{task}} = 0.25; \beta_{b/w} = 0.4; \text{Mapping criteria: deP}$
Energy-aware strategies on heterogeneous platforms

cor_{\text{task}} = 0.25; \beta_{b/w} = 0.4; \text{Mapping criteria: random}

<table>
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<th>$K$</th>
<th>$\text{Ratio to the baseline}$</th>
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<tr>
<td>0.9</td>
<td><img src="image" alt="Graph" /></td>
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<tr>
<td>0.92</td>
<td><img src="image" alt="Graph" /></td>
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<tr>
<td>0.94</td>
<td><img src="image" alt="Graph" /></td>
</tr>
<tr>
<td>0.96</td>
<td><img src="image" alt="Graph" /></td>
</tr>
<tr>
<td>0.98</td>
<td><img src="image" alt="Graph" /></td>
</tr>
</tbody>
</table>
\( \text{corr}_{\text{task}} = 0.25; \ \beta_{b/w} = 0.6; \ \text{Mapping criteria: inE} \)

<table>
<thead>
<tr>
<th>N</th>
<th>Basic Work Ratio to the baseline</th>
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<tbody>
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<td>0.9</td>
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<td>0.96</td>
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<tr>
<td>0.98</td>
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</tbody>
</table>

- LowerBound
- energy-energy
- time-time
- energy-energy
- time-energy
- randomShuffling

Energy-aware strategies on heterogeneous platforms
$\text{cor}_{\text{task}} = 0.25$; $\beta_{b/w} = 0.6$; Mapping criteria: deR

<table>
<thead>
<tr>
<th>$\mathcal{N}$</th>
<th>$\text{Ratio to the baseline}$</th>
</tr>
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<tbody>
<tr>
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<tr>
<td>0.92</td>
<td></td>
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<tr>
<td>0.94</td>
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<tr>
<td>0.96</td>
<td></td>
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<tr>
<td>0.98</td>
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</table>

Basic Work

Ratio to the baseline

Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

c_{\text{task}} = 0.25; \beta_{b/w} = 0.6; Mapping criteria: deP

\begin{tabular}{|c|c|c|c|c|}
\hline
\textbf{Ratio to the baseline} & \textbf{LowerBound} & \textbf{energy-time} & \textbf{time-energy} & \textbf{randomShuffling} \\
\hline
\end{tabular}

\begin{tabular}{|c|c|c|c|c|}
\hline
\textbf{Basic Work} & 0.10 & 0.15 & 0.20 & 0.25 \\
\hline
\end{tabular}
Energy-aware strategies on heterogeneous platforms

\[ R = 0.9 \]

\[ \text{cor}_{\text{proc}} = 0 \]

\[ \text{cor}_{\text{proc}} = 0.25 \]

\[ \text{cor}_{\text{proc}} = 0.5 \]

\[ \text{cor}_{\text{proc}} = 0.75 \]

\[ \text{cor}_{\text{proc}} = 1 \]

Basic Work

Ratio to the baseline

scheduling

lowerBound

time-energy

time-time

randomShuffling

\[ \text{cor}_{\text{task}} = 0.25, \beta_{\text{bw}} = 0.6 \]

Mapping criteria: random

\[ R = 0.92 \]

\[ R = 0.9 \]

\[ R = 0.96 \]

\[ R = 0.98 \]

rr n° 9324
Energy-aware strategies on heterogeneous platforms

cor_{task} = 0.25; \beta_{b/w} = 0.8; Mapping criteria: inE

Basic Work

Ratio to the baseline

0.00 0.25 0.50 0.75 1.00 1.25

LowerBound  energy-energy  energy-time  time-energy  time-time  randomShuffling

0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50 0.55 0.60 0.65 0.70 0.75 0.80 0.85 0.90 0.95 1.00

R = 0.9  R = 0.92  R = 0.94  R = 0.96  R = 0.98

Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.25; \ \beta_{b/w} = 0.8; \text{Mapping criteria: deR} \]
Energy-aware strategies on heterogeneous platforms
cor_{task} = 0.25; \beta_{b/w} = 0.8; Mapping criteria: random
Energy-aware strategies on heterogeneous platforms

\[ R = 0.9, R = 0.92, R = 0.94, R = 0.96 \]

\[ \text{R} = 0.10, \text{R} = 0.15, \text{R} = 0.20, \text{R} = 0.25, \text{R} = 0.30 \]

cor proc = 0, cor proc = 0.25, cor proc = 0.5, cor proc = 0.75, cor proc = 1

Basic Work

Ratio to the baseline

scheduling

LowerBound

energy-energy

time-energy
time-time

\[ \text{Mapping criteria:} \ inE \]

RR n° 9324
Energy-aware strategies on heterogeneous platforms

c_{\text{task}} = 0.25; \beta_{b/w} = 1; \text{Mapping criteria: deR}
$c_{ortask} = 0.25$; $\beta_{b/w} = 1$; Mapping criteria: deP

<table>
<thead>
<tr>
<th>$N$</th>
<th>$R = 0.9$</th>
<th>$R = 0.92$</th>
<th>$R = 0.94$</th>
<th>$R = 0.96$</th>
<th>$N = 0.98$</th>
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<tbody>
<tr>
<td>Basic Work</td>
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<td>0.15</td>
<td>0.20</td>
<td>0.25</td>
<td>0.30</td>
</tr>
</tbody>
</table>

**Mapping criteria:** deP
Energy-aware strategies on heterogeneous platforms

cor_{task} = 0.25; \beta_{b/w} = 1; Mapping criteria: random

[Graph showing comparisons between different ratios to the baseline for various values of K and scheduling criteria.]
Energy-aware strategies on heterogeneous platforms

cor$_{task} = 0.5$; $\beta_{b/w} = 0.2$; Mapping criteria: inE
$\text{cor}_{\text{task}} = 0.5; \beta_{\text{bw}} = 0.2$; Mapping criteria: deR

Energy-aware strategies on heterogeneous platforms

### Basic Work

<table>
<thead>
<tr>
<th>$R$</th>
<th>0.9</th>
<th>0.92</th>
<th>0.94</th>
<th>0.96</th>
<th>0.98</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{Ratio to the baseline}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

### Scheduling

- LowerBound
- energy-time
- time-energy
- randomShuffling
$cor_{task} = 0.5; \beta_{b/w} = 0.2$; Mapping criteria: deP
\( \text{cor}_{\text{task}} = 0.5; \beta_{b/w} = 0.2 \); Mapping criteria: random
$\text{cor}_{\text{task}} = 0.5; \beta_{\text{bw}} = 0.4$; Mapping criteria: inE
Energy-aware strategies on heterogeneous platforms

Basic Work
Ratio to the baseline

scheduling | energy-time | energy-energy | time-energy | time-time | randomShuffling

cor_{prev} = 0 | cor_{prev} = 0.25 | cor_{prev} = 0.5 | cor_{prev} = 0.75 | cor_{prev} = 1

R = 0.98

R = 0.96

R = 0.94

R = 0.92

R = 0.9

\( \text{cor}_{\text{task}} = 0.5, \beta_{\text{w}} = 0.4 \), Mapping criteria: deR

RR n° 9324
Energy-aware strategies on heterogeneous platforms

\( c_{\text{task}} = 0.5; \beta_{\text{b/f}} = 0.4; \) Mapping criteria: deP

Basic Work

Ratio to the baseline

1.00

0.75

0.50

0.25

0.00

0.10

0.15

0.20

0.25

0.30

0.00

0.25

0.50

0.75

1.00

1.25

\( R = 0.9 \)

\( R = 0.92 \)

\( R = 0.94 \)

\( R = 0.96 \)

\( R = 0.98 \)
$\text{cor}_{\text{task}} = 0.5; \beta_{j,w} = 0.4$; Mapping criteria: random

Basic Work: Ratio to the baseline

scheduling: LowerBound, energy-time, time-energy, randomShuffling
Energy-aware strategies on heterogeneous platforms

cor_{task} = 0.5; \beta_{j,w} = 0.6; Mapping criteria: inE

Basic Work

Ratio to the baseline

$cor_{task} = 0.5; \beta_{j,w} = 0.6$; Mapping criteria: inE

scheduling

LowerBound

energy-time

time-energy

energy-energy

time-time

randomShuffling

RR n. 924
\( \text{cor}_{\text{task}} = 0.5; \beta_{b/w} = 0.6; \) Mapping criteria: deR

Energy-aware strategies on heterogeneous platforms
$\text{cor}_{\text{task}} = 0.5$; $\beta_{b/w} = 0.6$; Mapping criteria: deP

Ratio to the baseline

Basic Work

Energy-aware strategies on heterogeneous platforms

scheduling

LowerBound, energy-time, time-energy, randomShuffling
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.5; \beta_{\text{b/w}} = 0.6; \text{Mapping criteria: random} \]

![Graph showing energy-time, time-energy, and energy-energy trade-offs](image)

- LowerBound
- energy-time
- time-energy
- randomShuffling

Basic Work
Ratio to the baseline

<table>
<thead>
<tr>
<th>K = 0.9</th>
<th>K = 0.92</th>
<th>K = 0.94</th>
<th>K = 0.96</th>
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<td>0.20</td>
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</tbody>
</table>
Energy-aware strategies on heterogeneous platforms

\[ R = 0.9 \]

Correlation: in \( E \)

Correlation: between \( n \) to \( 0.8 \), Mapping criteria: in \( E \)

Basic Work

Ratio to the baseline

scheduling

LowerBound

energy-energy

energy-time

time-energy

time-time

randomShuffling

RR n° 9324
Energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{task}} = 0.5; \; \beta_{b/w} = 0.8; \) Mapping criteria: deR

<table>
<thead>
<tr>
<th>( K )</th>
<th>( R )</th>
<th>LowerBound</th>
<th>energy-energy</th>
<th>energy-time</th>
<th>time-energy</th>
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</tr>
</tbody>
</table>

Basic Work

Ratio to the baseline

scheduling

LowerBound energy-energy energy-time time-energy randomShuffling
Energy-aware strategies on heterogeneous platforms

\( \text{corr}_\text{task} = 0.5; \beta_{bw} = 0.8; \) Mapping criteria: deP

Basic Work

Ratio to the baseline

\( R \) = 0.9, 0.92, 0.94, 0.96, 0.98

\( \text{LowerBound} \) energy-energy, energy-time, time-energy, randomShuffling

Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

$c_{\text{cor} \cdot \text{task}} = 0.5; \beta_{\text{b/w}} = 0.8; \text{Mapping criteria: random}$
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.5; \beta_{b/w} = 1; \text{Mapping criteria: } \text{inE} \]

<table>
<thead>
<tr>
<th>( R = 0.9 )</th>
<th>( R = 0.92 )</th>
<th>( R = 0.94 )</th>
<th>( R = 0.96 )</th>
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Basic Work

Ratio to the baseline

<table>
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Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

c_{\text{task}} = 0.5; \beta_{b/w} = 1; Mapping criteria: deR

<table>
<thead>
<tr>
<th>$R$</th>
<th>LowerBound</th>
<th>energy-energy</th>
<th>energy-time</th>
<th>time-energy</th>
<th>time-time</th>
<th>randomShuffling</th>
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</tbody>
</table>
Energy-aware strategies on heterogeneous platforms

\( cor_{\text{task}} = 0.5; \beta_{b/w} = 1; \) Mapping criteria: deP

Basic Work

Ratio to the baseline

\( \frac{\text{energy}}{\text{time}} \)

\( \frac{\text{time}}{\text{energy}} \)

\( \frac{\text{time}}{\text{time}} \)

\( \frac{\text{random Shuffling}}{\text{random Shuffling}} \)

\( \frac{\text{Lower Bound}}{\text{Lower Bound}} \)

\( \frac{\text{energy-energy}}{\text{energy-energy}} \)

\( \frac{\text{time-energy}}{\text{time-energy}} \)

\( \frac{\text{random Shuffling}}{\text{random Shuffling}} \)
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.5; \beta_{\text{b/w}} = 1; \] Mapping criteria: random

<table>
<thead>
<tr>
<th>( \mathcal{R} )</th>
<th>( \mathcal{R} = 0.9 )</th>
<th>( \mathcal{R} = 0.92 )</th>
<th>( \mathcal{R} = 0.94 )</th>
<th>( \mathcal{R} = 0.96 )</th>
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<td>Ratio to the baseline</td>
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<tr>
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</tbody>
</table>

**LEGEND**
- LowerBound
- energy-energy
- time-time
- energy-time
- randomShuffling
$corr_{task} = 0.75; \beta_{b/w} = 0.2$; Mapping criteria: inE
cor_{\text{task}} = 0.75; \beta_{b/w} = 0.2; \text{Mapping criteria: deR}
$\text{cor}_{\text{task}} = 0.75$; $\beta_{b/w} = 0.2$; Mapping criteria: deP
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

cor\text{task} = 0.75; \beta_{b/w} = 0.4; Mapping criteria: inE

scheduling LowerBound energy-time time-energy randomShuffling
Energy-aware strategies on heterogeneous platforms

cor\_task = 0.75; \beta_{b/w} = 0.4; Mapping criteria: deR
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.75; \quad \beta_{b/w} = 0.4; \quad \text{Mapping criteria: deP} \]

<table>
<thead>
<tr>
<th>( R )</th>
<th>0.9</th>
<th>0.92</th>
<th>0.94</th>
<th>0.96</th>
<th>0.98</th>
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<td>1.25</td>
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</table>

![Graph](image-url)
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.75; \beta_{b/w} = 0.4; \text{Mapping criteria: random} \]

\[ R = 0.9 \]

\[ R = 0.92 \]

\[ R = 0.94 \]

\[ R = 0.96 \]

\[ R = 0.98 \]
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.75; \ \beta_{b/w} = 0.6; \text{Mapping criteria: inE} \]

Basic Work

Ratio to the baseline

\begin{align*}
\text{Energy-energy} & \quad \text{Energy-time} & \quad \text{Time-energy} & \quad \text{Time-time} & \quad \text{randomShuffling}
\end{align*}

LowerBound

energy-energy

energy-time

time-energy

randomShuffling
$cor_{task} = 0.75$; $\beta_{b/w} = 0.6$; Mapping criteria: deR
Energy-aware strategies on heterogeneous platforms

corr_{task} = 0.75; \ \beta_{bw} = 0.6; \ \text{Mapping criteria: deP}

Basic Work

Ratio to the baseline

scheduling

LowerBound  energy-time  time-energy  randomShuffling
Energy-aware strategies on heterogeneous platforms

\[ R = 0.9; \ \beta = 0.6; \text{Mapping criteria: random} \]
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

cor\text{task} = 0.75; \beta_{b/w} = 0.8; \text{Mapping criteria: deR}
Energy-aware strategies on heterogeneous platforms

\[ R = 0.98 \]

\[ R = 0.96 \]

\[ R = 0.94 \]

\[ R = 0.92 \]

\[ \text{cor}_{\text{proc}} = 0 \]

\[ \text{cor}_{\text{proc}} = 0.25 \]

\[ \text{cor}_{\text{proc}} = 0.5 \]

\[ \text{cor}_{\text{proc}} = 0.75 \]

\[ \text{cor}_{\text{proc}} = 1 \]

Basic Work

ratio to the baseline

scheduling

energy-time

time-energy

randomShuffling

Mapping criteria: deP

\[ \text{cor}_{\text{task}} = 0.75, \beta_{\text{uw}} = 0.8 \]
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.75; \ \beta_{b/w} = 0.8; \text{Mapping criteria: random} \]
Energy-aware strategies on heterogeneous platforms

\[ \text{Time} = 0.75; \ \beta_{b/w} = 1; \ \text{Mapping criteria: inE} \]

\[ R = 0.9 \]

\[ R = 0.92 \]

\[ R = 0.94 \]

\[ R = 0.96 \]

\[ R = 0.98 \]
Energy-aware strategies on heterogeneous platforms

c_{\text{task}} = 0.75; \beta_{b/w} = 1; \text{Mapping criteria: deR}

Basic Work

Ratio to the baseline
Energy-aware strategies on heterogeneous platforms

- Basic Work
  - Ratio to the baseline

\( \text{cor}_{\text{task}} = 0.75; \ \beta_{\text{b/w}} = 1; \ \text{Mapping criteria: deP} \)

<table>
<thead>
<tr>
<th>Ratio to the baseline</th>
<th>Basic Work</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.10</td>
<td>0.15</td>
</tr>
<tr>
<td>0.15</td>
<td>0.20</td>
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<tr>
<td>0.30</td>
<td>0.35</td>
</tr>
</tbody>
</table>

- LowerBound
- energy-energy
- time-energy
- randomShuffling
$c_{\text{task}} = 0.75$; $\beta_{\text{b/w}} = 1$; Mapping criteria: random
\[ r = 0.9, 0.92, 0.94, 0.96, 0.98 \]  
\[ cor_{task} = 1; \beta_{b/w} = 0.2; \text{Mapping criteria: inE} \]  

<table>
<thead>
<tr>
<th>R</th>
<th>CorrProc</th>
<th>Basic Work</th>
<th>Ratio to the baseline</th>
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<tr>
<td>0.9</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
</tr>
<tr>
<td>0.92</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
</tr>
<tr>
<td>0.94</td>
<td>0.20</td>
<td>0.20</td>
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<tr>
<td>0.96</td>
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<tr>
<td>0.98</td>
<td>0.30</td>
<td>0.30</td>
<td>0.30</td>
</tr>
</tbody>
</table>

Energy-aware strategies on heterogeneous platforms
$core_{task} = 1$; $\beta_{b/w} = 0.2$; Mapping criteria: deR

Basic Work

Ratio to the baseline

Energy-aware strategies on heterogeneous platforms
$\text{cor}_{\text{task}} = 1$; $\beta_{b/w} = 0.2$; Mapping criteria: deP
Energy-aware strategies on heterogeneous platforms

\( cor_{task} = 1; \beta_{b/w} = 0.2; \) Mapping criteria: random
Energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{task}} = 1; \; \beta_{b/w} = 0.4; \; \text{Mapping criteria: inE} \)

<table>
<thead>
<tr>
<th>R</th>
<th>Basic Work Ratio to the baseline</th>
<th>LowerBound</th>
<th>energy-energy</th>
<th>time-energy</th>
<th>randomShuffling</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>0.92</td>
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<td>0.98</td>
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</tr>
</tbody>
</table>

RR n° 9231
Energy-aware strategies on heterogeneous platforms

cor\textsubscript{task} = 1; \beta_{b/w} = 0.4; Mapping criteria: deR

Ratio to the baseline

Basic Work

scheduling

LowerBound

time-time

time-energy

randomShuffling

energy-energy

cor\textsubscript{proc} = 0

cor\textsubscript{proc} = 0.25

cor\textsubscript{proc} = 0.5

cor\textsubscript{proc} = 0.75

cor\textsubscript{proc} = 1
where $\text{RR n} = \sum_{i=1}^{n} \frac{\text{energy(i)}}{\text{time(i)}}$.

Energy-aware strategies on heterogeneous platforms

$sampling = 1$; $\beta_{b/w} = 0.4$; Mapping criteria: deP

Ratio to the baseline

Basic Work
$\text{cor}_{\text{task}} = 1$; $\beta_{b/w} = 0.4$; Mapping criteria: random
$cor_{task} = 1; \beta_{b/w} = 0.6; \text{Mapping criteria: inE}$

<table>
<thead>
<tr>
<th>$R$</th>
<th>0.9</th>
<th>0.92</th>
<th>0.94</th>
<th>0.96</th>
<th>0.98</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R$</td>
<td>0.10</td>
<td>0.15</td>
<td>0.20</td>
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</tr>
<tr>
<td>$R$</td>
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<td>0.25</td>
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<tr>
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<td>0.15</td>
<td>0.20</td>
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<td>0.25</td>
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</tr>
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<td>0.15</td>
<td>0.20</td>
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<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
<td>1.00</td>
</tr>
</tbody>
</table>

**Graphical Representation:**

- **Legend:**
  - LowerBound
  - energy-time
  - time-energy
  - randomShuffling

**Labeling:**

- Basic Work
- Ratio to the baseline
- $R = \gamma w$
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 1; \ \beta_{b/w} = 0.6; \ \text{Mapping criteria: deR} \]
Energy-aware strategies on heterogeneous platforms

cor_task = 1; \beta_{b/w} = 0.6; Mapping criteria: deP

Basic Work

Ratio to the baseline

1.25
1.00
0.75
0.50
0.25
0.00

0.10 0.15 0.20 0.25 0.30 0.10 0.15 0.20 0.25 0.30 0.10 0.15 0.20 0.25 0.30
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

cor\textsubscript{task} = 1; \beta \textsubscript{b/w} = 0.8; Mapping criteria: inE
$cor_{task} = 1$; $\beta_{b/w} = 0.8$; Mapping criteria: deR
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 1; \ \beta_{b/w} = 0.8; \text{ Mapping criteria: deP} \]

<table>
<thead>
<tr>
<th>( R )</th>
<th>0.9</th>
<th>0.92</th>
<th>0.94</th>
<th>0.96</th>
<th>0.98</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>( \text{Ratio to the baseline} )</th>
<th>1.25</th>
<th>1.25</th>
<th>1.25</th>
<th>1.25</th>
<th>1.25</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>( \text{Basic Work} )</th>
<th>0.10</th>
<th>0.15</th>
<th>0.20</th>
<th>0.25</th>
<th>0.30</th>
</tr>
</thead>
</table>

- LowerBound
- energy-energy
- time-energy
- randomShuffling

RR n° 9234
Energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{task}} = 1 \); \( \beta_{b/w} = 0.8 \); Mapping criteria: random

\[ R = 0.9 \quad R = 0.92 \quad R = 0.94 \quad R = 0.96 \quad R = 0.98 \]

**Basic Work**
- Ratio to the baseline
- **Scheduling**: LowerBound, energy-energy, time-time, energy-time, randomShuffling

\( \text{cor}_{\text{proc}} = 0.25 \); \( \text{cor}_{\text{proc}} = 0.5 \); \( \text{cor}_{\text{proc}} = 0.75 \)
Energy-aware strategies on heterogeneous platforms

\[ R = 0.9 \]

\[ R = 0.92 \]

\[ R = 0.94 \]

\[ R = 0.96 \]

\[ R = 0.98 \]

\[ \text{mapping criteria: inE} \]

\[ \text{cor task} = 1; \beta_{b/w} = 1 \]

Basic Work

Ratio to the baseline
$\text{cor}_{\text{task}} = 1; \ \beta_{b/w} = 1; \ \text{Mapping criteria: deR}$

$R = 0.9$  

$R = 0.92$  

$R = 0.94$  

$R = 0.96$  

$R = 0.98$

**Ratio to the baseline**

- $\text{LowerBound}$
- $\text{energy-energy}$
- $\text{time-energy}$
- $\text{time-time}$

**Basic Work**

<table>
<thead>
<tr>
<th>$0.10$</th>
<th>$0.15$</th>
<th>$0.20$</th>
<th>$0.25$</th>
<th>$0.30$</th>
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<td>$1.00$</td>
</tr>
</tbody>
</table>

**Energy-aware strategies on heterogeneous platforms**
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 1; \beta_{b/w} = 1; \text{Mapping criteria: deP} \]