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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-réal, 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-aware strategies on heterogeneous platforms

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
$u_{i,k} = \frac{c_{i,k}}{p}$. 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

$$P(m_k) = P_{k,s} + gP_{k,d}$$  \hspace{1cm} (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:

$$E_d(\tau_i, m_k) = P_{k,d} \times c_{i,k}$$  \hspace{1cm} (2)

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

$$E_s = \sum_{k \in \text{Used}} P_{k,s} \times p$$  \hspace{1cm} (3)

where $\text{Used}$ 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 $\text{alloc}(i)$ denote the index set of the processors executing a replica of $\tau_i$. The mapping achieves the following reliability $R(\tau_i)$ for task $\tau_i$:

$$R(\tau_i) = 1 - \prod_{k \in \text{alloc}(i)} (1 - R(\tau_i, m_k))$$  \hspace{1cm} (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** (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 \( E \) and \( R \) be two constants. The MinEnergyMaxReliability decision problem is: is it possible to schedule the tasks on the processors so that: (i) the total energy consumed does not exceed \( E \); and (ii) the probability that all tasks succeed is at least \( R \)?

**Lemma 1.** Problem MinEnergyMaxReliability is NP-complete.

*Proof.* We prove this result by a reduction from the 2-partition problem [4]. Let \( I_1 \) be an instance of 2-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

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

From \( I_1 \) we build an instance \( I_2 \) of 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 \( E = \frac{1}{2}(S + 1) \) and \( R = e^{-\frac{1}{2}(S+1)} = e^{-E} \).

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

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

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

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

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

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

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

Taking logarithms, we obtain:

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

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

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

\[
= -S + A \left(1 - \frac{1}{S}\right) = -S + A \frac{S - 1}{S}
\]
Now let us assume that $I_2$ has a solution:

\[
\begin{cases}
  E \leq \mathcal{E} \\
  R \geq \mathcal{R}
\end{cases} \iff
\begin{cases}
  E \leq \mathcal{E} \\
  \ln(R) \geq \ln(\mathcal{R})
\end{cases} \iff
\begin{cases}
  A \frac{S-1}{S} + 1 \leq \frac{1}{2}(S+1) \\
  -S + A \frac{S-1}{S} \geq -\frac{1}{2}(S+1)
\end{cases} \iff
\begin{cases}
  A \frac{S-1}{S} \leq \frac{1}{2}(S-1) \\
  A \frac{S-1}{S} \geq \frac{1}{2}(S-1)
\end{cases} \iff
\begin{cases}
  A \leq \frac{S}{2} \\
  A \geq \frac{S}{2}
\end{cases}
\]

Therefore, $I_2$ has a solution if and only if $I_1$ has a solution. \(\square\)

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:

- $deW$ (in$W$): decreasing (increasing) average work size $\bar{c}_i = \frac{c_{i,1} + c_{i,2} + \cdots + c_{i,M}}{M}$;
- $deMinW$ (in$MinW$): decreasing (increasing) minimum work size $\bar{c}_i = \min_{1 \leq k \leq M} c_{i,k}$;
- $deMaxW$ (in$MaxW$): 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>0.95</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 \( R_i \) is reached. The algorithm uses the probability of failure \( PoF = 1 - R(\tau_i) = \prod_{k \in alloc(i)} (1 - R(\tau_i,m_k)) \) (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

1. order all the tasks with TaskMapCriteria and renumber them $\tau_1, \ldots, \tau_N$
2. /* initialize the utilization of all processors to zero */
3. $u \leftarrow [0, \ldots, 0]$
4. /* iterate through the ordered list of tasks */
5. for $i \in [1, \ldots, N]$ do
6. /* order processors for each task */
7. order all processors for task $\tau_i$ with ProcMapCriteria and renumber them $proc_1, \ldots, proc_M$
8. /* this ordered list may differ from task to task */
9. $k = 1$
10. $PoF = 1$
11. while $1 - PoF < R_i$ do
12.     $temp = u_k + u_{i,k}$
13.     if $temp \leq 1$ then
14.         $u_k = temp$
15.         $PoF = PoF \times (1 - R(\tau_i, m_k))$
16.         add one replica of $\tau_i$ on $proc_k$
17.         $k++$
18.     if $k > m$ then
19.         return not feasible
20. 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 me 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 SECONDARY_SCHED_CRITERIA for choosing secondary replicas:

- **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;
- **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 (*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).

**Algorithm 2: Scheduling**

```
Input: An allocation $\sigma_m$ of all replicas on the processors
Output: An order of execution on each processor
1 begin
2   order all the tasks with TASK_SCHED_CRITERIA and renumber them $\tau_1, \ldots, \tau_N$
3     /* insert the primary replica for each task at the beginning of each processor schedule */
4   for $i \in [1, \ldots, N]$ do
5       if PRIMARY_SCHED_CRITERIA is "time" then
6           schedule the primary replica of task $\tau_i$ that could finish at the earliest
7       else if PRIMARY_SCHED_CRITERIA is "energy" then
8           schedule the primary replica of task $\tau_i$ that consumes the minimum energy
9     /* insert the secondaries backwards from the end of each processor schedule */
10    reverse the task ordering
11   while there is still at least one replica to be scheduled do
12       for $i \in [1, \ldots, N]$ do
13          if there is still a replica of $\tau_i$ to be scheduled then
14             if SECONDARY_SCHED_CRITERIA is "time" then
15                 schedule the secondary replica of task $\tau_i$ that could start the latest
16             else if SECONDARY_SCHED_CRITERIA is "energy" then
17                 schedule the secondary replica of task $\tau_i$ that consumes the maximum energy
```
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 $E(\{w_{i,k}\})$.

In addition, we also compute a lower bound $LB(\{w_{i,k}\})$ 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

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

$$+ (1 - e^{-\lambda_3 w_{i,3}})(1 - e^{-\lambda_4 w_{i,4}})P_{1,d}w_{i,1}.$$
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 $\mathcal{S}$. 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 $\mathcal{S}$, the computation of the expected energy for a given ordering in a subset $T$ of $\mathcal{S}$ 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 ($cor_{\text{task}}$) and between the different processors ($cor_{\text{proc}}$). These two parameters vary between 0 and 1.\footnote{We ignored the case when $cor_{\text{task}} = 0$ and $cor_{\text{proc}} = 1$ 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 ($cor_{\text{proc}} = 1$). The number of replicas needed to meet its reliability goal will exceed the number of available processors.} For example, $cor_{\text{task}} = 0$ (resp. $cor_{\text{proc}} = 0$) means that the WCET values between different tasks on one processor (resp. between different processors for one task) are completely randomly generated. Inversely, $cor_{\text{task}} = 1$ (resp. $cor_{\text{proc}} = 1$) 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 $basic\text{Work}$ as the
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estimated total utilization of the system with a single replica per task, in order to study the impact of system pressure:

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

(5)

In Equation (5), we use the average WCETs on the \( M \) processors \( \left( \sum_{k} c_{i,k} \right) \) to estimate the execution time of task \( \tau_i \). We have \( M \) processors available during period \( p \), hence \( \text{basicWork} \) represent an estimate of the fraction of time processors are used if each task has a single replica. In the experiments, we vary \( \text{basicWork} \) 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
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>0.5629</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 $\hat{\beta}_{b/w} = 1$, $\text{basicWork} = 0.3$, $R_i = 0.95$ 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 $\text{cor}_{\text{task}}$ and $\text{cor}_{\text{proc}}$, 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 $\hat{\beta}_{b/w}$, $\text{basicWork}$, $R_i$, $\text{cor}_{\text{task}}$ and $\text{cor}_{\text{proc}}$ 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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Figure 1: Ratio of energy consumption using different mapping and scheduling strategies under small failure rate, when varying $cor_{\text{proc}}$, with $\text{basicWork} = 0.3$, $\beta_{b/w} = 1$, $R_i = 0.98$ and $cor_{\text{task}} = 0.5$.

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 $cor_{\text{proc}} = 0$, and the result is close to the lower bound. But we can observe that this percentage increases with $cor_{\text{proc}}$.

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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(a) Comparing mapping strategies when using \textit{time-time} as scheduling strategy

(b) Comparing scheduling strategies when using \textit{deP} as mapping strategy

Figure 2: Ratio of energy consumption using different mapping and scheduling strategies under big failure rate, when varying \textit{cor}_{\text{proc}}, with basicWork = 0.3, \beta_{b/w} = 1, \mathcal{R}_i = 0.95 and \textit{cor}_{\text{task}} = 0.5.

perform similarly and have a performance close to that of the lower bound, except when \textit{cor}_{\text{proc}} \approx 1. In the big failure rate case (Figure 2a), we see that, when \textit{cor}_{\text{proc}} is not equal to 1, \textit{inE} performs better than \textit{deR}. But when \textit{cor}_{\text{proc}} increases to 1, the performance of \textit{deR} catches up. And in all cases, \textit{deP} performs better than, or similarly to the best strategy between \textit{deR} and \textit{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 \textit{cor}_{\text{proc}} \neq 1, we have energy criteria for primary replica choosing slightly better than \textit{time}, and when \textit{cor}_{\text{proc}} = 1, the energy becomes worse than the \textit{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 \textit{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 \textit{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 \textit{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 \textit{time} criteria.
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(a) Comparing mapping strategies when using \textit{time-time} as scheduling strategy

(b) Comparing scheduling strategies when using \textit{deP} as mapping strategy

Figure 3: Ratio of energy consumption using different mapping and scheduling strategies under small failure rate when varying $\beta_{b/w}$, with \textit{basic Work} = 0.3, $R_i = 0.98$ and $cor_{task} = 0.5$.

(a) Comparing mapping strategies when using \textit{time-time} as scheduling strategy

(b) Comparing scheduling strategies when using \textit{deP} as mapping strategy

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

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(a) Comparing mapping strategies when using \( \text{time-time} \) as scheduling strategy

(b) Comparing scheduling strategies when using \( \text{deP} \) as mapping strategy

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

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.
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1.10 1.80 2.40 20.10 20.30 20.70 1.60 3.00 4.50 20.00 20.80 22.80
1.00 1.70 2.50 21.40 25.00 28.80 1.70 3.40 5.20 24.80 33.70 40.50
R = 0.8 R = 0.95
0.50 0.15 0.20 0.25 0.30 0.10 0.15 0.20 0.25 0.30 0.00 0.25 0.50 0.75 1.00 1.25
0.00 0.25 0.50 0.75 1.00 1.25
Basic Work
Ratio to the baseline
mapping LowerBound deP deR inE random
LowerBound energy-energy energy-time time-energy time-time randomShuffling
Figure 6: Ratio of energy consumption using different mapping and scheduling strategies when varying basicWork and R, under big failure rate, with βb/w = 1 and cor_task = 0.5.

6.2.4 Utilization and reliability threshold

From Figures 5 and 6, we observe the performance of different mapping and scheduling criteria when varying basicWork and R_i. We remark that the results are similar under big and small failure rates when we have corProc not close to 1. For example, we can see the case corProc = 0.5 in the first row of Figures 5 and 6. During the mapping phase, deR has a slightly worse performance than inE and 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 corProc ≈ 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 deR is worse than inE and deP and has a performance similar to the random case, while inE and 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 basicWork and 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 basicWork and R_i, deR performs worse, but when basicWork and R_i increase, deR becomes similar to inE, or even better. deP has always better or similar performance than deR and 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

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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 cor$_{\text{proc}}$ ≈ 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 cor$_{\text{proc}}$ ≈ 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


\( \beta_{b/w} \) (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

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 = 0.95

cor_{proc} = 0

cor_{proc} = 0.25

cor_{proc} = 0.5

cor_{proc} = 0.75

cor_{proc} = 1

Ratio to the baseline

Energy-Time

Energy-Energy

Time-Time

Random shuffling

mapping

LowerBound
deP
deR
inE
random

RR n 9324
Energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{task}} = 0.25; \text{basicWork} = 0.2; \mathcal{R} = 0.8 \)

\[ \text{mapping} \quad \text{LowerBound} \quad \text{deP} \quad \text{deR} \quad \text{inE} \quad \text{random} \]
Energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{task}} = 0.25; \text{basicWork} = 0.2; \mathcal{R} = 0.85 \)
Energy-aware strategies on heterogeneous platforms

cor_task = 0.25; basicWork = 0.2; R = 0.9

mapping

LowerBound deP deR inE random

RR n° 524

Energy-aware strategies on heterogeneous platforms

39
$\text{cor}_{\text{task}} = 0.25$; $\text{basicWork} = 0.2$; $R = 0.95$

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

cor\textsubscript{task} = 0.25; basic\textit{Work} = 0.3; R = 0.8

\begin{figure}
\centering
\includegraphics[width=\textwidth]{energy-time}
\caption{Energy-time mapping for different cor\textsubscript{proc} values.}
\end{figure}
Energy-aware strategies on heterogeneous platforms

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

- **Energy-energy**
- **Energy-time**
- **RandomShuffling**
- **Time-energy**
- **Time-time**

### Correlation Analysis
- $\text{cor}_{\text{proc}} = 0.70$
- $\text{cor}_{\text{proc}} = 0.80$
- $\text{cor}_{\text{proc}} = 0.90$
- $\text{cor}_{\text{proc}} = 1.00$

### Task Mapping
- $\beta_{\text{deP}, \text{deR}, \text{inE}, \text{random}}$

### Parameters
- $\text{cor}_{\text{task}} = 0.25$
- $\text{basicWork} = 0.33$
- $\mathcal{R} = 0.85$

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

corr_{task} = 0.25; basicWork = 0.3; R = 0.9

[Diagram with various bars and lines indicating ratios to the baseline for different parameters.]
Energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{task}} = 0.25; \text{basic Work} = 0.3; \ R = 0.95 \)

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

Ratio to the baseline

\( \beta_{b/w} \)

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

<table>
<thead>
<tr>
<th>$\text{cor}_\text{task} = 0.5$; $\text{basicWork} = 0.1$; $R = 0.8$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{cor}_\text{proc} = 0$</td>
</tr>
<tr>
<td>$\text{cor}_\text{proc} = 0.25$</td>
</tr>
<tr>
<td>$\text{cor}_\text{proc} = 0.5$</td>
</tr>
<tr>
<td>$\text{cor}_\text{proc} = 0.75$</td>
</tr>
<tr>
<td>$\text{cor}_\text{proc} = 1$</td>
</tr>
</tbody>
</table>

| $\beta_{b/w}$ | $0.00$ | $0.25$ | $0.50$ | $0.75$ | $1.00$ |
| $\text{Ratio to the baseline}$ |

| $\text{mapping}$ | LowerBound | deP | deR | inE | random |
| $\rho_b/w$ | $0.00$ | $0.25$ | $0.50$ | $0.75$ | $1.00$ |

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

\[ \text{cor}_{\text{task}} = 0.5; \ \text{basicWork} = 0.1; \ \mathcal{R} = 0.85 \]
Energy-aware strategies on heterogeneous platforms

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

\( \text{cor}_{\text{task}} = 0.5; \text{basicWork} = 0.1; R = 0.95 \)

\( m_{\text{corr}} = 0 \)
\( \text{basicWork} = 0.1 \)
\( R_{\text{corr}} = 0.95 \)

\[ \text{mapping} \quad \text{LowerBound} \quad \text{deP} \quad \text{deR} \quad \text{inE} \quad \text{random} \]
Energy-aware strategies on heterogeneous platforms

cor\text{task} = 0.5; \text{basicWork} = 0.2; \mathcal{R} = 0.8

\begin{table}
\centering
\begin{tabular}{|c|c|c|c|c|}
\hline
\text{cor\text{proc}} & 0 & 0.25 & 0.5 & 0.75 & 1.0 \\
\hline
\hline
\text{ratio to the baseline} & 0.00 & 0.25 & 0.50 & 0.75 & 1.00 \\
\hline
\end{tabular}
\end{table}
Energy-aware strategies on heterogeneous platforms

cor\text{task} = 0.5; \text{basicWork} = 0.2; \mathcal{R} = 0.85

<table>
<thead>
<tr>
<th>\text{cor}_{\text{proc}}</th>
<th>\text{Ratio to the baseline}</th>
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</tr>
<tr>
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<tr>
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<td>1.5</td>
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<td>0.75</td>
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<table>
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<th>\text{random}</th>
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<tbody>
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</tbody>
</table>
Energy-aware strategies on heterogeneous platforms

cor_{task} = 0.5; basicWork = 0.2; R = 0.95

![Graph showing energy-aware strategies on heterogeneous platforms with various correlation coefficients and basic work]

- cor_{task} = 0.5
- basicWork = 0.2
- R = 0.95

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

\[ \text{cor}_{\text{task}} = 0.5; \text{basicWork} = 0.3; \mathcal{R} = 0.8 \]
Energy-aware strategies on heterogeneous platforms

cor_{task} = 0.5; basicWork = 0.3; \mathcal{R} = 0.85

\begin{figure}
\centering
\includegraphics[width=\textwidth]{figure.png}
\caption{Comparison of energy-time and energy-energy trade-off for different correlation values and basic work ratios.}
\end{figure}

\begin{table}
\centering
\begin{tabular}{|c|c|c|c|c|}
\hline
\textbf{cor}_{proc} & 0 & 0.25 & 0.5 & 0.75 & 1 \\
\hline
\textbf{basicWork} & 0.25 & 0.5 & 0.75 & 1 & 2.5 \\
\hline
\end{tabular}
\caption{Comparison of energy-time and energy-energy trade-off for different correlation values and basic work ratios.}
\end{table}
Energy-aware strategies on heterogeneous platforms

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

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

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

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

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

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

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

\[ \beta_{b/w} \]

\[ \text{LowerBound} \]

\[ \text{deP} \]

\[ \text{deR} \]

\[ \text{inE} \]

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

corr_task = 0.5; basicWork = 0.3; R = 0.95

Ratio to the baseline

mapping LowerBound deP deR i.e. random
\( \text{cor}_{\text{task}} = 0.75; \text{basicWork} = 0.1; R = 0.8 \)
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.75; \text{basicWork} = 0.1; R = 0.9 \]
Energy-aware strategies on heterogeneous platforms

corr_{task} = 0.75; basicWork = 0.1; R = 0.95
Energy-aware strategies on heterogeneous platforms

\( cor_{\text{task}} = 0.75; \ basicWork = 0.2; \ R = 0.85 \)
$\text{cor}_{\text{task}} = 0.75$; $\text{basicWork} = 0.2$; $R = 0.95$

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

Energy-aware strategies on heterogeneous platforms
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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<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
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</tbody>
</table>

Correlation coefficient: 0.75
Baseline work: 0.85
RR n° 9324
Energy-aware strategies on heterogeneous platforms
$\text{cor}_{\text{task}} = 0.75$; $\text{basicWork} = 0.3$; $R = 0.95$
Energy-aware strategies on heterogeneous platforms

cor_{task} = 1; basicWork = 0.1; R = 0.8
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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<tr>
<td>0.60</td>
<td>0.70</td>
<td>0.80</td>
<td>0.90</td>
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</table>

cor proc = 0.25

β

Ratio to the baseline

mapping

LowerBound

deP

deR

BasicWork = 0.1; R = 0.85

RR n° 9324
Energy-aware strategies on heterogeneous platforms

cor_task = 1; basicWork = 0.1; \( R = 0.9 \)
Energy-aware strategies on heterogeneous platforms
cor_{task} = 1; basicWork = 0.2; R = 0.8
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
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<th>energy-time</th>
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<tr>
<td>ratio</td>
<td></td>
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</table>

Ratio to the baseline

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

BasicWork = 0.2; R = 0.85

RR n° 9324
Energy-aware strategies on heterogeneous platforms

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

The figures depict the ratio to the baseline for different correlation values between the task and the processor. The lines represent different mapping strategies: LowerBound, deP, deR, inE, and random. Each subplot corresponds to a different correlation coefficient for the processor. The x-axis represents the ratio to the baseline, and the y-axis represents the correlation coefficient values.

<table>
<thead>
<tr>
<th>corr_task</th>
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<th>Time</th>
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<tbody>
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<td>1.00</td>
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<td>1.50</td>
<td>1.60</td>
<td>23.20</td>
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</tbody>
</table>

The energy and time values are represented in the data above, showing the performance trade-offs for different mapping strategies.
Energy-aware strategies on heterogeneous platforms
\( \text{cor}_{\text{task}} = 1; \text{basicWork} = 0.3; R = 0.85 \)
Energy-aware strategies on heterogeneous platforms

\[-0.01\]

\[corr_{task} = 1; \ basicWork = 0.3; \ R = 0.95\]

---

**Note:** The image contains a graph showing energy-time trade-offs for different correlation factors and basic workloads. The x-axis represents the ratio of baseline, ranging from 0.00 to 1.00, and the y-axis represents the energy consumption, ranging from 0.00 to 1.25. The graph compares various strategies, including LowerBound, deP, deR, inE, and random, each represented by different colors or markers. The graph highlights the performance of these strategies under different conditions, with a focus on optimizing energy efficiency while maintaining task performance.
\( \beta_{b/w} \) (Scheduling)

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

RR n° 9324
Energy-aware strategies on heterogeneous platforms

\begin{align*}
\text{cor}_{\text{task}} &= 0.25; \quad \text{basicWork} = 0.1; \quad \mathcal{R} = 0.85
\end{align*}

\begin{figure}
\centering
\includegraphics[width=\textwidth]{chart.png}
\caption{Ratio to the baseline}\label{fig:ratioBaseline}
\end{figure}

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

\( \text{cor}_{\text{task}} = 0.25; \text{basicWork} = 0.1; R = 0.9 \)

\( S_{\text{task}} = 0.25; S_{\text{basicWork}} = 0.1; R = 0.9 \)

\( \text{scheduling} \quad \text{LowerBound} \quad \text{energy-time} \quad \text{time-energy} \quad \text{randomShuffling} \)

\( \beta_{\text{b/w}} \)

\( \text{Ratio to the baseline} \)

\( \text{LowerBound} \quad \text{energy-energy} \quad \text{time-energy} \quad \text{randomShuffling} \)

\( \text{LowerBound} \quad \text{energy-energy} \quad \text{time-energy} \quad \text{randomShuffling} \)
$\text{cor}_{\text{task}} = 0.25; \text{basicWork} = 0.1; \mathcal{R} = 0.95$
Energy-aware strategies on heterogeneous platforms

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

cor\text{task} = 0.25; \text{basicWork} = 0.2; \mathcal{R} = 0.85

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|c|c|}
\hline
\text{cor\text{proc}} & 0.00 & 0.25 & 0.50 & 0.75 & 1.00 \\
\hline
\text{time-energy} & 0.2 & 0.4 & 0.6 & 0.8 & 1.0 \\
\hline
\end{tabular}
\end{table}
$cor_{task} = 0.25; \ basicWork = 0.2; \ R = 0.9$

![Diagram](image-url)
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

cor\textsubscript{task} = 0.25; basic\textsubscript{Work} = 0.3; \mathcal{R} = 0.8
Energy-aware strategies on heterogeneous platforms

\[ cor_{\text{task}} = 0.25; \text{basicWork} = 0.3; R = 0.85 \]

<table>
<thead>
<tr>
<th>( R )</th>
<th>( \beta_{b/w} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>0.25</td>
</tr>
<tr>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>0.50</td>
<td>0.25</td>
</tr>
<tr>
<td>0.75</td>
<td>0.25</td>
</tr>
<tr>
<td>1.00</td>
<td>0.25</td>
</tr>
</tbody>
</table>

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

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

\[ \text{cor}_{\text{task}} = 0.25; \text{basicWork} = 0.3; R = 0.9 \]
Energy-aware strategies on heterogeneous platforms

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

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

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

\[ \text{Energy-energy} \]

\[ \text{Energy-time} \]

\[ \text{Time-energy} \]

\[ \text{time-time} \]

\[ \text{RandomShuffling} \]

\[ \text{scheduling} \]

\[ \text{LowerBound} \]

\[ \text{energy-energy} \]

\[ \text{time-energy} \]

\[ \text{randomShuffling} \]

\[ \text{cor_{task}} = 0.5; \text{basicWork} = 0.1; R = 0.8 \]
cor_{task} = 0.5; basicWork = 0.1; R = 0.85
Energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{task}} = 0.5; \text{basicWork} = 0.1; \mathcal{R} = 0.9 \)

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

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

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

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

\( \text{cor}_{\text{proc}} = 1 \)

\( \beta \)
\[ \text{corr}_{\text{task}} = 0.5; \text{basicWork} = 0.1; \mathcal{R} = 0.95 \]

<table>
<thead>
<tr>
<th>( \text{corr}_{\text{proc}} )</th>
<th>Ratio to the baseline</th>
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<tbody>
<tr>
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<td>( \text{LowerBound} )</td>
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<tr>
<td>0.25</td>
<td>( \text{energy-energy} )</td>
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<tr>
<td>0.50</td>
<td>( \text{time-energy} )</td>
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<tr>
<td>0.75</td>
<td>( \text{randomShuffling} )</td>
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<tr>
<td>1.00</td>
<td>( \text{randomShuffling} )</td>
</tr>
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</table>

Energy-aware strategies on heterogeneous platforms

- \( \beta_{\text{bw}} \)
Energy-aware strategies on heterogeneous platforms

\( cor_{task} = 0.5; \) basicWork = 0.2; \( R = 0.8 \)
Energy-aware strategies on heterogeneous platforms

cor_task = 0.5; basicWork = 0.2; \mathcal{R} = 0.85

![Graph showing energy ratio to baseline for different scheduling algorithms and values of \( \beta \).]
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.5; \text{basicWork} = 0.2; R = 0.9 \]

<table>
<thead>
<tr>
<th>( \text{cor}_{\text{proc}} )</th>
<th>( \beta_{\text{h/w}} )</th>
<th>( \text{scheduling} )</th>
</tr>
</thead>
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<tr>
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<td>0.25</td>
<td>energy-time</td>
</tr>
<tr>
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<td>time-energy</td>
</tr>
<tr>
<td>0.75</td>
<td>0.75</td>
<td>randomShuffling</td>
</tr>
</tbody>
</table>

Diagram showing the ratio to the baseline for different energy-time scheduling strategies with varying \( \text{cor}_{\text{proc}} \) and \( \beta_{\text{h/w}} \) values. The diagram illustrates the performance of various strategies against baseline performance across different workloads and energy efficiencies.
$cor_{task} = 0.5; \, basicWork = 0.2; \, R = 0.95$

<table>
<thead>
<tr>
<th>$cor_{proc}$</th>
<th>Ratio to the baseline</th>
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</thead>
<tbody>
<tr>
<td>0</td>
<td>LowerBound, energy-time, time-energy, randomShuffling</td>
</tr>
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<td>0.25</td>
<td>LowerBound, energy-time, time-energy, randomShuffling</td>
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<tr>
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<td>LowerBound, energy-time, time-energy, randomShuffling</td>
</tr>
<tr>
<td>0.75</td>
<td>LowerBound, energy-time, time-energy, randomShuffling</td>
</tr>
<tr>
<td>1</td>
<td>LowerBound, energy-time, time-energy, randomShuffling</td>
</tr>
</tbody>
</table>

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

cor\textsubscript{task} = 0.5; basicWork = 0.3; R = 0.85
Energy-aware strategies on heterogeneous platforms

cor\textsubscript{task} = 0.5; basicWork = 0.3; \mathcal{R} = 0.9

\begin{figure}
\centering
\includegraphics[width=\textwidth]{figures}
\end{figure}

Energy-aware strategies on heterogeneous platforms

There is a table or diagram showing energy comparisons across different scenarios, likely related to task scheduling or resource allocation in heterogeneous environments. The details of the table or diagram are not fully visible, but it seems to compare energy consumption or performance across various conditions.

RR n° 9324
Energy-aware strategies on heterogeneous platforms

Corr. proc = 0.75, basicWork = 0.1, R = 0.85
Energy-aware strategies on heterogeneous platforms

cor proc = 0.75; basicWork = 0.9; R = 0.9
Energy-aware strategies on heterogeneous platforms

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

<table>
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<th>( \text{cor}_{\text{proc}} = 0.5 )</th>
<th>( \text{cor}_{\text{proc}} = 0.75 )</th>
<th>( \text{cor}_{\text{proc}} = 1 )</th>
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<td>( \text{energy-energy} )</td>
<td>( \text{energy-time} )</td>
<td>( \text{time-energy} )</td>
<td>( \text{randomShuffling} )</td>
</tr>
<tr>
<td>( \beta_{b/w} )</td>
<td>( \beta_{b/w} )</td>
<td>( \beta_{b/w} )</td>
<td>( \beta_{b/w} )</td>
<td>( \beta_{b/w} )</td>
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<tr>
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</tr>
</tbody>
</table>

**Energy-aware strategies on heterogeneous platforms**
$\text{cor}_\text{task} = 0.75$; $\text{basicWork} = 0.2$; $R = 0.8$

Energy-aware strategies on heterogeneous platforms
cor_{task} = 0.75; basicWork = 0.2; R = 0.85
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>deP</th>
<th>deR</th>
<th>iaE</th>
<th>random</th>
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<tr>
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<tr>
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<td>0.0</td>
<td>0.12</td>
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</tbody>
</table>

Correlation values:
- $r_{b/w} = 0.75$
- $r_{task} = 0.33$
- $R = 0.8$

Scheduling strategies:
- LowerBound
- energy-energy
- time-energy
- randomShuffling

Ratio to the baseline:
- $RR_n = 93.24$

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

<table>
<thead>
<tr>
<th>Schedule</th>
<th>Cor proc 0.75</th>
<th>Cor proc 0.75</th>
<th>Cor proc 0.75</th>
<th>Cor proc 0.75</th>
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<tr>
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<td>0.50</td>
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</tr>
<tr>
<td>random</td>
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<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
</tr>
</tbody>
</table>

### Ratio to the baseline

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

- BasicWork = 0.3; R = 0.85
Energy-aware strategies on heterogeneous platforms

\[
\text{cor}_{\text{task}} = 0.75; \quad \text{basicWork} = 0.3; \quad R = 0.9
\]
Energy-aware strategies on heterogeneous platforms

cor\textsubscript{task} = 0.75; basicWork = 0.3; \mathcal{R} = 0.95
cor\textsubscript{task} = 1; basic\textit{Work} = 0.1; R = 0.8

<table>
<thead>
<tr>
<th>cor\textsubscript{proc}</th>
<th>Ratio to the baseline</th>
</tr>
</thead>
<tbody>
<tr>
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<td>0.00, 0.25, 0.50, 0.75, 1.00</td>
</tr>
<tr>
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<td>0.00, 0.25, 0.50, 0.75, 1.00</td>
</tr>
<tr>
<td>0.50</td>
<td>0.00, 0.25, 0.50, 0.75, 1.00</td>
</tr>
<tr>
<td>0.75</td>
<td>0.00, 0.25, 0.50, 0.75, 1.00</td>
</tr>
<tr>
<td>1.00</td>
<td>0.00, 0.25, 0.50, 0.75, 1.00</td>
</tr>
</tbody>
</table>

scheduling

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

\[ \text{cor}_{\text{task}} = 1; \ \text{basicWork} = 0.1; \ \mathcal{R} = 0.85 \]
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 1; \text{basicWork} = 0.1; \mathcal{R} = 0.9 \]

<table>
<thead>
<tr>
<th>cor_{proc}</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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<td>1.00</td>
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<td>0.25</td>
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<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>

\[ \beta_{b/w} \]

Ratio to the baseline

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

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

$c_{\text{task}} = 1$; $basicWork = 0.2$; $\mathcal{R} = 0.8$

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{energy-aware-strategies}
\caption{Energy-aware strategies on heterogeneous platforms}
\end{figure}
Energy-aware strategies on heterogeneous platforms

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

Ratio to the baseline

$scheduling$

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

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

<table>
<thead>
<tr>
<th>( \text{corr}_\text{proc} )</th>
<th>0.00</th>
<th>0.25</th>
<th>0.50</th>
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</tbody>
</table>

scheduling

- LowerBound
- energy-energy
- energy-time
- time-energy
- randomShuffling
cor_{\text{task}} = 1; \text{basicWork} = 0.3; R = 0.8
\( \text{cor}_{\text{task}} = 1; \text{basicWork} = 0.3; R = 0.9 \)

<table>
<thead>
<tr>
<th>( \text{cor}_{\text{proc}} )</th>
<th>( \beta_{b/w} )</th>
<th>( \text{LowerBound} )</th>
<th>( \text{energy-energy} )</th>
<th>( \text{time-energy} )</th>
<th>( \text{time-time} )</th>
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</table>

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

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

\[
\begin{array}{cccccc}
\text{cor}_{\text{proc}} = 0 & \text{cor}_{\text{proc}} = 0.25 & \text{cor}_{\text{proc}} = 0.5 & \text{cor}_{\text{proc}} = 0.75 & \text{cor}_{\text{proc}} = 1 \\
\hline
\text{Ratio to the baseline} & \text{time-energy} & \text{energy-time} & \text{energy-energy} & \text{time-time} & \text{randomShuffling} \\
\end{array}
\]

\[ \text{cor}_{\text{proc}} \text{ tasks} \]

\[ \text{cor}_{\text{proc}} \text{ basicWork} \]

\[ \text{cor}_{\text{proc}} \text{ R} \]

\[ \text{cor}_{\text{proc}} \text{ randomShuffling} \]
Correlation (Mapping)

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

### Processor correlation

- **Ratio to the baseline**
- **mapping**

### Values

- $\beta_{\text{in}} = 0.2$; basicWork = 0.1; $\mathcal{R} = 0.8$
- $\beta_{\text{out}} = 0.2$; basicWork = 0.1; $\mathcal{R} = 0.8$

**Legend:**
- dB: dB
- dR: dR
- random
Energy-aware strategies on heterogeneous platforms

Processor correlation

β_{\text{cor}} = 0.2; \text{basicWork}= 0.1; \text{R} = 0.85
Energy-aware strategies on heterogeneous platforms

![Graphs showing processor correlation and ratio to the baseline for different parameter settings.]

-processor correlation
-mapping
-b/w

...
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.2; \ \text{basicWork} = 0.1; \ \mathcal{R} = 0.95 \]

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

\[ \beta_{\text{bar}} = 0.2; \text{BasicWork} = 0.2; \mathcal{R} = 0.8 \]

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

\[ \text{randomShuffling} \]

\[ \text{time-energy} \]

\[ \text{time-time} \]

\[ \text{Processor correlation} \]

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

\[ \text{LowerBound} \]

\[ \text{deP} \]

\[ \text{deR} \]

\[ \text{inE} \]

\[ \text{random} \]

\[ \beta_{\text{bar}} = 0.2; \text{BasicWork} = 0.2; \mathcal{R} = 0.8 \]

RR n° 9324
<table>
<thead>
<tr>
<th>Correlation</th>
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<th>deP</th>
<th>deR</th>
<th>inE</th>
<th>random</th>
<th>β</th>
<th>b/w</th>
<th>basicWork</th>
<th>R</th>
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<td>0.50</td>
<td>0.75</td>
<td>1.00</td>
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<td>0.2</td>
<td>0.25</td>
<td>0.32</td>
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</table>
\[ \beta_{b/w} = 0.2; \quad \text{basicWork} = 0.2; \quad R = 0.9 \]

<table>
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<tr>
<th>( \text{cor task} )</th>
<th>( \text{time-energy} )</th>
<th>( \text{energy-time} )</th>
<th>( \text{time-time} )</th>
<th>( \text{energy-energy} )</th>
</tr>
</thead>
<tbody>
<tr>
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<td>0.50</td>
<td>0.75</td>
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<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Processor correlation

Ratio to the baseline

mapping - LowerBound, deP, deR, inE, random

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

Correlation coefficients:

- $\beta_{b\rightarrow w} = 0.2$, $\text{basicWork} = 0.3$, $R = 0.85$

Processor correlation:

- Ratio to the baseline

LowerBound mapping

RR n° 9324
Energy-aware strategies on heterogeneous platforms

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

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Processor correlation

Ratio to the baseline

mapping

LowerBound
deP
deR
inE
random

β_w = 0.2, basicWork, k = 0.3, R = 0.95

RR n° 9324
Energy-aware strategies on heterogeneous platforms

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

| $\beta_{0w}$ = 0.4; basicWork = 0.1; $R$ = 0.9 |
|---|---|---|---|---|---|
| $\epsilon_{rad} = 1$ | $\epsilon_{rad} = 0.75$ | $\epsilon_{rad} = 0.5$ | $\epsilon_{rad} = 0.25$ |

<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>
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<td>$0.00$</td>
<td>$0.00$</td>
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</tbody>
</table>

**Legend:**
- Processor correlation
- $\beta_{0w}$ correlation
- basicWork correlation
- $R$ correlation
- mapping
Processor correlation

<table>
<thead>
<tr>
<th>energy-energy</th>
<th>energy-time</th>
<th>randomShuffling</th>
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<th>time-time</th>
</tr>
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<td>inE</td>
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<tr>
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<td></td>
</tr>
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<td>cor_task = 0.75</td>
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</tr>
<tr>
<td>cor_task = 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$\beta_{i,j} = 0.4; \text{basicWork} = 0.1; \mathcal{R} = 0.95$

RR n° 9324
Energy-aware strategies on heterogeneous platforms

[Graphical representation of processor correlation]

\( \beta_{\text{map}} = 0.4 \), basicWork\( e = 0.2 \), \( R = 0.8 \)

RR n° 9324
Energy-aware strategies on heterogeneous platforms

\[ R = 0.85 \]

\[ \beta_{\text{basic work}} = 0.4, \beta_{\text{work}} = 0.2 \]

\[ \text{Processor correlation} \]

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

\[ \text{mapping} \]

- \( \text{energy-energy} \)
- \( \text{energy-time} \)
- \( \text{randomShuffling} \)
- \( \text{time-energy} \)
- \( \text{time-time} \)

\[ \text{LowerBound} \]

\[ \text{deP} \]

\[ \text{deR} \]

\[ \text{inE} \]
$\beta_{ir} = 0.4$; \textit{basicWork} = 0.2; $\mathcal{R} = 0.9$

<table>
<thead>
<tr>
<th>$\text{cor}_{\text{task}}$</th>
<th>$\text{time}_{-\text{time}}$</th>
<th>$\text{time}_{-\text{energy}}$</th>
<th>$\text{energy}_{-\text{energy}}$</th>
<th>$\text{time}_{-\text{time}}$</th>
<th>$\text{time}_{-\text{energy}}$</th>
<th>$\text{energy}_{-\text{energy}}$</th>
<th>$\text{time}_{-\text{time}}$</th>
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<td>0.75</td>
<td>1.00</td>
<td>1.25</td>
<td>0.00</td>
<td>0.25</td>
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<td>0.50</td>
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<td>1.00</td>
<td>1.25</td>
<td>0.00</td>
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</tr>
<tr>
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<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
<td>1.00</td>
<td>1.25</td>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
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<tr>
<td>1.00</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>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
</tr>
</tbody>
</table>

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

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

- Energy-energy
- Energy-time
- RandomShuffling
- Time-energy
- Time-time

Processor correlation

Baseline:
- \( \beta_{b/w} = 0.4 \)
- \( \text{basicWork} = 0.2 \)
- \( R = 0.95 \)

\[ r_n = 0.9324 \]
Energy-aware strategies on heterogeneous platforms

cor task = 0.25.
cor task = 0.5.
cor task = 0.75.

Processor correlation

Ratio to the baseline

mapping

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

β_\text{W} = 0.4; \text{basic work} = 0.3; R = 0.8
### Energy-aware strategies on heterogeneous platforms

#### Table 1: Performance Comparison

<table>
<thead>
<tr>
<th>Parameter Combination</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>$\beta_{\text{inL}} = 0.4$</td>
<td>$\beta_{\text{inL}} = 0.3$</td>
<td>$\beta_{\text{inL}} = 0.3$</td>
<td>$\beta_{\text{inL}} = 0.3$</td>
<td>$\beta_{\text{inL}} = 0.3$</td>
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<tr>
<td>$\beta_{\text{inL}} = 0.5$</td>
<td>$\beta_{\text{inL}} = 0.5$</td>
<td>$\beta_{\text{inL}} = 0.5$</td>
<td>$\beta_{\text{inL}} = 0.5$</td>
<td>$\beta_{\text{inL}} = 0.5$</td>
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<td>$\beta_{\text{inL}} = 0.7$</td>
<td>$\beta_{\text{inL}} = 0.7$</td>
<td>$\beta_{\text{inL}} = 0.7$</td>
<td>$\beta_{\text{inL}} = 0.7$</td>
<td>$\beta_{\text{inL}} = 0.7$</td>
<td>$\beta_{\text{inL}} = 0.7$</td>
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</tbody>
</table>

#### Diagram 1: Processor Correlation

- Energy-time mapping
- RandomShuffling mapping
- Time-energy mapping
- Time-time mapping

#### Notes
- For each parameter combination, the graphs show the correlation between different energy and time metrics.
- The baseline ratio is shown for each parameter set.
Energy-aware strategies on heterogeneous platforms

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

<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>RandomShuffling</th>
<th>Time-energy</th>
<th>Time-time</th>
<th>Energy-energy</th>
<th>Energy-time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ratio to the baseline</td>
<td>mapping</td>
<td>deP</td>
<td>deR</td>
<td>inE</td>
<td>random</td>
</tr>
</tbody>
</table>

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

0.80 0.90 1.50 2.20 2.70
20.40 20.40 21.00 22.10 23.00

0.80 0.90 1.40 2.20 2.70
20.40 20.40 21.00 22.10 23.00

0.80 1.10 1.50 2.00 2.50
20.40 20.40 20.60 21.10 22.20

0.90 1.30 1.70 2.00 2.50
20.40 20.40 20.50 20.70 21.20

1.00 1.30 1.90 2.30 2.70
20.30 20.40 20.40 20.50 21.10

\[ \beta_{\text{nl}} = 0.6; \beta_{\text{nl}} = 0.6; \beta_{\text{nl}} = 0.2; R = 0.85 \]

RR n° 9324
$\beta_{b/w} = 0.6$; basicWork $= 0.2$; $R = 0.9$

Ratio to the baseline
Energy-aware strategies on heterogeneous platforms

Processor correlation

Ratio to the baseline

Mapping

Lower Bound

Upper Bound

random

deP

deR

inE

Basic Work

Broad Work

β_b/a = 0.6; basicWork or k = 0.2; R = 0.95

RR n° 9324
Energy-aware strategies on heterogeneous platforms

![Diagram showing processor correlation ratio to the baseline mapping with different correlation values and mappings.](image-url)
Energy-aware strategies on heterogeneous platforms

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

Ratio to the baseline vs. Processor correlation for different processor correlations and mapping strategies.

- LowerBound
- deP
- deR
- inE
- random

Energy-time vs. energy-energy for different correlation values.
Energy-aware strategies on heterogeneous platforms

$\beta_{b/w} = 0.6$; $basicWork = 0.3$; $R = 0.9$

*Processor correlation*

*Ratio to the baseline*

*LowerBound* - deP - deR - imE - random
Energy-aware strategies on heterogeneous platforms

Processor correlation

Ratio to the baseline

$\beta_{0.6} = 0.6; \text{basic} \beta_{0.3} = 0.3; R = 0.95$

$\beta_{0.6} = 0.6; \text{basic} \beta_{0.3} = 0.3; R = 0.95$

$\beta_{0.6} = 0.6; \text{basic} \beta_{0.3} = 0.3; R = 0.95$

$\beta_{0.6} = 0.6; \text{basic} \beta_{0.3} = 0.3; R = 0.95$

$\beta_{0.6} = 0.6; \text{basic} \beta_{0.3} = 0.3; R = 0.95$

$\beta_{0.6} = 0.6; \text{basic} \beta_{0.3} = 0.3; R = 0.95$

$\beta_{0.6} = 0.6; \text{basic} \beta_{0.3} = 0.3; R = 0.95$

$\beta_{0.6} = 0.6; \text{basic} \beta_{0.3} = 0.3; R = 0.95$

$\beta_{0.6} = 0.6; \text{basic} \beta_{0.3} = 0.3; R = 0.95$

$\beta_{0.6} = 0.6; \text{basic} \beta_{0.3} = 0.3; R = 0.95$

$\beta_{0.6} = 0.6; \text{basic} \beta_{0.3} = 0.3; R = 0.95$

$\beta_{0.6} = 0.6; \text{basic} \beta_{0.3} = 0.3; R = 0.95$

$\beta_{0.6} = 0.6; \text{basic} \beta_{0.3} = 0.3; R = 0.95$

$\beta_{0.6} = 0.6; \text{basic} \beta_{0.3} = 0.3; R = 0.95$

$\beta_{0.6} = 0.6; \text{basic} \beta_{0.3} = 0.3; R = 0.95$

$\beta_{0.6} = 0.6; \text{basic} \beta_{0.3} = 0.3; R = 0.95$
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>Ratio to the baseline</th>
<th>mapping</th>
<th>Processor correlation</th>
<th>Ratio to the baseline</th>
<th>mapping</th>
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<tbody>
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<td>energy-energy</td>
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<tr>
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<td>energy-time</td>
<td>0.80</td>
<td>0.50</td>
</tr>
<tr>
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<td>randomShuffling</td>
<td>1.00</td>
<td>0.75</td>
</tr>
<tr>
<td>time-energy</td>
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<td>1.00</td>
<td>time-energy</td>
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<tr>
<td>time-time</td>
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<td>0.50</td>
<td>time-time</td>
<td>0.00</td>
<td>0.50</td>
</tr>
</tbody>
</table>

\[
\beta_{\text{b/w}} = 0.8, \quad \text{basicWork} = 0.1; \quad R = 0.9
\]

RR n° 9324
card

"cor_task = 0.25" "cor_task = 0.5" "cor_task = 0.75" "cor_task = 1"

"β_{b/w} = 0.8; basicWork = 0.1; R = 0.95"
<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>
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<tbody>
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<td>Correlation: 0.75</td>
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</tr>
<tr>
<td>Correlation: 0.5</td>
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<td>Correlation: 0.0</td>
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</tbody>
</table>

**Beta** = 0.8, **basic workload** = 0.2, **R** = 0.8

RR n° 9324
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.8; \text{ basicWork} = 0.2; \; R = 0.85 \]
Energy-aware strategies on heterogeneous platforms

\[ \beta_w = 0.8, \ \beta/r = 0.2, \ \mathcal{R} = 0.9 \]
Energy-aware strategies on heterogeneous platforms

Processor correlation to the baseline

LowerBound = 0.8; basicWork = 0.3; R = 0.8
Energy-aware strategies on heterogeneous platforms

$\beta_{b/w} = 0.8$; $\text{basicWork} = 0.3$; $R = 0.85$

[Graph showing various energy-time and time-energy trade-offs with mappings like LowerBound, deP, deR, inE, and random.]
\[ \beta_{b/w} = 0.8; \text{basicWork} = 0.3; \ R = 0.9 \]
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>
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<tbody>
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<td>Correlation = 0.5</td>
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<td>Correlation = 0.25</td>
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Ratio to the baseline

<table>
<thead>
<tr>
<th>Mapping</th>
<th>LowerBound</th>
<th>deP</th>
<th>deR</th>
<th>inE</th>
<th>random</th>
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<tr>
<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ \beta_{\text{basic}} = 0.8; \beta_{\text{work}} = 0.3; R = 0.95 \]

RR n° 9324
\( \beta_{b/w} = 1; \; basicW = 0.1; \; R = 0.8 \)
\[ \beta_{b/w} = 1; \text{basicWork} = 0.1; R = 0.85 \]
Energy-aware strategies on heterogeneous platforms

1.00 1.10 1.70 2.60 3.20 20.40 20.40 21.00 22.10 23.00
1.00 1.10 1.70 2.60 3.20 20.40 20.40 21.00 22.10 23.00
1.00 1.10 1.80 2.60 3.20 20.40 20.40 21.00 22.10 23.00
1.00 1.10 1.80 2.60 3.30 20.40 20.40 21.00 22.10 23.00
1.00 1.30 1.80 2.40 3.10 20.40 20.40 20.60 21.10 22.20
1.00 1.30 1.80 2.40 3.10 20.40 20.40 20.60 21.10 22.20
1.00 1.30 1.70 2.40 3.10 20.40 20.40 20.60 21.10 22.20
1.00 1.30 1.80 2.50 3.10 20.40 20.40 20.60 21.10 22.20
1.00 1.30 1.80 2.50 3.10 20.40 20.40 20.60 21.10 22.20
1.10 1.40 2.10 2.50 3.00 20.40 20.40 20.50 20.70 21.20
1.10 1.40 2.10 2.50 3.00 20.40 20.40 20.50 20.70 21.20
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1.10 1.40 2.10 2.50 3.10 20.40 20.40 20.50 20.70 21.20
1.10 1.50 2.30 2.80 3.10 20.30 20.40 20.40 20.50 21.10
1.10 1.50 2.30 2.80 3.10 20.30 20.40 20.40 20.50 21.10
1.10 1.50 2.40 2.80 3.10 20.30 20.40 20.40 20.50 21.10
1.10 1.50 2.40 2.80 3.10 20.30 20.40 20.40 20.50 21.10
1.10 1.50 2.30 2.80 3.10 20.30 20.40 20.40 20.50 21.10
1.10 1.50 2.30 2.80 3.10 20.30 20.40 20.40 20.50 21.10
1.10 1.50 2.30 2.80 3.10 20.30 20.40 20.40 20.50 21.10
1.10 1.50 2.30 2.80 3.10 20.30 20.40 20.40 20.50 21.10
\( \beta_{b/w} = 1; \) basicWork = 0.2; \( R = 0.9 \)
1. Energy-aware strategies on heterogeneous platforms

2. Processor correlation

3. Ratio to the baseline

4. mapping

5. Processor correlation

6. LowerBound

7. deP

8. deR

9. inE

10. random

11. \( \beta_{\text{rad}} = 1 \), \( \text{basicWork} = 0.2 \), \( R = 0.95 \)

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

Processor correlation

Ratio to the baseline

Lower Bound

deP, deR, inE, random

β/β_0 = 1, basicWork = 0.3, R = 0.85

0.00 0.25 0.50 0.75 1.00

0.00 0.25 0.50 0.75 1.00

0.00 0.25 0.50 0.75 1.00

0.00 0.25 0.50 0.75 1.00

0.00 0.25 0.50 0.75 1.00

0.00 0.25 0.50 0.75 1.00

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>0.00</td>
<td>0.25</td>
</tr>
<tr>
<td>0.50</td>
<td>0.75</td>
</tr>
<tr>
<td>1.00</td>
<td>1.25</td>
</tr>
</tbody>
</table>

$\beta_{b/w} = 1$, $\text{basicWork} = 0.3$, $R = 0.9$
Energy-aware strategies on heterogeneous platforms

RR n° 9324
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

<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>Ratio to the baseline</th>
<th>scheduling</th>
</tr>
</thead>
<tbody>
<tr>
<td>deP</td>
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</tr>
<tr>
<td>deR</td>
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<td>0.5</td>
</tr>
<tr>
<td>deE</td>
<td>0.75</td>
<td>0.75</td>
</tr>
<tr>
<td>random</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

\[
\beta_{\text{bs}} = 0.2; \quad \text{basicWork} = 0.1; \quad \gamma = 0.8
\]

RR n° 9324
Energy-aware strategies on heterogeneous platforms

Processor correlation
Ratio to the baseline

LowerBound
energy-time
time-energy
randomShuffling

β_{w_i} = 0.2; basicWork = 0.1; R = 0.85

RR n° 9324
\( \beta_{b/w} = 0.2; \text{basicWork} = 0.1; \mathcal{R} = 0.9 \)
Energy-aware strategies on heterogeneous platforms

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

![Graph showing energy consumption for different tasks and correlations](image)

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

**Task Correlation (\(\text{cor}_{\text{task}}\):)**
- \(\text{cor}_{\text{task}} = 0.25\)
- \(\text{cor}_{\text{task}} = 0.5\)
- \(\text{cor}_{\text{task}} = 0.75\)
- \(\text{cor}_{\text{task}} = 1\)

**Processor Correlation (\(\text{cor}_{\text{proc}}\):)**
- \(\text{cor}_{\text{proc}} = 0\)
- \(\text{cor}_{\text{proc}} = 0.25\)
- \(\text{cor}_{\text{proc}} = 0.50\)
- \(\text{cor}_{\text{proc}} = 0.75\)
- \(\text{cor}_{\text{proc}} = 1\)

**Energy Consumption:**
- LowerBound
- Energy-Time
- Time-Energy
- Random Shuffling

**Ratio to the Baseline:**
- Scheduling
- Energy-Time
- Time-Energy
- Random Shuffling
\[ \beta_{bw} = 0.2; \ \text{basicWork} = 0.2; \ R = 0.8 \]

<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>( \alpha_{\text{rand}} = 0.25 )</th>
<th>( \alpha_{\text{rand}} = 0.5 )</th>
<th>( \alpha_{\text{rand}} = 0.75 )</th>
<th>( \alpha_{\text{rand}} = 1 )</th>
</tr>
</thead>
<tbody>
<tr>
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<td>0.00</td>
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<tr>
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</tr>
</tbody>
</table>

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

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

\[ \text{RR n°9324} \]
Energy-aware strategies on heterogeneous platforms

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

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

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

- Processor correlation
- Ratio to the baseline

#### Processor correlation

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

#### Ratio to the baseline

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

#### LowerBound: energy-energy

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

#### energy-time: time-energy

- randomShuffling

#### time-time: randomShuffling

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

**Note:**

- $\beta_{\text{hi}} = 0.2$; basicWork: $e = 0.3$; $R = 0.85$.
Energy-aware strategies on heterogeneous platforms
\( \beta_{b/w} = 0.2; \) basicWork = 0.3; \( R = 0.95 \)
\( \beta_{\text{b/t}} = 0.4; \text{basicWork} = 0.1; \mathcal{R} = 0.8 \)
Energy-aware strategies on heterogeneous platforms

\[ \text{Processor correlation} \]

Ratio to the baseline

<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>Processor correlation</th>
<th>Processor correlation</th>
<th>Processor correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
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<tr>
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<td>1.25</td>
<td>1.50</td>
<td>1.75</td>
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</tbody>
</table>

\[ \text{LowerBound} \]

energy-energy

time-energy

time-time

\[ \text{randomShuffling} \]

basicWork = 0.1; R = 0.85

\[ \beta_{b/w} = 0.4; \text{basicWork} = 0.1; R = 0.85 \]
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>inE</td>
<td>random</td>
</tr>
</tbody>
</table>

- Processor correlation: \( \beta_{\text{deP}} = 0.4; \ \text{basicWork} = 0.1; \ \text{R} = 0.9 \)

- \( \beta_{\text{deP}}; \ \text{basicWork} \)
- \( \text{R} \)

- \( \beta_{\text{deP}} = 0.4; \ \text{basicWork} = 0.1; \ \text{R} = 0.9 \)

- \( \beta_{\text{deP}}; \ \text{basicWork} \)
- \( \text{R} \)

- \( \beta_{\text{deP}} = 0.4; \ \text{basicWork} = 0.1; \ \text{R} = 0.9 \)

- \( \beta_{\text{deP}}; \ \text{basicWork} \)
- \( \text{R} \)

- \( \beta_{\text{deP}} = 0.4; \ \text{basicWork} = 0.1; \ \text{R} = 0.9 \)

- \( \beta_{\text{deP}}; \ \text{basicWork} \)
- \( \text{R} \)
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>Ratio to the baseline</th>
<th>scheduling</th>
<th>Lower Bound</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>
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<td>0.50</td>
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<tr>
<td>deR</td>
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<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
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<tr>
<td>inE</td>
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<td>0.50</td>
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<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
</tr>
</tbody>
</table>

\[ \beta_{\text{bw}} = 0.4; \text{basicWork} = 0.1; R = 0.95 \]
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>
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<tbody>
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<td>1.00</td>
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<tr>
<td>random</td>
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<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>

cor<sub>task</sub> = 0.25; basicWork<sub>b/w</sub> = 0.2; R = 0.8

RR n° 9324
Energy-aware strategies on heterogeneous platforms

Processor correlation

Ratio to the baseline

LowerBound

energy-energy
time-energy
time-time

randomShuffling

β₁₀ = 0.4, basicWork = 0.2; R = 0.85

RR n° 9324
Energy-aware strategies on heterogeneous platforms

\[
\begin{array}{cccc}
\text{energy-time} & \text{time-energy} & \text{energy-energy} & \text{time-time} \\
\text{randomShuffling} & \text{randomShuffling} & \text{randomShuffling} & \text{randomShuffling} \\
\end{array}
\]
Energy-aware strategies on heterogeneous platforms

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

```
cor_task = 0.25
```

```
cor_task = 0.5
```

```
cor_task = 0.75
```

```
β_{b/w} = 0.4; basicWork = 0.3; R = 0.9
```

 Processor correlation

Ratio to the baseline

scheduling

energy-energy

time-energy

energy-time

time-time
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>
<th>scheduling</th>
</tr>
</thead>
<tbody>
<tr>
<td>deP</td>
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<tr>
<td>deR</td>
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<td></td>
</tr>
<tr>
<td>deE</td>
<td>0.25</td>
<td></td>
</tr>
<tr>
<td>random</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

### Parameters

- $\beta_{\text{work}} = 0.6$; basicWork $\alpha = 0.1$; $R = 0.85$

### Observations

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

\[ \beta_{bw} = 0.6; \text{ basicWork} = 0.1; R = 0.9 \]

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

\[ \text{cor task} = \{0, 0.25, 0.5, 0.75, 1.0\} \]

\[ \text{LowerBound energy-energy, energy-time, time-energy, time-time} \]

\[ \text{scheduling} \]

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

![Graph showing energy correlation and ratio to the baseline for different scheduling strategies. The x-axis represents the ratio to the baseline, and the y-axis represents the processor correlation. The graph includes lines for different scheduling methods such as classical Shuffling and random Shuffling, with varying correlation values and baseline ratios.]
Energy-aware strategies on heterogeneous platforms

Processor correlation

Ratio to the baseline

scheduling


cor task $= 0.25$

cor task $= 0.5$

cor task $= 0.75$

$\beta_{bw} = 0.6$, basicWork $= 0.2$, $R = 0.8$

RR n° 9324
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>Ratio to the baseline</th>
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<tbody>
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<td>lower-bound</td>
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<td></td>
<td>time-energy</td>
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<td></td>
<td>time-time</td>
</tr>
<tr>
<td>randomShuffling</td>
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</table>

### Table

<table>
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<th>deR</th>
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<tr>
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<td>corr task</td>
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<tr>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
</tr>
</tbody>
</table>

### Diagram

- Processor correlation
- Ratio to the baseline
- Lower-bound energy-energy
- Time-energy
- Time-time
- RandomShuffling

### Equations

- \( \beta_{h_0} = 0.6 \)
- basic \( \text{W} \) roll \( \text{R} = 0.2 \)
- \( R = 0.85 \)

RR n° 9324
Energy-aware strategies on heterogeneous platforms

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

![Graph showing processor correlation and ratio to the baseline for different scenarios]

$\beta_{\text{lat}} = 0.6$, basicWork $= 0.2$, $R = 0.9$

RR n° 9324
$\beta_{b/w} = 0.6; \; basicWork = 0.2; \; R = 0.95$
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>Ratio to the baseline</th>
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<tbody>
<tr>
<td>randomShuffling</td>
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<td></td>
<td>energy-energy</td>
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<td></td>
<td>time-energy</td>
</tr>
<tr>
<td></td>
<td>energy-time</td>
</tr>
</tbody>
</table>

Processor correlation

\[ \beta_{\text{in}} = 0.6; \beta_{\text{out}} = 0.3; R = 0.8 \]

RR n° 9324
Energy-aware strategies on heterogeneous platforms
<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>Time to Energy</th>
<th>Energy to Energy</th>
<th>Energy to Time</th>
<th>Time to Time</th>
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<td>Processor correlation</td>
<td>Time to Energy</td>
<td>Energy to Energy</td>
<td>Energy to Time</td>
<td>Time to Time</td>
</tr>
</tbody>
</table>

Energy-aware strategies on heterogeneous platforms

RR n° 9324
Energy-aware strategies on heterogeneous platforms

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

\[ \beta_{b/w} = 0.8; \ basicWork = 0.1; \ R = 0.85 \]
Energy-aware strategies on heterogeneous platforms

Processor correlation

Ratio to the baseline

scheduling

energy-energy
time-energy
time-time

lowerBound

randomShuffling

β \beta_{b/w} = 0.8; basicWork x \times 0.1; \ R = 0.9

RR n° 9324
\( \beta_{b/w} = 0.8; \ basicWork = 0.1; \ R = 0.95 \)

- \( \alpha_{\text{task}} = 0.25 \)
- \( \alpha_{\text{task}} = 0.5 \)
- \( \alpha_{\text{task}} = 0.75 \)
- \( \alpha_{\text{task}} = 1 \)

Energy-aware strategies on heterogeneous platforms

- Processor correlation
- Ratio to the baseline
- Scheduling
- LowerBound
- Energy-time
- Time-energy
- RandomShuffling
- Random
- Energy-energy
- Time-time
- LowerBound
\( \beta_{b/w} = 0.8; \text{ basicWork} = 0.2; \ R = 0.8 \)

<table>
<thead>
<tr>
<th>Processor Correlation</th>
<th>Correlation Schedule</th>
<th>Correlation Energy</th>
<th>Correlation Time</th>
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<td>time-energy</td>
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RR n° 9234
$\beta_{b/w} = 0.8$; basicWork = 0.2; $R = 0.85$

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<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
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</tbody>
</table>

Processor correlation ratios to the baseline for different scheduling strategies and correlation values.

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

Energy-aware strategies on heterogeneous platforms
\[ \beta_{b/w} = 0.8; \quad \text{basicWork} = 0.2; \quad R = 0.9 \]
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.8; \ \text{basicWork} = 0.2; \ R = 0.95 \]

<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>Ratio to the baseline</th>
<th>LowerBound</th>
<th>energy-time</th>
<th>time-energy</th>
<th>randomShuffling</th>
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scheduling
- LowerBound
- energy-time
- time-energy
- randomShuffling

Energy-aware strategies on heterogeneous platforms

RR n 924
Energy-aware strategies on heterogeneous platforms

\( \beta_{b/w} = 0.8; \; \text{basicWork} = 0.3; \; R = 0.8 \)

![Graph showing the relationship between processor correlation and energy efficiency for different COV values and scheduling strategies.](image-url)
Energy-aware strategies on heterogeneous platforms

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

\[ \beta_{\text{b/w}} = 0.8; \; \text{basicWork} = 0.3; \; R = 0.9 \]
Energy-aware strategies on heterogeneous platforms

Processor correlation

Ratio to the baseline scheduling

energy-energy energy-time time-energy randomShuffling

β_/ω_ = 0.8, basicWork = 0.3, R = 0.95

RR n° 9324
$\beta_{b/w} = 1; \text{basicWork} = 0.1; \mathcal{R} = 0.85$
Energy-aware strategies on heterogeneous platforms

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

\[
\beta_{\text{no}} = 1, \text{ basicWork} = 0.1, R = 0.9
\]

RR n° 9324
Energy-aware strategies on heterogeneous platforms

![Graph showing processor correlation ratios to the baseline for different scheduling methods and beta values.]
<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>Ratio to the baseline</th>
</tr>
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<tbody>
<tr>
<td>deP</td>
<td>deR</td>
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<tr>
<td>random</td>
<td>random</td>
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</tbody>
</table>

Processor correlation = 1, basicWork = 0.2, \( R = 0.85 \)

\( \beta_{\text{b/w}} = 1 \), basicWork = 0.2, \( R = 0.85 \)

RR n° 9324
Energy-aware strategies on heterogeneous platforms

Processor correlation
Ratio to the baseline

$\beta_{bc} = 1$, basicWork = 0.2, $R = 0.9$

$\beta_{bc} = 0.5$

$\beta_{bc} = 0.25$

$\beta_{bc} = 0.1$

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>time-energy</th>
<th>time-time</th>
</tr>
</thead>
<tbody>
<tr>
<td>BetaWork = 0, R = 0.25</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cor = 1</td>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
</tr>
<tr>
<td>Cor = 0.75</td>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
</tr>
<tr>
<td>Cor = 0.5</td>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
</tr>
<tr>
<td>Cor = 0.25</td>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
</tr>
</tbody>
</table>

RR n° 9324
Energy-aware strategies on heterogeneous platforms

Processor correlation

Ratio to the baseline

scheduling

time-energy
time-time
energy-energy
energy-time

\[ \beta_{\text{in}} = 1, \text{ basicWork} = 0.3, R = 0.8 \]

RR n° 9324
Energy-aware strategies on heterogeneous platforms

```
dP  dR  inE  random
  cor = 1
  cor = 0.75
  cor = 0.5
  cor = 0.25
  \beta_{bw} = 1, basicWork = 0.3, \mathcal{R} = 0.85
```

Ratio to the baseline

- Processor correlation
- energy-energy
- energy-time
- time-energy
- time-time

randomShuffling

RR n° 9324
Energy-aware strategies on heterogeneous platforms

- Processor correlation
- Ratio to the baseline
- Scheduling
- LowerBound
- RandomShuffling
- time-energy
- energy-time
- energy-energy
- time-time
- randomShuffling

<table>
<thead>
<tr>
<th>$\beta_{0_{0}} = 1$, basicWork = 0.3, $R = 0.9$</th>
<th>$\beta_{0_{0}} = 0.75$, basicWork = 0.3, $R = 0.9$</th>
<th>$\beta_{0_{0}} = 0.5$, basicWork = 0.3, $R = 0.9$</th>
<th>$\beta_{0_{0}} = 0.25$, basicWork = 0.3, $R = 0.9$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta_{0_{0}} = 1$, basicWork = 0.3, $R = 0.9$</td>
<td>$\beta_{0_{0}} = 0.75$, basicWork = 0.3, $R = 0.9$</td>
<td>$\beta_{0_{0}} = 0.5$, basicWork = 0.3, $R = 0.9$</td>
<td>$\beta_{0_{0}} = 0.25$, basicWork = 0.3, $R = 0.9$</td>
</tr>
</tbody>
</table>

RR n° 9324
The following section presents ratio of energy consumption using different mapping strategies under big failure rate, when varying basicWork and $\mathcal{R}$. 
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>$\alpha_{\text{cor}} = 0$</th>
<th>$\alpha_{\text{cor}} = 0.25$</th>
<th>$\alpha_{\text{cor}} = 0.5$</th>
<th>$\alpha_{\text{cor}} = 0.75$</th>
<th>$\alpha_{\text{cor}} = 1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R = 0.5$</td>
<td>$R = 0.5$</td>
<td>$R = 0.5$</td>
<td>$R = 0.5$</td>
<td>$R = 0.5$</td>
</tr>
<tr>
<td>$0.10$</td>
<td>$0.15$</td>
<td>$0.20$</td>
<td>$0.25$</td>
<td>$0.30$</td>
</tr>
<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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<tr>
<td>$0.10$</td>
<td>$0.15$</td>
<td>$0.20$</td>
<td>$0.25$</td>
<td>$0.30$</td>
</tr>
<tr>
<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

Mapping

LowerBound

aP

aR

aM

aK

$\alpha_{\text{cor}} = 0.25, \beta_{\text{bw}} = 0.2$, Scheduling criteria: time-time

RR

°
Energy-aware strategies on heterogeneous platforms

\[ R = 0.85 \]

\[ R = 0.9 \]

\[ R = 0.95 \]

\[ R = 1 \]

Basic Work

Ratio to the baseline

mapping

LowerBound

deP

deR

$\beta_{\text{in}} = 0.25$; $\beta_{\text{out}} = 0.2$; Scheduling criteria: time-energy

RR n° 9324
\[ r_{\text{task}} = 0.25; \beta_{b/w} = 0.2; \text{Scheduling criteria: energy-time} \]
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

Cor = 0.85

Basic Work

RR n° 9324
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.25; \ \beta_{b/w} = 0.4; \text{Scheduling criteria: time-time} \]
Energy-aware strategies on heterogeneous platforms

\[ R = 0.85 \]

\[ \text{cor}_{\text{proc}} = 0.25, \; \beta_{\text{ru}} = 0.4 \]

Scheduling criteria: time-energy

Basic Work

map, Emap, \text{deP}, \text{deR}, \text{inE}, \text{random}

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

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

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

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

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

RR n° 9324
Energy-aware strategies on heterogeneous platforms

![Graph showing performance with different parameters and mapping strategies.]
Energy-aware strategies on heterogeneous platforms

\[ R = 0.8 \]

\[ R = 0.9 \]

\[ R = 0.85 \]

\[ R = 0.8 \]

\[ cor_{\text{act}} = 0.25; \beta_{\text{sw}} = 0.4 \]

Scheduling criteria: randomShuffling

Basic Work

Ratio to the baseline

LowerBound

deP

deR

inE

random

RR n° 9324
Energy-aware strategies on heterogeneous platforms

\[ R = 0.85 \]

\[ \text{Basic Work} \]

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

\[ \text{LowerBound} \]

\[ \text{deP} \]

\[ \text{deR} \]

\[ \text{inE} \]

\[ \text{random} \]

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

\[ \text{cor} \]

\[ \text{task} = 1; \beta_{w} = 1 \]

\[ \text{RR} = 9.324 \]

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

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

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

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

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

\[ \text{Basic Work} \]

\[ \text{LowerBound} \]

\[ \text{deP} \]

\[ \text{deR} \]

\[ \text{inE} \]

\[ \text{random} \]

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

\[ \text{cor} \]

\[ \text{task} = 1; \beta_{w} = 1 \]

\[ \text{RR} = 9.324 \]
Energy-aware strategies on heterogeneous platforms

$cor_{task} = 0.25$; $\beta_{bw} = 0.6$; Scheduling criteria: time-energy

mapping | LowerBound | deP | deR | inE | random

Basic Work | Ratio to the baseline

$R = 0.8$ | 0.00 | 0.25 | 0.50 | 0.75 | 1.00 | 1.25

$R = 0.85$ | 0.00 | 0.25 | 0.50 | 0.75 | 1.00 | 1.25

$R = 0.9$ | 0.00 | 0.25 | 0.50 | 0.75 | 1.00 | 1.25

$R = 0.95$ | 0.00 | 0.25 | 0.50 | 0.75 | 1.00 | 1.25
Energy-aware strategies on heterogeneous platforms

\[ R = 0.85 \]

Basic Work

\[ \text{cor} \text{task} = 0.25, \beta_{\text{g}} = 0.6, \text{Scheduling criteria: energy-time} \]

\[ R = 0.8 \]

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

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

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

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

\[ \text{cor} \text{proc} = 1 \]
Energy-aware strategies on heterogeneous platforms

### Table: Basic Work Ratio to the baseline

<table>
<thead>
<tr>
<th>$cor_{perv}$</th>
<th>$R = 0.85$</th>
<th>$R = 0.9$</th>
<th>$R = 0.95$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$cor_{task}$</td>
<td>$0.25$, $\beta_{u} = 0.6$, $\alpha_{u} = 0.6$, $\gamma_{u} = 0.6$</td>
<td>$0.15$, $\beta_{u} = 0.4$, $\alpha_{u} = 0.4$, $\gamma_{u} = 0.4$</td>
<td>$0.05$, $\beta_{u} = 0.2$, $\alpha_{u} = 0.2$, $\gamma_{u} = 0.2$</td>
</tr>
</tbody>
</table>

### Diagram: LowerBound deP deR inE random

**Legend:**
- **Basic Work**
- **LowerBound**
- **deP**
- **deR**
- **inE**
- **random**

**Parameters:**
- $R = 0.85$
- $R = 0.9$
- $R = 0.95$
- $cor_{perv} = 0, 0.25, 0.5, 0.75, 1$
- $cor_{task} = 0, 0.25$

**Scheduling criteria:** energy-energy

**Note:** The diagrams show the relationship between the basic work ratio and $cor_{perv}$ for different values of $R$ and $cor_{task}$. The graphs illustrate how changes in $cor_{perv}$ and $R$ affect the performance metrics under the specified scheduling criteria.
Energy-aware strategies on heterogeneous platforms

\begin{center}
\begin{tabular}{|c|c|c|c|c|c|}
\hline
$R_{\text{proc}}$ & 0 & 0.25 & 0.5 & 0.75 & 1 \\
\hline
0.0 & 0.0 & 0.0 & 0.0 & 0.0 & 0.0 \\
0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 \\
0.2 & 0.2 & 0.2 & 0.2 & 0.2 & 0.2 \\
0.3 & 0.3 & 0.3 & 0.3 & 0.3 & 0.3 \\
0.4 & 0.4 & 0.4 & 0.4 & 0.4 & 0.4 \\
0.5 & 0.5 & 0.5 & 0.5 & 0.5 & 0.5 \\
0.6 & 0.6 & 0.6 & 0.6 & 0.6 & 0.6 \\
0.7 & 0.7 & 0.7 & 0.7 & 0.7 & 0.7 \\
0.8 & 0.8 & 0.8 & 0.8 & 0.8 & 0.8 \\
0.9 & 0.9 & 0.9 & 0.9 & 0.9 & 0.9 \\
1.0 & 1.0 & 1.0 & 1.0 & 1.0 & 1.0 \\
\hline
\end{tabular}
\end{center}

Basic Work

\begin{center}
\begin{tabular}{|c|c|c|c|c|c|}
\hline
$R_{\text{proc}}$ & 0 & 0.25 & 0.5 & 0.75 & 1 \\
\hline
0.0 & 0.0 & 0.0 & 0.0 & 0.0 & 0.0 \\
0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 \\
0.2 & 0.2 & 0.2 & 0.2 & 0.2 & 0.2 \\
0.3 & 0.3 & 0.3 & 0.3 & 0.3 & 0.3 \\
0.4 & 0.4 & 0.4 & 0.4 & 0.4 & 0.4 \\
0.5 & 0.5 & 0.5 & 0.5 & 0.5 & 0.5 \\
0.6 & 0.6 & 0.6 & 0.6 & 0.6 & 0.6 \\
0.7 & 0.7 & 0.7 & 0.7 & 0.7 & 0.7 \\
0.8 & 0.8 & 0.8 & 0.8 & 0.8 & 0.8 \\
0.9 & 0.9 & 0.9 & 0.9 & 0.9 & 0.9 \\
1.0 & 1.0 & 1.0 & 1.0 & 1.0 & 1.0 \\
\hline
\end{tabular}
\end{center}

Basic Work

\begin{center}
\begin{tabular}{|c|c|c|c|c|c|}
\hline
$R_{\text{proc}}$ & 0 & 0.25 & 0.5 & 0.75 & 1 \\
\hline
0.0 & 0.0 & 0.0 & 0.0 & 0.0 & 0.0 \\
0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 \\
0.2 & 0.2 & 0.2 & 0.2 & 0.2 & 0.2 \\
0.3 & 0.3 & 0.3 & 0.3 & 0.3 & 0.3 \\
0.4 & 0.4 & 0.4 & 0.4 & 0.4 & 0.4 \\
0.5 & 0.5 & 0.5 & 0.5 & 0.5 & 0.5 \\
0.6 & 0.6 & 0.6 & 0.6 & 0.6 & 0.6 \\
0.7 & 0.7 & 0.7 & 0.7 & 0.7 & 0.7 \\
0.8 & 0.8 & 0.8 & 0.8 & 0.8 & 0.8 \\
0.9 & 0.9 & 0.9 & 0.9 & 0.9 & 0.9 \\
1.0 & 1.0 & 1.0 & 1.0 & 1.0 & 1.0 \\
\hline
\end{tabular}
\end{center}

Basic Work

\begin{center}
\begin{tabular}{|c|c|c|c|c|c|}
\hline
$R_{\text{proc}}$ & 0 & 0.25 & 0.5 & 0.75 & 1 \\
\hline
0.0 & 0.0 & 0.0 & 0.0 & 0.0 & 0.0 \\
0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 \\
0.2 & 0.2 & 0.2 & 0.2 & 0.2 & 0.2 \\
0.3 & 0.3 & 0.3 & 0.3 & 0.3 & 0.3 \\
0.4 & 0.4 & 0.4 & 0.4 & 0.4 & 0.4 \\
0.5 & 0.5 & 0.5 & 0.5 & 0.5 & 0.5 \\
0.6 & 0.6 & 0.6 & 0.6 & 0.6 & 0.6 \\
0.7 & 0.7 & 0.7 & 0.7 & 0.7 & 0.7 \\
0.8 & 0.8 & 0.8 & 0.8 & 0.8 & 0.8 \\
0.9 & 0.9 & 0.9 & 0.9 & 0.9 & 0.9 \\
1.0 & 1.0 & 1.0 & 1.0 & 1.0 & 1.0 \\
\hline
\end{tabular}
\end{center}

Basic Work

\begin{center}
\begin{tabular}{|c|c|c|c|c|c|}
\hline
$R_{\text{proc}}$ & 0 & 0.25 & 0.5 & 0.75 & 1 \\
\hline
0.0 & 0.0 & 0.0 & 0.0 & 0.0 & 0.0 \\
0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 \\
0.2 & 0.2 & 0.2 & 0.2 & 0.2 & 0.2 \\
0.3 & 0.3 & 0.3 & 0.3 & 0.3 & 0.3 \\
0.4 & 0.4 & 0.4 & 0.4 & 0.4 & 0.4 \\
0.5 & 0.5 & 0.5 & 0.5 & 0.5 & 0.5 \\
0.6 & 0.6 & 0.6 & 0.6 & 0.6 & 0.6 \\
0.7 & 0.7 & 0.7 & 0.7 & 0.7 & 0.7 \\
0.8 & 0.8 & 0.8 & 0.8 & 0.8 & 0.8 \\
0.9 & 0.9 & 0.9 & 0.9 & 0.9 & 0.9 \\
1.0 & 1.0 & 1.0 & 1.0 & 1.0 & 1.0 \\
\hline
\end{tabular}
\end{center}

Basic Work
$cor_{task} = 0.25$; $\beta_{b/w} = 0.8$; Scheduling criteria: time-time
Energy-aware strategies on heterogeneous platforms

\[
c_{\text{cor task}} = 0.25; \quad \beta_{b/w} = 0.8; \quad \text{Scheduling criteria: time-energy}
\]
Energy-aware strategies on heterogeneous platforms

corr_{task} = 0.25; \beta_{b/w} = 0.8; Scheduling criteria: energy-time

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

\[ R = 0.85 \]

\[ R = 0.9 \]

\[ R = 0.95 \]

\[ \text{Cor} = 0.25; \ \beta_{\text{uu}} = 1; \text{Scheduling criteria: time-time} \]
<table>
<thead>
<tr>
<th>$R_{\text{proc}}$</th>
<th>$R_{\text{tag}}$</th>
<th>$R_{\text{loc}}$</th>
<th>$R_{\text{pub}}$</th>
<th>$R_{\text{com}}$</th>
<th>$R_{\text{cor}}$</th>
<th>$R_{\text{proc}}$</th>
<th>$R_{\text{tag}}$</th>
<th>$R_{\text{loc}}$</th>
<th>$R_{\text{pub}}$</th>
<th>$R_{\text{com}}$</th>
<th>$R_{\text{cor}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>0.25</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
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<td>0.5</td>
<td>0.25</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>0.75</td>
<td>0.25</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
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<td>0.5</td>
<td>0.5</td>
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</tr>
<tr>
<td>0.9</td>
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<td>0.5</td>
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<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Scheduling criteria: energy-time
$\text{cor}_\text{task} = 0.25$; $\beta_{b/w} = 1$; Scheduling criteria: energy-energy
$cor_{task} = 0.25$; $\beta_{b/w} = 1$; Scheduling criteria: randomShuffling.
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

\[ R = 0.8 \]

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

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

Scheduling criteria: energy-time

Basic Work

Fad to the baseline
Energy-aware strategies on heterogeneous platforms

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

R = 0.85; \beta_{b/w} = 0.4; Scheduling criteria: time-time

RR n° 9324
Energy-aware strategies on heterogeneous platforms

\[ R = 0.8 \]

\[ R = 0.85 \]

\[ R = 0.9 \]

\[ R = 0.95 \]

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

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

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

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

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

Basic Work

Ratio to the baseline

Mapping

Lower bound

Dep P

R = b/w

\[ \text{cor}_{\text{task}} = 0.5, \beta_{r,w} = 0.4 \]

Scheduling criteria: time-energy

RR n° 9324
Energy-aware strategies on heterogeneous platforms

$R = 0.8$

$R = 0.9$

$R = 0.85$

$R = 0.8$

Correlation task = 0.5, $\beta_{\text{w}} = 0.4$. Scheduling criteria: energy-energy

Basic Work
$corr_{task} = 0.5; \beta_{j,w} = 0.4; \text{Scheduling criteria: randomShuffling}$
Energy-aware strategies on heterogeneous platforms

\[ R = 0.8 \]

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

\[ \text{Basic Work} \]

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

\[ \text{Lower Bound} \]

\[ \text{deP} \]

\[ \text{deR} \]

\[ \text{inE} \]

\[ \text{random} \]

\[ \text{cor}_{\text{task}} = 0.5, \beta_{\text{w}} = 0.6 \]

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

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

\[ \text{Lower Bound} \]

\[ \text{deP} \]

\[ \text{deR} \]

\[ \text{inE} \]

\[ \text{random} \]

RR n° 9324
Energy-aware strategies on heterogeneous platforms

RR n° 9324
Energy-aware strategies on heterogeneous platforms

RR n° 9324
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>$\text{cor}_{\text{pre}}$</th>
<th>$R$</th>
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<tr>
<td>1</td>
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<td>0.85</td>
<td>0.9</td>
<td>0.95</td>
<td></td>
</tr>
</tbody>
</table>

Basic Work

R n° 9324
### Energy-aware strategies on heterogeneous platforms

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

- **Correlation**: $\rho_{\text{task}} = 0.5$, $\beta_{\text{w}} = 0.8$
- **Scheduling criteria**: time-energy
- **R**
  - $R = 0.95$
  - $R = 0.9$
  - $R = 0.85$
  - $R = 0.8$

**Basic Work**

- **LowerBound**
- **deP**
- **deR**
- **inE**

*Note: Diagram and tables are placeholders. Actual data and visualizations would need to be inserted.*
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>CorProc</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>0.00</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
<td>1.00</td>
</tr>
<tr>
<td>0.10</td>
<td>0.15</td>
<td>0.20</td>
<td>0.25</td>
<td>0.30</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>0.10</td>
<td>0.15</td>
<td>0.20</td>
<td>0.25</td>
<td>0.30</td>
</tr>
</tbody>
</table>

Basic Work: LowerBound, deP, deR, inE, random

Scheduling criteria: energy-time

$\text{cor}_{\text{task}} = 0.5$, $\beta_{w} = 0.8$
Energy-aware strategies on heterogeneous platforms

---

Figure showing energy consumption comparison across different settings.

- **R**: 0.8
- **R**: 0.9
- **R**: 0.85
- **R**: 0.95

Scheduling criteria: energy-energy

**cor**: 0.5, **β**: 0.8

Basic Work

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

\[ R = 0.8 \]

\[ R = 0.9 \]

\[ R = 0.85 \]

\[ R = 0.8 \]

\[ cor_{pre} = 0 \]

\[ cor_{pre} = 0.25 \]

\[ cor_{pre} = 0.5 \]

\[ cor_{pre} = 0.75 \]

\[ cor_{pre} = 1 \]

Basic Work

Ratio to the baseline

mapping
dep

dep

\[ cor_{task} = 0.5, \beta_{\alpha_w} = 0.8 \]

Scheduling criteria: randomShuffling

\[ cor_{task} = 0.5, \beta_{\alpha_w} = 0.8 \]

Scheduling criteria: randomShuffling

RR n° 9324
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>$\cos \varphi_{\text{proc}}$</th>
<th>0</th>
<th>0.25</th>
<th>0.5</th>
<th>0.75</th>
<th>1</th>
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<tr>
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<td>$R = 0.9$</td>
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<td>$R = 0.95$</td>
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Basic Work

Ratio to the baseline

LowerBound

deP

deR

$\text{inE}$

random

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

- **$R = 0.85$**
  - $\text{cor}_{\text{proc}} = 0$
  - $\text{cor}_{\text{proc}} = 0.25$
  - $\text{cor}_{\text{proc}} = 0.5$
  - $\text{cor}_{\text{proc}} = 0.75$
  - $\text{cor}_{\text{proc}} = 1$

- **$R = 0.9$**
  - $\text{cor}_{\text{proc}} = 0$
  - $\text{cor}_{\text{proc}} = 0.25$
  - $\text{cor}_{\text{proc}} = 0.5$
  - $\text{cor}_{\text{proc}} = 0.75$
  - $\text{cor}_{\text{proc}} = 1$

- **$R = 0.95$**
  - $\text{cor}_{\text{proc}} = 0$
  - $\text{cor}_{\text{proc}} = 0.25$
  - $\text{cor}_{\text{proc}} = 0.5$
  - $\text{cor}_{\text{proc}} = 0.75$
  - $\text{cor}_{\text{proc}} = 1$

**Basic Work**
- $\text{ratio to the baseline}$
- **Lower Bound**
- $\text{dep}$
- $\text{dR} = \text{adP}$
- $\text{rn\&kon}$

Scheduling criteria: time-energy

$\text{cor}_{\text{task}} = 0.5$, $\beta_{d_w} = 1$
Energy-aware strategies on heterogeneous platforms

![Graphical representation of energy-aware strategies on heterogeneous platforms.](image)

- **Basic Work**
- **Ratio to the baseline**
- **Mapping**
- **LowerBound**
- **deP**
- **deR**
- **inE**
- **random**

**Scheduling criteria: energy-time**

- **\( \text{cor}_{\text{task}} = 0.5, \beta_{w} = 1 \)**
- **\( \text{cor}_{\text{task}} = 0.5, \beta_{w} = 1 \)**

**Energy-aware strategies on heterogeneous platforms**

\( R = 0.95 \)

\( R = 0.9 \)

\( R = 0.85 \)

\( R = 0.8 \)

RR n° 9324
\( e_{\text{task}} = 0.5 \), \( \beta_{\text{b/w}} = 1 \); Scheduling criteria: randomShuffling

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

![Graph showing energy-aware strategies on heterogeneous platforms](image-url)
cor_task = 0.75; β_{b/w} = 0.2; Scheduling criteria: time-energy
$cor_{task} = 0.75$; $\beta_{b/w} = 0.2$; Scheduling criteria: energy-time
Energy-aware strategies on heterogeneous platforms

cor\textsubscript{task} = 0.75; \beta_{b/w} = 0.2; Scheduling criteria: randomShuffling

Basic Work

Ratio to the baseline

0.00 0.25 0.50 0.75 1.00 1.25
0.00 0.25 0.50 0.75 1.00 1.25
0.00 0.25 0.50 0.75 1.00 1.25

Mapping: LowerBound, deP, deR, inE, random

RR n = 9214
### Energy-aware strategies on heterogeneous platforms

#### Table 1: Basic Work

| Task | Ratio to the baseline | deP | deR | inE | mapping | Costs
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#### Figure 1: Scheduling criteria time-time

- **Mapping**: Low transport, dP, dR, unk, unk
- **Costs**: Basic Work

**Note:** The figure shows the relationship between the ratio of basic work to the baseline and various costs under different mapping criteria. The values range from 0.75 to 1.00, with increments of 0.25. The mapping criteria include low transport, dP, dR, unk, unk, each with a unique color to denote different cost levels.
Energy-aware strategies on heterogeneous platforms

RR n° 9324
Energy-aware strategies on heterogeneous platforms

\[ R = 0.8 \]

\[ R = 0.9 \]

\[ R = 0.95 \]

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

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

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

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

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

Basic Work

\[ \text{mapping} \]

\[ \text{deP} \]

\[ \text{deR} \]

\[ \text{inE} \]

\[ \text{random} \]

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

Scheduling criteria: energy-time

RR n° 9324
Energy-aware strategies on heterogeneous platforms

<table>
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<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>
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</tbody>
</table>

Basic Work

$\text{cor}_{\text{task}} = 0.75, \beta_{\text{cpu}} = 0.4$, Scheduling criteria: energy-energy

$\text{cor}_{\text{proc}} = 0.85$
Energy-aware strategies on heterogeneous platforms

\[ R = 0.8 \]

\[ R = 0.9 \]

\[ R = 0.95 \]

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

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

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

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

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

Basic Work

Ratio to the baseline

mapping

LowerBound

dep

\[ \beta_{\text{map}} = 0.75; \beta_{\text{cor}} = 0.4 \]

Scheduling criteria: randomShuffling

\[ \text{cor}_{\text{map}} = 0.8 \]

\[ \text{cor}_{\text{map}} = 0.85 \]

\[ \text{cor}_{\text{map}} = 0.9 \]
Energy-aware strategies on heterogeneous platforms

\[
R = 0.80, 0.90, 1.20, 20.00, 20.20, 20.30 \quad \text{and} \quad 0.80, 0.90, 1.30, 1.70, 20.10, 20.20, 20.40.
\]

\[
R = 0.90, 1.10, 1.70, 20.10, 20.20, 20.50
\]

\[
R = 1.20, 2.00, 2.90, 20.00, 20.20, 21.00
\]

\[
R = 1.40, 2.50, 3.70, 20.00, 20.30, 21.90
\]

\[
R = 0.70, 0.90, 1.10, 21.00, 21.40, 22.50
\]

\[
R = 0.80, 1.20, 1.80, 21.10, 22.70, 26.90
\]

\[
R = 1.00, 1.80, 2.60, 21.70, 27.60, 33.00
\]

\[
R = 1.20, 2.10, 3.10, 22.50, 30.60, 36.20
\]

\[
R = 1.40, 2.70, 3.90, 24.90, 34.30, 40.00
\]

Basic Work

Ratio to the baseline

\[
\text{LowerBound} = \text{deP}, \text{deR}, \text{ine}, \text{random}
\]

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

\[
\text{cor}, \text{task} = 0.75, \beta_{yw} = 0.6
\]

RR n° 9324
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

Mapping

LowerBound

UpperBound

\[ \text{deP} \]

\[ \text{deR} \]

\[ \text{inE} \]

\[ \text{random} \]

\[ \beta_{\text{bw}} = 0.6 \]

Scheduling criteria: time-energy

\[ \text{cor}_{\text{task}} = 0.75; \beta_{\text{bw}} = 0.6 \]
### Energy-aware strategies on heterogeneous platforms

#### Table: Performance Evaluation

<table>
<thead>
<tr>
<th>( \text{cor}_{\text{prior}} )</th>
<th>( R = 0.85 )</th>
<th>( R = 0.8 )</th>
<th>( R = 0.9 )</th>
<th>( R = 0.95 )</th>
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<tr>
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<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
<td>1.00</td>
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</table>

#### Diagram: Mapping and Scheduling Criteria

- Basic Work
- Lower Bound
- \( \text{deP} \)
- \( \text{deR} \)
- \( \text{inE} \)

### Scheduling Criteria: Energy-Time
- \( \text{cor}_{\text{task}} = 0.75 \)
- \( \beta_{\text{sw}} = 0.6 \)
Energy-aware strategies on heterogeneous platforms

\[ R = 0.8 \]

\[ R = 0.9 \]

\[ R = 0.85 \]

\[ R = 0.8 \]

\[ \text{Basic Work} \]

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

\[ \text{Mapping} \]

\[ \text{Lower Bound} \]

\[ \text{deP} \]

\[ \text{deR} \]

\[ \text{inE} \]

\[ \text{random} \]

\[ \beta_{uw} = 0.6 \]

\[ \beta_{uw} = 0.75 \]

\[ \beta_{uw} = 0.8 \]
Energy-aware strategies on heterogeneous platforms

\[ corr_{task} = 0.75; \beta_{b/w} = 0.6; \text{Scheduling criteria: randomShuffling} \]
\( \text{cor}_\text{task} = 0.75; \ \beta_{b/w} = 0.8; \) Scheduling criteria: time-time
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.75; \ \beta_{b/w} = 0.8; \ \text{Scheduling criteria: time-energy} \]
Energy-aware strategies on heterogeneous platforms

RR n° 9324
$cor_{task} = 0.75$; $\beta_{b/w} = 0.8$; Scheduling criteria: energy-energy
Energy-aware strategies on heterogeneous platforms

\[ R = 0.85 \]

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

\[ \text{Basic Work} \]

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

\[ \text{LowerBound} \]

\[ \text{deP} \]

\[ \text{deR} \]

\[ \text{inE} \]

\[ \text{random} \]

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

\[ \text{cor}_{\text{task}} = 0.75, \beta_{\text{uw}} = 0.8 \]
### Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>$\text{cor}_{\text{proc}}$</th>
<th>$R = 0.85$</th>
<th>$R = 0.9$</th>
<th>$R = 0.95$</th>
<th>$R = 1$</th>
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</thead>
<tbody>
<tr>
<td>$\text{cor}<em>{\text{task}} = 0.75, \beta</em>{\text{w}} = 1$</td>
<td>Scheduling criteria: time-time</td>
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</table>

### Basic Work

- $\text{LowerBound}$
- $\text{UpperBound}$

### Mapping

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

<table>
<thead>
<tr>
<th>$\text{cor}_{\text{pre}}$</th>
<th>$R$</th>
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<td>$\text{cor}_{\text{post}}$</td>
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Basic Work

<table>
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$\text{cor}_{\text{post}} = 0.75$, $\text{cor}_{\text{post}} = 1$; Scheduling criteria: energy-time
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>$\alpha_{\text{task}}$</th>
<th>$\beta_{\text{schedule}}$</th>
<th>$R_{\text{baseline}}$</th>
<th>Mapping</th>
<th>LowerBound</th>
<th>deP</th>
<th>deR</th>
<th>inE</th>
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RR n° 9324
$cor_{task} = 1$; $\beta_{b/w} = 0.2$; Scheduling criteria: time-energy

Energy-aware strategies on heterogeneous platforms
$cor_{task} = 1; \beta_{b/w} = 0.2$; Scheduling criteria: energy-time
Energy-aware strategies on heterogeneous platforms

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

- $R = 0.8$
- $R = 0.9$
- $R = 0.95$
- $R = 1.0$

- $cor_{pred} = 0$
- $cor_{pred} = 0.25$
- $cor_{pred} = 0.5$
- $cor_{pred} = 0.75$
- $cor_{pred} = 1$

- Basic Work
- Ratio to the baseline
- Mapping
- LowerBound
- deP
- deR
- inE
- random

- $cor_{ask} = 1$, $\beta_{0,\alpha} = 0.2$
- Scheduling criteria: energy-energy
Energy-aware strategies on heterogeneous platforms

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

The graph illustrates the performance of various energy-aware strategies under different conditions. The y-axis represents the ratio of the baseline, and the x-axis shows the ratio to the baseline. The strategies are compared across different values of cos (0, 0.25, 0.5, 0.75, and 1), with cos values indicating the degree of correlation between tasks and processors.

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

The scheduling criteria include randomShuffling. The graph visually represents how these strategies perform across various_cos values, highlighting their effectiveness in terms of energy efficiency compared to the baseline.
Energy-aware strategies on heterogeneous platforms

\[ cor_{task} = 1; \beta_{b/w} = 0.4; \text{Scheduling criteria: time-time} \]
Energy-aware strategies on heterogeneous platforms

cor_{task} = 1; \beta_{b/w} = 0.4; Scheduling criteria: time-energy
Energy-aware strategies on heterogeneous platforms

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

\[
\begin{array}{cccc}
\text{Basic Work} & 0.10 & 0.15 & 0.20 & 0.25 & 0.30 & 0.35 & 0.40 & 0.45 & 0.50 \\
\text{Ratio to the baseline} & 0.10 & 0.15 & 0.20 & 0.25 & 0.30 & 0.35 & 0.40 & 0.45 & 0.50 \\
\end{array}
\]
\[ \text{cor}_{\text{task}} = 1; \; \beta_{b/w} = 0.4; \; \text{Scheduling criteria: energy-energy} \]
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>cos(\alpha) = 0</th>
<th>cos(\alpha) = 0.25</th>
<th>cos(\alpha) = 0.5</th>
<th>cos(\alpha) = 0.75</th>
<th>cos(\alpha) = 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>(R = 0.05)</td>
<td>(R = 0.10)</td>
<td>(R = 0.15)</td>
<td>(R = 0.20)</td>
<td>(R = 0.25)</td>
</tr>
<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>(0.25)</td>
<td>(0.25)</td>
<td>(0.25)</td>
<td>(0.25)</td>
</tr>
<tr>
<td>(0.50)</td>
<td>(0.50)</td>
<td>(0.50)</td>
<td>(0.50)</td>
<td>(0.50)</td>
</tr>
<tr>
<td>(0.75)</td>
<td>(0.75)</td>
<td>(0.75)</td>
<td>(0.75)</td>
<td>(0.75)</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>

Basic Work

\(\text{cor task} = 1; \beta_{\text{cor}} = 0.4\); Scheduling criteria: randomShuffling

\(R = 0.65\)

\(R = 0.8\)

RR n° 9324
Energy-aware strategies on heterogeneous platforms

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

```
<table>
<thead>
<tr>
<th>R</th>
<th>0.8</th>
<th>0.9</th>
<th>0.95</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.8</td>
<td>\text{R} = 0.85</td>
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<td>\text{R} = 0.95</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
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<th>0.25</th>
<th>0.50</th>
<th>0.75</th>
<th>1.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>\text{inE}</td>
<td>\text{deP}</td>
<td>\text{deR}</td>
<td>\text{inE}</td>
<td>random</td>
<td></td>
</tr>
</tbody>
</table>
```

Basic Work

Ratio to the baseline

```
<table>
<thead>
<tr>
<th>Basic Work</th>
<th>0.10</th>
<th>0.15</th>
<th>0.20</th>
<th>0.25</th>
<th>0.30</th>
<th>0.35</th>
<th>0.40</th>
<th>0.45</th>
<th>0.50</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>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
```

```
Energy-aware strategies on heterogeneous platforms
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

deP

deR

inE

random

Scheduling criteria: energy-energy

$$\text{cor}_{task} = 1; \beta_{io} = 0.6$$

$$\text{cor}_{\text{proc}} = 0.85$$

$$\text{cor}_{\text{proc}} = 0.8$$

RR n° 9324
cor\textsubscript{task} = 1; \beta b/w = 0.6; Scheduling criteria: randomShuffling
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>$\alpha$</th>
<th>$\beta$</th>
<th>$\gamma$</th>
<th>$\delta$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
</tr>
</tbody>
</table>

Mapping: LowerBound, dep, dR, 1:1, mak

Basic Work: time

Scheduling criteria: time-time

$\text{cor} = 1; \betaSJ = 0.8$; Scheduling criteria: time-time

$\text{cor} = 0; \betaSJ = 0.8$; Scheduling criteria: time-time

$\text{cor} = 0.25; \betaSJ = 0.8$; Scheduling criteria: time-time

$\text{cor} = 0.5; \betaSJ = 0.8$; Scheduling criteria: time-time

$\text{cor} = 0.75; \betaSJ = 0.8$; Scheduling criteria: time-time

$\text{cor} = 1; \betaSJ = 0.8$; Scheduling criteria: time-time

RR n° 9324
Energy-aware strategies on heterogeneous platforms

RR n° 9324
Energy-aware strategies on heterogeneous platforms

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

![Graphs showing energy-aware strategies on heterogeneous platforms with various parameters]

**Basic Work Ratio to the baseline**

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

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

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

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

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

Scheduling criteria: time-time

\[ \alpha_{\text{w}} = 1, \beta_{\text{w}} = 1 \]

RR n°9324
Energy-aware strategies on heterogeneous platforms

\[ R = 0.8 \]

\[ R = 0.5 \]

\[ R = 0.2 \]

\[ \text{cor}_{\text{base}} = 1; \beta_{j,u} = 1; \text{Scheduling criteria: time-energy} \]

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

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

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

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

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

Basic Work

\[ \text{Basic Work} \]

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

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

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

\[ \text{Baseline to the baseline} \]
Energy-aware strategies on heterogeneous platforms

\[ R = 0.85 \]

\[ R = 0.75 \]

\[ R = 0.5 \]

\[ R = 0.95 \]

\[ R = 0.8 \]

\[ cor_{pre} = 0 \]
\[ cor_{pre} = 0.25 \]
\[ cor_{pre} = 0.5 \]
\[ cor_{pre} = 0.75 \]
\[ cor_{pre} = 1 \]

Basic Work

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

\[ \text{Mapping} \]

\[ \text{LowerBound} \]

\[ \text{inE} \]

\[ \text{random} \]

Scheduling criteria: energy-time

\[ \beta_{b/w} = 1; \beta_{b/w} = 1 \]
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 1; \beta_{b/w} = 1; \text{Scheduling criteria: energy-energy} \]

Basic Work vs. Ratio to the baseline for different values of R (0.8, 0.85, 0.9, 0.95)

Legend:
- LowerBound
- deP
- deR
- inE
- random
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 $\mathcal{R}$. 
### Energy-aware strategies on heterogeneous platforms

#### Table 1: Comparison of Energy and Time Efficiency

<table>
<thead>
<tr>
<th>Correlation</th>
<th>Energy Efficiency</th>
<th>Time Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.40</td>
<td>0.50</td>
<td>0.70</td>
</tr>
<tr>
<td>0.60</td>
<td>1.00</td>
<td>1.50</td>
</tr>
<tr>
<td>0.90</td>
<td>1.70</td>
<td>2.50</td>
</tr>
<tr>
<td>1.20</td>
<td>2.40</td>
<td>3.60</td>
</tr>
</tbody>
</table>

#### Figure 2: Impact of Correlation on Energy Consumption

- **R = 0.05**
- **R = 0.10**
- **R = 0.15**
- **R = 0.20**
- **R = 0.25**
- **R = 0.30**

**Mapping Criteria:** $\beta_{nn} = 0.2$; $\beta_{in} = 0.25$
Energy-aware strategies on heterogeneous platforms

$$\text{cor}_{\text{task}} = 0.25; \; \beta_{b/w} = 0.2; \; \text{Mapping criteria: deR}$$
Energy-aware strategies on heterogeneous platforms

\( \text{corr}_{\text{task}} = 0.25; \ \beta_{/w} = 0.2; \ \text{Mapping criteria: deP} \)

- Basic Work
- Ratio to the baseline
- \( R = 0.8 \)
- \( R = 0.85 \)
- \( R = 0.9 \)
- \( R = 0.95 \)

\( \text{scheduling} \)
- LowerBound
- energy-energy
- time-energy
- randomShuffling

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

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

Ratio to the baseline

Basic Work

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

The graph above illustrates the performance of different energy-aware scheduling algorithms on heterogeneous platforms. The x-axis represents the ratio to the baseline, and the y-axis shows the energy consumption. Each column corresponds to a different correlation parameter $\rho_{\text{proc}}$, with $\rho_{\text{proc}} = 0$, $\rho_{\text{proc}} = 0.25$, $\rho_{\text{proc}} = 0.5$, $\rho_{\text{proc}} = 0.75$, and $\rho_{\text{proc}} = 1$. The algorithms compared include Basic Work, Random Shuffling, and Lower Bound.

- For $\rho_{\text{proc}} = 0$, the energy consumption is significantly lower than for other values of $\rho_{\text{proc}}$.
- As $\rho_{\text{proc}}$ increases, the energy consumption also increases, indicating a trade-off between energy efficiency and the correlation of the tasks.

The diagrams show that the algorithms perform differently depending on the specific value of $\rho_{\text{proc}}$. For $\rho_{\text{proc}} = 0$, Random Shuffling outperforms the other algorithms, while for higher values of $\rho_{\text{proc}}$, Basic Work becomes more effective.

### Mapping criteria deR

The mapping criteria deR, which balances the energy consumption with the processing time, is also shown in the diagrams. The parameters $\alpha = 0.25$, $\beta = 0.4$, and $\psi_{\text{wr}} = 0.4$ are used.

---

**Correlations to the baseline:**

- $\rho_{\text{corr}}$ values: 0.95, 0.85, 0.75.
Energy-aware strategies on heterogeneous platforms

cor_{task} = 0.25, \beta_{du} = 0.4; Mapping criteria: deP

RR n° 9324
Energy-aware strategies on heterogeneous platforms

cor_{task} = 0.25; \beta_{b/w} = 0.4; Mapping criteria: random
$\text{corr}_{\text{task}} = 0.25$; $\beta_{b/w} = 0.6$; Mapping criteria: inE

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

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

scheduling

<table>
<thead>
<tr>
<th>Basic Work</th>
<th>LowerBound</th>
<th>energy-time</th>
<th>time-time</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>20.00</td>
<td>20.00</td>
<td>20.00</td>
</tr>
<tr>
<td>0.25</td>
<td>20.00</td>
<td>20.00</td>
<td>20.00</td>
</tr>
<tr>
<td>0.50</td>
<td>20.00</td>
<td>20.00</td>
<td>20.00</td>
</tr>
<tr>
<td>0.75</td>
<td>20.00</td>
<td>20.00</td>
<td>20.00</td>
</tr>
<tr>
<td>1.00</td>
<td>20.00</td>
<td>20.00</td>
<td>20.00</td>
</tr>
</tbody>
</table>

Energy-aware strategies on heterogeneous platforms

3.63
Energy-aware strategies on heterogeneous platforms

\[ R = 0.85 \]

\[ \text{cor}_{\text{proc}} = 0.25; \beta_{\text{w}} = 0.6; \text{Mapping criteria: deP} \]
$cor_{task} = 0.25; \beta_{b/w} = 0.6; $ Mapping criteria: random

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

\begin{align*}
\text{cor}_{\text{proc}} &= 0.25, \beta_{\text{w}} &= 0.8; \text{Mapping criteria: inE} \\
R &= 0.9; \text{inE}
\end{align*}
Energy-aware strategies on heterogeneous platforms

\[ R = 0.8 \]

Correlation between task and resource: \( \rho_{tr} = 0.8 \)

Mapping criteria: \( dR \)

Basic Work

Ratio to the baseline

scheduling
Energy-aware strategies on heterogeneous platforms

The table and diagrams illustrate the performance of different energy-aware scheduling strategies on heterogeneous platforms. The strategies are compared based on their energy consumption and execution time, with varying correlation parameters. The graphs show the ratio to the baseline for different mapping criteria and performance metrics, such as energy and time.

### Table

<table>
<thead>
<tr>
<th>Correlation</th>
<th>Energy Consumption</th>
<th>Execution Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correlation 0.25</td>
<td>0.10</td>
<td>0.15</td>
</tr>
<tr>
<td>Correlation 0.50</td>
<td>0.20</td>
<td>0.25</td>
</tr>
<tr>
<td>Correlation 0.75</td>
<td>0.30</td>
<td>0.35</td>
</tr>
<tr>
<td>Correlation 1.00</td>
<td>0.40</td>
<td>0.45</td>
</tr>
</tbody>
</table>

### Diagrams

- **Correlation 0.0**: Initial baseline performance.
- **Correlation 0.1**: Performance improvement as correlation increases.
- **Correlation 0.2**: Further improvement with higher correlation.
- **Correlation 0.3**: Optimal performance with the highest correlation.

The diagrams display a clear trend indicating that higher correlation leads to better energy efficiency and reduced execution time. The ratio to the baseline is shown on both axes, with the y-axis representing the ratio and the x-axis showing the scenario numbers.

**Mapping Criteria**: The diagrams use different colors to represent various mapping criteria, allowing for a visual comparison of performance across different criteria.

**Scheduling Strategies**: The impact of different scheduling strategies is also visualized, emphasizing the effectiveness of energy-aware strategies on heterogeneous platforms.

**Analysis**: The analysis highlights the importance of choosing the right correlation and mapping criteria to optimize energy consumption and execution time effectively.
Energy-aware strategies on heterogeneous platforms

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

\[ \text{cor ag} = 0.25; \beta_{b/w} = 0.8; \text{Mapping criteria: random} \]
Energy-aware strategies on heterogeneous platforms

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

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

- \( \text{Baseline Work} \)
- \( \text{Ratio to the baseline} \)

- \( \text{scheduling:} \) LowerBound, energy-energy, energy-time, time-energy, randomShuffling

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

\[ R = 0.8 \]

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

\[ \text{Mapping criteria: inE} \]

\[ \text{Basic Work} \]

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

\[ \text{scheduling} \]

\[ \text{LowerBound} \]

\[ \text{energy-energy} \]

\[ \text{energy-time} \]

\[ \text{time-energy} \]

\[ \text{time-time} \]

\[ \text{randomShuffling} \]

RR n° 9324
$\sigma_{\text{task}} = 0.5$, $\beta_{\text{bin}} = 0.2$; Mapping criteria: deR
Energy-aware strategies on heterogeneous platforms

\[
R = 0.85
\]

\[
\text{cor}_{\text{proc}} = 0.5, \beta_{\text{w}} = 0.2, \text{Mapping criteria: deP}
\]

RR n° 9324
cor_{\text{task}} = 0.5; \beta_{b/w} = 0.4; \text{Mapping criteria: inE}
\( \text{cor}_{\text{task}} = 0.5; \beta_{\text{b/w}} = 0.4; \text{Mapping criteria: deR} \)
Energy-aware strategies on heterogeneous platforms

For $\text{cor}_{\text{task}} = 0.5$, $\beta_{b,w} = 0.6$; Mapping criteria: inE

<table>
<thead>
<tr>
<th>$R$</th>
<th>corr proc</th>
<th>corr proc</th>
<th>corr proc</th>
<th>corr proc</th>
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</thead>
<tbody>
<tr>
<td>0.8</td>
<td>0.5; $\beta_{b,w} = 0.6$; Mapping criteria: inE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.85</td>
<td>0.5; $\beta_{b,w} = 0.6$; Mapping criteria: inE</td>
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<td></td>
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</tr>
<tr>
<td>0.9</td>
<td>0.5; $\beta_{b,w} = 0.6$; Mapping criteria: inE</td>
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</tr>
<tr>
<td>0.95</td>
<td>0.5; $\beta_{b,w} = 0.6$; Mapping criteria: inE</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Basic Work

Ratio to the baseline

scheduling

LowerBound  energy-time  time-energy  randomShuffling

Energy aware strategies on heterogeneous platforms

382
cor_{task} = 0.5; \beta_{j,w} = 0.6; Mapping criteria: deR
\( \text{cor}_{\text{task}} = 0.5; \beta_{j,w} = 0.6; \text{Mapping criteria: deP} \)
$cor_{task} = 0.5; \beta_{j,w} = 0.6; $ Mapping criteria: random

<table>
<thead>
<tr>
<th>$R$</th>
<th>$\beta_{j,w}$</th>
<th>Mapping criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.8</td>
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<td>random</td>
</tr>
<tr>
<td>0.85</td>
<td>0.6</td>
<td>random</td>
</tr>
<tr>
<td>0.9</td>
<td>0.5</td>
<td>random</td>
</tr>
<tr>
<td>0.95</td>
<td>0.6</td>
<td>random</td>
</tr>
</tbody>
</table>

### Energy-aware scheduling

<table>
<thead>
<tr>
<th>Basic Work</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>0.10</td>
<td>0.10</td>
<td>0.20</td>
<td>0.30</td>
<td>0.40</td>
<td>0.50</td>
</tr>
<tr>
<td>0.15</td>
<td>0.15</td>
<td>0.25</td>
<td>0.35</td>
<td>0.45</td>
<td>0.55</td>
</tr>
<tr>
<td>0.20</td>
<td>0.20</td>
<td>0.30</td>
<td>0.40</td>
<td>0.50</td>
<td>0.60</td>
</tr>
<tr>
<td>0.25</td>
<td>0.25</td>
<td>0.35</td>
<td>0.45</td>
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<td>0.65</td>
</tr>
<tr>
<td>0.30</td>
<td>0.30</td>
<td>0.40</td>
<td>0.50</td>
<td>0.60</td>
<td>0.70</td>
</tr>
</tbody>
</table>

---

**Energy-aware strategies on heterogeneous platforms**

---

RR n 9324
Energy-aware strategies on heterogeneous platforms

\( \rho_{\text{task}} = 0.5, \beta_{\text{bw}} = 0.8; \) Mapping criteria: inE

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

\[ \text{cor}_{\text{task}} = 0.5; \ \beta_{b/w} = 0.8; \ \text{Mapping criteria: deR} \]
Energy-aware strategies on heterogeneous platforms

\( cor_{\text{task}} = 0.5; \ \beta_{b/w} = 0.8; \) Mapping criteria: random

![Graph showing energy-efficiency trade-offs for different scheduling algorithms and energy levels.](image-url)
Energy-aware strategies on heterogeneous platforms

cor_{task} = 0.5; \beta_{bw} = 1; Mapping criteria: inE

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

Ratio to the baseline

Basic Work

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

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

\begin{align*}
cor_{\text{task}} = 0.5; \quad \beta_{b/w} = 1; 
\text{Mapping criteria: deP}
\end{align*}

<table>
<thead>
<tr>
<th>$R$</th>
<th>$\mu$</th>
<th>$\nu$</th>
<th>$\lambda$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.8</td>
<td>0.70</td>
<td>0.80</td>
<td>0.80</td>
</tr>
<tr>
<td>0.85</td>
<td>0.70</td>
<td>0.80</td>
<td>0.80</td>
</tr>
<tr>
<td>0.9</td>
<td>0.70</td>
<td>0.80</td>
<td>0.80</td>
</tr>
<tr>
<td>0.95</td>
<td>0.70</td>
<td>0.80</td>
<td>0.80</td>
</tr>
</tbody>
</table>

\begin{itemize}
\item LowerBound
\item energy-energy
\item energy-time
\item time-energy
\item randomShuffling
\end{itemize}
Energy-aware strategies on heterogeneous platforms

\[ cor_{task} = 0.5; \beta_{j,w} = 1; \text{Mapping criteria: random} \]
Energy-aware strategies on heterogeneous platforms

\(c_{\text{runtask}} = 0.75; \beta_{b/w} = 0.2; \) Mapping criteria: deR

<table>
<thead>
<tr>
<th>(R)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.8</td>
</tr>
<tr>
<td>0.85</td>
</tr>
<tr>
<td>0.9</td>
</tr>
<tr>
<td>0.95</td>
</tr>
</tbody>
</table>

<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>0.10</td>
<td>0.15</td>
</tr>
<tr>
<td>0.10</td>
<td>0.15</td>
</tr>
<tr>
<td>0.10</td>
<td>0.15</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>$\cos_{\text{pre}}$</th>
<th>$\cos_{\text{pre}}$</th>
<th>$\cos_{\text{pre}}$</th>
<th>$\cos_{\text{pre}}$</th>
<th>$\cos_{\text{pre}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.40</td>
<td>0.50</td>
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<td>0.90</td>
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<td>20.10</td>
</tr>
<tr>
<td>1.10</td>
<td>1.80</td>
<td>2.70</td>
<td>20.00</td>
<td>20.40</td>
</tr>
</tbody>
</table>

$R = 0.8$; $\beta_{\text{b/w}} = 0.2$; Mapping criteria: deP
$cor_{task} = 0.75; \beta_{b/w} = 0.2; $ Mapping criteria: random
Energy-aware strategies on heterogeneous platforms

cor\_task = 0.75; \beta_{b/w} = 0.4; Mapping criteria: inE

Basic Work

Ratio to the baseline

LowerBound  energy-time  time-energy  randomShuffling

scheduling
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.75; \quad \beta_{b/w} = 0.4; \quad \text{Mapping criteria: deP} \]

\[ R = 0.8 \quad \text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{
### Energy-aware strategies on heterogeneous platforms

#### Table 1: Performance Comparison

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Schedule</th>
<th>Energy (J)</th>
<th>Time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpha</td>
<td>LowBound</td>
<td>0.70</td>
<td>0.80</td>
</tr>
<tr>
<td>Beta</td>
<td>LowBound</td>
<td>0.90</td>
<td>0.60</td>
</tr>
<tr>
<td>Correlated</td>
<td>LowBound</td>
<td>0.50</td>
<td>0.70</td>
</tr>
<tr>
<td>Random</td>
<td>LowBound</td>
<td>0.30</td>
<td>0.90</td>
</tr>
</tbody>
</table>

#### Figure 1: Performance Metrics

- **Correlation (R)**: The correlation coefficient between energy and time for different schedules.
- **Time-energy** and **Energy-time** axes show the trade-off between time and energy consumption.
- **Basic Work** is plotted against the ratio to the baseline.

---

RR n° 9324
Energy-aware strategies on heterogeneous platforms

$cor_{task} = 0.75; \beta_{b/w} = 0.6; \text{Mapping criteria: deR}$
Energy-aware strategies on heterogeneous platforms

cor\_{\text{task}} = 0.75; \beta_{b/w} = 0.6; \text{Mapping criteria: deP}
Energy-aware strategies on heterogeneous platforms

![Graph of energy consumption vs. various parameters]

- $R = 0.60$
- $R = 0.70$
- $R = 0.90$
- $R = 1.00$

- $cor_{prex} = 0$
- $cor_{prex} = 0.25$
- $cor_{prex} = 0.5$
- $cor_{prex} = 0.75$
- $cor_{prex} = 1$

- Basic Work
- Ratio to the baseline

- $cor_{max} = 0.75$, $\beta_{lw} = 0.8$, Mapping criteria: deR

- RandomShuffling
- LowerBound

- Energy-time
- Time-energy

RR n° 9324
Energy-aware strategies on heterogeneous platforms

![Chart showing energy comparison and mapping criteria](chart.png)
cor_{task} = 0.75; \beta_{b/w} = 0.8; \text{Mapping criteria: random}
Energy-aware strategies on heterogeneous platforms

![Graph and Table]

For the full context of the image, please refer to the original document.
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>$cor_{pren}$</th>
<th>$R$</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>$0.70$</td>
<td>$0.05$</td>
<td>$0.70$</td>
<td>$0.80$</td>
<td>$1.00$</td>
<td>$20.00$</td>
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<td>$0.05$</td>
<td>$0.80$</td>
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<td>$20.00$</td>
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<td>$1.60$</td>
<td>$2.30$</td>
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<td>$20.20$</td>
</tr>
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<td>$3.00$</td>
<td>$4.50$</td>
<td>$20.00$</td>
<td>$25.10$</td>
</tr>
</tbody>
</table>

$R = 0.85$

$R = 0.9$

$R = 0.95$

$cor_{task} = 0.75, \beta_{bw} = 1$; Mapping criteria: deR

Basic Work

Ratio to the baseline
Energy-aware strategies on heterogeneous platforms

$c_{\text{task}} = 0.75; \beta_w = 1$; Mapping criteria: deP
Energy-aware strategies on heterogeneous platforms

\[ R = 0.75; \beta_{b/w} = 1; \text{Mapping criteria: random} \]

\[ \text{cor}_{\text{task}} = 0.75; \beta_{b/w} = 1; \text{Mapping criteria: random} \]
Energy-aware strategies on heterogeneous platforms

\[ R = 0.8 \]

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

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

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

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

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

\[ \text{cor}_{\text{task}} = 1; \beta_{\text{uw}} = 0.2; \text{Mapping criteria: inE} \]

\[ \text{cor}_{\text{task}} = 1; \beta_{\text{uw}} = 0.2; \text{Mapping criteria: inE} \]

\[ \text{Basic Work} \]

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

\[ \text{scheduling} \]

\[ \text{LowerBound} \]

\[ \text{energy-time} \]

\[ \text{energy-energy} \]

\[ \text{time-energy} \]

\[ \text{time-time} \]

\[ \text{randomShuffling} \]
\( \text{corr}_{\text{task}} = 1; \ \beta_{b/w} = 0.2; \ \text{Mapping criteria: deR} \)

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

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

**Correlation (cor)**: values range from 0 to 1, indicating the strength of the correlation between performance and energy efficiency.

**Beta (β)**: values range from 0 to 1, influencing the mapping criteria.

**Mapping criteria**: deP = 1

**Baseline Work**: scheduling and mapping strategies for basic workloads.

**Lower Bound**: energy-time and time-energy trade-offs for lower bounds.

**Upper Bound**: energy-time and time-energy trade-offs for upper bounds.

**Random Shuffling**: a baseline scheduling approach for comparison.

**R**: correlation coefficient, showing the relationship between energy consumption and performance.

**RR n°**: reference number for the experiment or dataset.
$\rho_{\text{tot}} = 1; \beta_{\text{b/w}} = 0.2$; Mapping criteria: random

**Energy-aware strategies on heterogeneous platforms**

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

![Graph showing energy-aware strategies on heterogeneous platforms](image-url)
$c_{orr task} = 1; \beta_{b/w} = 0.4; \text{Mapping criteria: } \text{inE}$

Energy-aware strategies on heterogeneous platforms
\( \text{cor}_{\text{task}} = 1; \beta_{b/w} = 0.4; \text{Mapping criteria: deR} \)
Energy-aware strategies on heterogeneous platforms

cor\_task = 1; \beta_{b/w} = 0.4; Mapping criteria: deP

<table>
<thead>
<tr>
<th>R</th>
<th>cor_proc</th>
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</thead>
<tbody>
<tr>
<td>0.8</td>
<td>0.60</td>
</tr>
<tr>
<td>0.85</td>
<td>0.60</td>
</tr>
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<td>0.9</td>
<td>0.90</td>
</tr>
<tr>
<td>0.95</td>
<td>20.00</td>
</tr>
</tbody>
</table>

R = 0.85

<table>
<thead>
<tr>
<th>cor_proc</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.10</td>
</tr>
<tr>
<td>0.15</td>
</tr>
<tr>
<td>0.20</td>
</tr>
<tr>
<td>0.25</td>
</tr>
<tr>
<td>0.30</td>
</tr>
</tbody>
</table>

Basic Work

Ratio to the baseline

scheduling

LowerBound energy-energy energy-time time-energy randomShuffling
\( c_{or, \text{task}} = 1; \ \beta_{b/w} = 0.4; \ \text{Mapping criteria: random} \)
Energy-aware strategies on heterogeneous platforms

\[ R = 0.8 \]

\[ R = 0.85 \]

\[ R = 0.9 \]

\[ R = 0.95 \]

\[ \text{Basic Work} \]

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

\[ \text{scheduling} \]

\[ \text{LowerBound} \]

\[ \text{energy-energy} \]

\[ \text{energy-time} \]

\[ \text{time-energy} \]

\[ \text{time-time} \]

\[ \text{randomShuffling} \]

\[ \text{inE} \]

\[ \text{cor} = 1; \beta_{bu} = 0.6; \text{Mapping criteria: inE} \]

\[ \text{cor} = 0; \beta_{bu} = 0.6; \text{Mapping criteria: inE} \]

\[ \text{cor} = 0.25; \beta_{bu} = 0.6; \text{Mapping criteria: inE} \]

\[ \text{cor} = 0.5; \beta_{bu} = 0.6; \text{Mapping criteria: inE} \]

\[ \text{cor} = 0.75; \beta_{bu} = 0.6; \text{Mapping criteria: inE} \]

\[ \text{cor} = 1; \beta_{bu} = 0.6; \text{Mapping criteria: inE} \]
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{task} = 1; \beta_{b/w} = 0.6; \text{Mapping criteria: deP} \]
$cor_{task} = 1; \beta_{b/w} = 0.6; $ Mapping criteria: random

Basic Work

Ratio to the baseline

scheduling

LowerBound  energy-time  time-energy  randomShuffling
$corr_{task} = 1$; $\beta_{b/w} = 0.8$; Mapping criteria: inE
Energy-aware strategies on heterogeneous platforms

\[ R = 0.8 \]

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

**Task:** deR

**Mapping criteria:**

\[ \text{cor}_{\text{proc}} = 1; \beta_{\text{proc}} = 0.8; \text{Mapping criteria: deR} \]
Energy-aware strategies on heterogeneous platforms

```
R = 0.80

<table>
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<tr>
<th>cor[prev] = 0</th>
<th>cor[prev] = 0.25</th>
<th>cor[prev] = 0.5</th>
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</thead>
<tbody>
<tr>
<td>0.80</td>
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</tr>
<tr>
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<td>20.00</td>
<td>0.80</td>
</tr>
<tr>
<td>1.10</td>
<td>2.00</td>
<td>2.60</td>
<td>20.00</td>
<td>1.10</td>
</tr>
</tbody>
</table>
```

```
R = 0.90

<table>
<thead>
<tr>
<th>cor[prev] = 0</th>
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<td>20.00</td>
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</tr>
<tr>
<td>1.10</td>
<td>2.00</td>
<td>2.60</td>
<td>20.00</td>
<td>1.10</td>
</tr>
</tbody>
</table>
```

```
R = 0.95

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<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>0.80</td>
<td>0.80</td>
<td>1.10</td>
<td>20.00</td>
<td>0.80</td>
</tr>
<tr>
<td>0.80</td>
<td>1.20</td>
<td>1.80</td>
<td>20.00</td>
<td>0.80</td>
</tr>
<tr>
<td>1.10</td>
<td>2.00</td>
<td>2.60</td>
<td>20.00</td>
<td>1.10</td>
</tr>
</tbody>
</table>
```

```
cor[task] = 1; \beta_{bw} = 0.8; Mapping criteria: deP

Basic Work
```

RR n° 9324
Energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{task}} = 1; \ \beta_{b/w} = 0.8; \ \text{Mapping criteria: random} \)
$c_{\text{task}} = 1$; $\beta_{b/w} = 1$; Mapping criteria: inE

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

R = 0.8
R = 0.9
R = 0.95
cor proc = 0

cor proc = 0.25
cor proc = 0.5
cor proc = 0.75

cor proc = 1

Basic Work
Ratio to the baseline

time-space
time-energy
time-energy
time-space
time-space
time-energy
time-space
time-space
time-space
time-space
time-space
time-space
time-space
time-space
time-space
Energy-aware strategies on heterogeneous platforms

cor_{task} = 1; \beta_{b/w} = 1; Mapping criteria: deP

Ratio to the baseline
cor_{task} = 1; \beta_{b/w} = 1; Mapping criteria: random

Energy-aware strategies on heterogeneous platforms
\( \beta_{b/w} \) (Mapping)

The following section presents ratio of energy consumption using different mapping strategies under small failure rate when varying \( \beta_{b/w} \).
cor_{task} = 0; basicWork = 0.1; \mathcal{R} = 0.9

Energy-aware strategies on heterogeneous platforms
cor_{task} = 0; basicWork = 0.1; \mathcal{R} = 0.92
Energy-aware strategies on heterogeneous platforms

**Figure 1: Energy-time Performance**

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

**Legend:**
- Basic Work
- Basic Work + ∑p
- Basic Work + ∑p + mapping

**Metrics:**
- Ratio to the baseline
- Lower Bound
- R
- δp
- δR

**Parameters:**
- Cor task = 0, basicWork = 0.1; R = 0.94
Energy-aware strategies on heterogeneous platforms

corr = 0; basicWork = 0.1; $R = 0.96$

Ratio to the baseline

$\beta_{bw}$

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

![Diagram showing energy-aware strategies on heterogeneous platforms](image-url)
$\text{cor}_\text{task} = 0; \text{basicWork} = 0.2; R = 0.92$
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

cor\text{task} = 0; \text{basicWork} = 0.3; R = 0.9
$\text{cor}_{\text{task}} = 0; \text{basicWork} = 0.3; \mathcal{R} = 0.94$

Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms
$cor_{task} = 0$; $basicWork = 0.3$; $R = 0.98$
Energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{task}} = 0.25; \text{basicWork} = 0.1; R = 0.9 \)

\[ \text{task} = \text{basicWork} = 0.1; R = 0.9 \]

\[ \text{LowerBound} \]

\[ \text{drP} \]

\[ \text{drR} \]

\[ \text{inE} \]

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

\[ \text{cor}_\text{task} = 0.25; \text{basicWork} = 0.1; R = 0.94 \]
Energy-aware strategies on heterogeneous platforms

\[ \text{total} = 0.25; \text{basicWork} = 0.1; \mathcal{R} = 0.96 \]
cor_task = 0.25; basicWork = 0.1; \( R = 0.98 \)

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

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

Energy-aware strategies on heterogeneous platforms

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

\( \text{cor}_{\text{task}} = 0.25; \text{basicWork} = 0.2; \mathcal{R} = 0.9 \)
Energy-aware strategies on heterogeneous platforms

$\text{cor}_\text{task} = 0.25; \text{basicWork} = 0.2; R = 0.92$
$\text{cor}_{\text{task}} = 0.25; \text{basicWork} = 0.2; R = 0.94$

Ratio to the baseline

Energy-aware strategies on heterogeneous platforms

Mapping: LowerBound, deP, deR, inE, random
$\text{cor}_{\text{task}} = 0.25$; $\text{basicWork} = 0.2$; $R = 0.96$

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

\( \text{cor}_{\text{task}} = 0.25; \text{basicWork} = 0.2; \ R = 0.98 \)
Energy-aware strategies on heterogeneous platforms

cor\_task = 0.25; basic\_work = 0.3; R = 0.9

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

\[ \beta_{b/w} \]

LowerBound deP deR inE random
$cor_{task} = 0.25; basicWork = 0.3; R = 0.92$
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>energy-energy</th>
<th>energy-time</th>
<th>randomShuffling</th>
<th>time-energy</th>
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<td>cor proc = 1.0</td>
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</table>

Ratio to the baseline

- task = 0.25, basicWork = 0.3; R = 0.94

RR n° 9324
Energy-aware strategies on heterogeneous platforms

Cor proc = 0.25, basicWork = 0.3, R = 0.96

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

<table>
<thead>
<tr>
<th>cor proc</th>
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<table>
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<th>deP</th>
<th>deR</th>
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<tbody>
<tr>
<td>BasicWork = 0.25, basicWork = 0.3, R = 0.98</td>
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RR n° 9324
$\text{cor}_{\text{task}} = 0.5$; basicWork = 0.1; $\mathcal{R} = 0.9$
Energy-aware strategies on heterogeneous platforms

<table>
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<tr>
<th></th>
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Correlation between the baseline and the mapping of tasks to processors, R = 0.94.
Energy-aware strategies on heterogeneous platforms

cor_{task} = 0.5; basicWork = 0.1; \mathcal{R} = 0.96

\begin{align*}
\text{Ratio to the baseline} & \\
\beta_{b/w} & \\
\end{align*}

\begin{align*}
\text{Basic Work} & = 0.1; \\
\text{R} & = 0.96 \\
\end{align*}

\begin{align*}
cor_{proc} & = 0 \\
cor_{proc} & = 0.25 \\
cor_{proc} & = 0.5 \\
cor_{proc} & = 0.75 \\
cor_{proc} & = 1 \\
\end{align*}
$\text{cor}_{\text{task}} = 0.5; \text{basicWork} = 0.1; R = 0.98$
Energy-aware strategies on heterogeneous platforms

cor_task = 0.5; basicWork = 0.2; \mathcal{R} = 0.9
Energy-aware strategies on heterogeneous platforms

$cor_{\text{task}} = 0.5$; $basicWork = 0.2$; $R = 0.92$

<table>
<thead>
<tr>
<th>$cor_{\text{proc}}$</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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<tr>
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Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{task}} = 0.5; \text{basicWork} = 0.2; \mathcal{R} = 0.96 \)
Energy-aware strategies on heterogeneous platforms
cor_{task} = 0.5; basicWork = 0.3; \mathcal{R} = 0.9

\begin{align*}
\text{cor}_{proc} &= 0.00; \text{basicWork} = 0.3; \mathcal{R} = 0.9 \\
\text{cor}_{proc} &= 0.25; \text{basicWork} = 0.3; \mathcal{R} = 0.9 \\
\text{cor}_{proc} &= 0.5; \text{basicWork} = 0.3; \mathcal{R} = 0.9 \\
\text{cor}_{proc} &= 0.75; \text{basicWork} = 0.3; \mathcal{R} = 0.9 \\
\text{cor}_{proc} &= 1.00; \text{basicWork} = 0.3; \mathcal{R} = 0.9
\end{align*}
Energy-aware strategies on heterogeneous platforms

corr_{task} = 0.5; basicWork = 0.3; \mathcal{R} = 0.92

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

cor\textsubscript{task} = 0.5; basicWork = 0.3; R = 0.94
\(\text{\textit{cor}}_{\text{task}} = 0.5; \text{\textit{basicWork}} = 0.3; \mathcal{R} = 0.96\)
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>energy-energy</th>
<th>energy-time</th>
<th>randomShuffling</th>
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<th>time-time</th>
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Ratio to the baseline

RR n° 9324
$corr_{task} = 0.75; \text{BasicWork} = 0.1; R = 0.94$
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>energy-energy</th>
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<th>randomShuffling</th>
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Ratio to the baseline

LowerBound, deP, deR, inE, deP

mapping

RR n° 9324
$cor_{task} = 0.75; basicWork = 0.2; \mathcal{R} = 0.9$
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.75; \; \text{basicWork} = 0.2; \; R = 0.92 \]

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

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

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

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

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

Ratio to the baseline

Mapping

- LowerBound
- deP
- deR
- inE
- random
\( \text{cor}_{\text{task}} = 0.75; \) \( \text{basicWork} = 0.2; \) \( R = 0.94 \)

![Graph showing energy-time ratio for different \( \text{cor}_{\text{proc}} \) values](#)

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

**Legend:**
- "LowerBound"
- "dP"
- "dR"
- "inE"
- "random"
Energy-aware strategies on heterogeneous platforms

corr_task = 0.75; basicWork = 0.2; R = 0.96

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

\[ \beta_{bw} \]

\[ \text{LowerBound} \rightarrow \text{deP} \rightarrow \text{deR} \rightarrow \text{inE} \rightarrow \text{random} \]
Energy-aware strategies on heterogeneous platforms

cor\textsubscript{task} = 0.75; basicWork = 0.2; R = 0.98

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{energy-time}
\caption{Energy-time mapping}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{time-energy}
\caption{Time-energy mapping}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{time-time}
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\end{figure}

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\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{randomShuffling}
\caption{Random Shuffling}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{deP}
\caption{deP}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{deR}
\caption{deR}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{inE}
\caption{inE}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{random}
\caption{Random}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{LowerBound}
\caption{Lower Bound}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{energy-time}
\caption{Energy-time mapping}
\end{figure}

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\centering
\includegraphics[width=\textwidth]{randomShuffling}
\caption{Random Shuffling}
\end{figure}
Energy-aware strategies on heterogeneous platforms

cor\_task = 0.75; basic\_Work = 0.3; R = 0.9
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_\text{task} = 0.75; \text{basicWork} = 0.3; R = 0.92 \]

Task correlation: 0.75; basic work: 0.3; \( R = 0.92 \)
$\text{cor}_{\text{task}} = 0.75; \text{basicWork} = 0.3; R = 0.94$
Energy-aware strategies on heterogeneous platforms

corr\text{task} = 0.75; basic\text{Work} = 0.3; R = 0.96

\begin{align*}
corr_{\text{proc}} &= 0 \\
corr_{\text{proc}} &= 0.25 \\
corr_{\text{proc}} &= 0.50 \\
corr_{\text{proc}} &= 0.75 \\
corr_{\text{proc}} &= 1.00
\end{align*}

ratio to the baseline

$\beta_{\text{b/w}}$
\( \text{cor}_{\text{task}} = 0.75; \text{basicWork} = 0.3; \ R = 0.98 \)

<table>
<thead>
<tr>
<th>( \text{cor}_{\text{proc}} )</th>
<th>( \text{Ratio to the baseline} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>![Graph for ( \text{cor}_{\text{proc}} = 0 )]</td>
</tr>
<tr>
<td>0.25</td>
<td>![Graph for ( \text{cor}_{\text{proc}} = 0.25 )]</td>
</tr>
<tr>
<td>0.5</td>
<td>![Graph for ( \text{cor}_{\text{proc}} = 0.5 )]</td>
</tr>
<tr>
<td>0.75</td>
<td>![Graph for ( \text{cor}_{\text{proc}} = 0.75 )]</td>
</tr>
<tr>
<td>1</td>
<td>![Graph for ( \text{cor}_{\text{proc}} = 1 )]</td>
</tr>
</tbody>
</table>

**Legend:**
- mapping
- \( \text{LowerBound} \)
- \( \text{deP} \)
- \( \text{deR} \)
- \( \text{inE} \)
- random

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

\[ \text{cor}_{\text{task}} = 1; \text{basicWork} = 0.1; R = 0.92 \]

![Graph showing energy-aware strategies on heterogeneous platforms](image-url)
$c_{orr_{task}} = 1; \text{basicWork} = 0.1; R = 0.94$
$cor_{\text{task}} = 1; \ basicWork = 0.1; \ R = 0.96$

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

corr_task = 1; basicWork = 0.1; \( R = 0.98 \)
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

cor\textsubscript{task} = 1; basic\textit{Work} = 0.2; \textit{R} = 0.92

\begin{figure}
\centering
\includegraphics[width=\textwidth]{energy-time}
\end{figure}
Energy-aware strategies on heterogeneous platforms

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>
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<tr>
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<td>Correlation</td>
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<td>ρ = 1</td>
<td>ρ = 0.75</td>
<td>ρ = 0.5</td>
<td>ρ = 0.25</td>
<td>ρ = 0.0</td>
</tr>
</tbody>
</table>

<table>
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<th>R = 0.00</th>
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<tbody>
<tr>
<td>Basic Work</td>
<td>0.2</td>
<td>0.2</td>
<td>0.98</td>
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</tbody>
</table>

**Figure**: Correlation coefficient β between energy and time for different mapping strategies and task weights.

**Legend**:
- deP: Lower Bound mapping
- deR: Random mapping
- inE: Task Mapping

**Notes**:
- ρ: Correlation coefficient
- R: Mapping efficiency ratio to the baseline

RR n° 9324
cor\_task = 1; basicWork = 0.2; \( R = 0.98 \)
Energy-aware strategies on heterogeneous platforms

corr_task = 1; basicWork = 0.3; R = 0.9
Energy-aware strategies on heterogeneous platforms

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

\( \text{cor}_{\text{task}} = 1; \text{basicWork} = 0.3; \ R = 0.94 \)

<table>
<thead>
<tr>
<th>( \text{cor}_{\text{proc}} )</th>
<th>( \text{Ratio to the baseline} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.50</td>
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<tr>
<td>0.25</td>
<td>0.50</td>
</tr>
<tr>
<td>0.5</td>
<td>0.50</td>
</tr>
<tr>
<td>0.75</td>
<td>0.50</td>
</tr>
<tr>
<td>1.0</td>
<td>0.50</td>
</tr>
</tbody>
</table>

Mapping: LowerBound, deP, deR, inE, random
\( \text{cor}_{\text{task}} = 1; \text{basicWork} = 0.3; R = 0.96 \)
Energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{task}} = 1; \text{basicWork} = 0.3; R = 0.98 \)
\( \beta_{b/w} \) (Scheduling)

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

### Table: Energy-performance metrics for different scheduling strategies

<table>
<thead>
<tr>
<th>Scenario</th>
<th>dpP</th>
<th>dpR</th>
<th>inE</th>
<th>random</th>
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<tr>
<td>cor Proc</td>
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<td>inE</td>
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<tr>
<td>random</td>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
</tr>
</tbody>
</table>

### Diagram: Visualization of scheduling strategies

- **Baseline**: Constant time-energy trade-off
- **Random Shuffling**: Randomized time-energy trade-off
- **Energy-aware Scheduling**: Adaptive time-energy trade-off

**Legend**:
- Green: Lower bound on energy
- Red: Energy consumed
- Blue: Time consumed
- Yellow: Time-energy trade-off

**Metrics**:
- **Ratio to the baseline**: Performance relative to a baseline scenario
- **Energy-performance metrics** for different error percentages

**Note**: The diagram illustrates the performance trade-offs for various scheduling strategies under different error scenarios.
Energy-aware strategies on heterogeneous platforms

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

\[ \text{cor}_{\text{task}} = 0; \text{basicWork} = 0.1; R = 0.94 \]
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>Method</th>
<th>Energy-Time</th>
<th>Time-Energy</th>
<th>Random Shuffling</th>
<th>Lower Bound</th>
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<tbody>
<tr>
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<tr>
<td>inE</td>
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</tr>
<tr>
<td>random</td>
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</tbody>
</table>

**Figure:** Graph showing the ratio to the baseline for different methods and energy-time, time-energy, random shuffling, lower bound. The x-axis represents the ratio to the baseline, and the y-axis represents different energy levels (0.00, 0.25, 0.50, 0.75, 1.00). The methods are deP, deR, inE, and random. The graphs are color-coded to represent different energy levels.
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th></th>
<th>deP</th>
<th>deR</th>
<th>naE</th>
<th>random</th>
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<tr>
<td>corproc = 0.5</td>
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<tr>
<td>corproc = 0.25</td>
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</tbody>
</table>

Ratio to the baseline

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

\( \beta_{bw} = 0; \) basicWork = 0.1; \( R = 0.98 \)
Energy-aware strategies on heterogeneous platforms

$cor_{\text{task}} = 0$; $basicWork = 0.2$; $R = 0.9$

Ratio to the baseline

- LowerBound
- Energy-time
- Time-energy
- RandomShuffling

$scheduling$

- Energy-energy
- Time-time
- RandomShuffling
\( \text{cor}_{\text{task}} = 0; \text{basicWork} = 0.2; \ R = 0.92 \)
Energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{task}} = 0; \text{basicWork} = 0.2; R = 0.94 \)

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

\( \beta_{b/w} \)

Ratio to the baseline

\( \text{scheduling} \)

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

\( \text{cor}_{\text{task}} = 0; \, \text{basicWork} = 0.2; \, R = 0.96 \)

<table>
<thead>
<tr>
<th>\text{cor}_{\text{proc}}</th>
<th>\text{Ratio to the baseline}</th>
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<tbody>
<tr>
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<tr>
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</table>

\( \beta_{bw} \)
Energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{task}} = 0; \text{basicWork} = 0.2; R = 0.98 \)

<table>
<thead>
<tr>
<th>( \text{cor}_{\text{proc}} )</th>
<th>( \beta_{\text{bw}} )</th>
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</thead>
<tbody>
<tr>
<td>0</td>
<td>0.00</td>
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<tr>
<td></td>
<td>0.25</td>
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<tr>
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<td></td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>1.00</td>
</tr>
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\( \text{cor}_{\text{proc}} = 0 \)

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

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

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

\( \text{cor}_{\text{proc}} = 1 \)

\( \text{R} = 0.98 \)

\( \text{scheduling} \)

LowerBound, energy-time, time-energy
$cor_{\text{task}} = 0; \ basicWork = 0.3; \ R = 0.9$

<table>
<thead>
<tr>
<th>$cor_{\text{proc}}$</th>
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<tbody>
<tr>
<td>0.00</td>
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<tr>
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<td>1.00</td>
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<tr>
<td>0.50</td>
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<table>
<thead>
<tr>
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<th>0.6</th>
<th>0.8</th>
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<tr>
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</tbody>
</table>

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

corr_task = 0; basicWork = 0.3; R = 0.94

Ratio to the baseline

β/b

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

<table>
<thead>
<tr>
<th>deP</th>
<th>deR</th>
<th>mE</th>
<th>random</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="chart1.png" alt="Chart" /></td>
<td><img src="chart2.png" alt="Chart" /></td>
<td><img src="chart3.png" alt="Chart" /></td>
<td><img src="chart4.png" alt="Chart" /></td>
</tr>
</tbody>
</table>

The charts above illustrate the performance of different scheduling mechanisms for energy-aware strategies on heterogeneous platforms. The x-axis represents the ratio to the baseline, while the y-axis shows the energy consumption. Each chart compares the energy-efficiency of different scheduling approaches under varying conditions, highlighting the trade-offs between energy and performance.

<table>
<thead>
<tr>
<th>Method</th>
<th>Energy-Time</th>
<th>Time-Energy</th>
<th>RandomShuffling</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEP</td>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
</tr>
<tr>
<td>DEP+</td>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
</tr>
<tr>
<td>DEP++</td>
<td>0.00</td>
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<td>0.50</td>
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</tbody>
</table>

The charts use different colors to represent different conditions, aiding in the visualization of performance metrics such as energy consumption and task completion times. The comparison helps in understanding the effectiveness of each strategy in balancing energy usage and computational efficiency.
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>deP</th>
<th>deR</th>
<th>inE</th>
<th>random</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
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</tr>
<tr>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
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<tr>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Ratio to the baseline
Energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{task}} = 0.25; \text{basicWork} = 0.1; \mathcal{R} = 0.92 \)
Energy-aware strategies on heterogeneous platforms

cor\textsubscript{task} = 0.25; basicWork = 0.1; R = 0.94
Energy-aware strategies on heterogeneous platforms

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

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

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

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

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

\[ \text{deP} \]

\[ \text{deR} \]

\[ \text{naE} \]

\[ \text{random} \]

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

\[ \text{scheduling} \]

\[ \text{LowerBound} \]

\[ \text{energy-energy} \]

\[ \text{energy-time} \]

\[ \text{time-energy} \]

\[ \text{randomShuffling} \]

\[ \beta_{\text{bw}} \]

\[ \text{RR} n^\circ 9324 \]
Energy-aware strategies on heterogeneous platforms

![Graph showing energy consumption and runtime for different strategies]
<table>
<thead>
<tr>
<th>cor</th>
<th>proc</th>
<th>deP</th>
<th>deR</th>
<th>naE</th>
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</table>

Ratio to the baseline energy-time scheduling randomShuffling
Energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{task}} = 0.25; \text{basicWork} = 0.2; \mathcal{R} = 0.92 \)
Energy-aware strategies on heterogeneous platforms

Cor proc = 0.00
Cor proc = 0.25
Cor proc = 0.50
Cor proc = 0.75
Cor proc = 1.00

β/bw
Ratio to the baseline
scheduling
LowerBound
energy-energy
time-energy
time-time
randomShuffling

Cor task = 0.25, basicWork = 0.2; R = 0.44
Energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{task}} = 0.25; \text{basicWork} = 0.2; R = 0.96 \)
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.25; \text{basicWork} = 0.2; R = 0.98 \]
\( \text{cor}_{\text{Task}} = 0.25; \text{basicWork} = 0.3; \mathcal{R} = 0.9 \)
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>deP</th>
<th>deR</th>
<th>inE</th>
<th>random</th>
</tr>
</thead>
<tbody>
<tr>
<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>
</tr>
</tbody>
</table>

**Correlation and Proc:**
- cor proc = 0.10
- cor proc = 0.25
- cor proc = 0.50
- cor proc = 0.75
- cor proc = 1.00

**Ratio to the baseline:**
- deP: 0
- deR: 0
- inE: 0
- random: 0

**Lower Bound:**
- deP: 0
- deR: 0
- inE: 0
- random: 0

**Energy-Time:**
- deP: 0
- deR: 0
- inE: 0
- random: 0

**Time-Energy:**
- deP: 0
- deR: 0
- inE: 0
- random: 0

**RandomShuffling:**
- deP: 0
- deR: 0
- inE: 0
- random: 0

**β:**
- deP: 0
- deR: 0
- inE: 0
- random: 0

**RR:**
- 0

RR n° 9324
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>cor_{task} = 0.25; basicWork = 0.3; R = 0.94</th>
</tr>
</thead>
<tbody>
<tr>
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<tr>
<td>cor_{proc} = 0.25</td>
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<td>cor_{proc} = 0.5</td>
</tr>
<tr>
<td>cor_{proc} = 0.75</td>
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<tr>
<td>cor_{proc} = 1</td>
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Ratio to the baseline
$cor_{\text{task}} = 0.25; \ basicWork = 0.3; \ R = 0.96$

Ratio to the baseline

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

scheduling

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

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

<table>
<thead>
<tr>
<th>cor proc</th>
<th>cor proc</th>
<th>cor proc</th>
<th>cor proc</th>
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<tbody>
<tr>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
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<tr>
<td>1.00</td>
<td>1.25</td>
<td>1.50</td>
<td>1.75</td>
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<table>
<thead>
<tr>
<th>deP</th>
<th>deR</th>
<th>inE</th>
<th>random</th>
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<tbody>
<tr>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
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</tbody>
</table>

Ratio to the baseline

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

BasicWork = 0.3; R = 0.48

RR n° 9324
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>Correlation</th>
<th>Random</th>
<th>Correlation</th>
<th>Random</th>
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<tbody>
<tr>
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Ratio to the baseline

<table>
<thead>
<tr>
<th>Correlation</th>
<th>Random</th>
<th>Correlation</th>
<th>Random</th>
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</thead>
<tbody>
<tr>
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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
Energy-aware strategies on heterogeneous platforms

cor\_task = 0.5; basic\_Work = 0.1; \mathcal{R} = 0.98

<table>
<thead>
<tr>
<th>(cor_proc)</th>
<th>LowerBound</th>
<th>energy_time</th>
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</tbody>
</table>

\text{b/w Ratio to the baseline}
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.5; \text{basicWork} = 0.2; R = 0.9 \]
**Energy-aware strategies on heterogeneous platforms**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>deP</th>
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<td>corProc = 0.5</td>
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<td><img src="image6.png" alt="Graph" /></td>
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<td><img src="image11.png" alt="Graph" /></td>
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</tr>
<tr>
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<td><img src="image14.png" alt="Graph" /></td>
<td><img src="image15.png" alt="Graph" /></td>
<td><img src="image16.png" alt="Graph" /></td>
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</tbody>
</table>

**Diagram Notes:**
- The x-axis represents the ratio to the baseline.
- The y-axis represents the energy-time and time-energy lower bounds.
- The labels deP, deR, naE, and random refer to different energy-aware strategies.

**Table:**
<table>
<thead>
<tr>
<th>corProc</th>
<th>deP</th>
<th>deR</th>
<th>naE</th>
<th>random</th>
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<td><img src="image3.png" alt="Graph" /></td>
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<tr>
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<td><img src="image7.png" alt="Graph" /></td>
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<td><img src="image15.png" alt="Graph" /></td>
<td><img src="image16.png" alt="Graph" /></td>
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**Equations:**
- \( \text{corProc} = 0.5 \), basicWork = 0.2, \( R = 0.92 \)
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>cor_{prev} = 1</th>
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<td>random</td>
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<tr>
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<td>cor_{task} = 0.5, basicWork = 0.2, R = 0.94</td>
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<table>
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<th>time-time</th>
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<td>1.75</td>
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</tbody>
</table>

RR n° 9324
Energy-aware strategies on heterogeneous platforms


cor proc = 0.00

cor proc = 0.25

cor proc = 0.50

cor proc = 0.75

cor proc = 1.00

cor proc = 1.25

cor proc = 1.50

cor proc = 1.75

cor proc = 2.00

\( \beta \) b/w

Ratio to the baseline

scheduling

LaxBound

energy-time

time-energy

randomShuffling

basicWork = 0.2; \( R = 0.98 \)

\( \text{cor task} = 0.5 \), basicWork = 0.2; \( R = 0.98 \)

RR n° 9324
Energy-aware strategies on heterogeneous platforms

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

Ratio to the baseline

- \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

\( \beta_{b/w} \)

- \text{scheduling}
- \text{LowerBound}
- \text{energy-energy}
- \text{energy-time}
- \text{time-energy}
- \text{randomShuffling}
cor\_task = 0.5; basicWork = 0.3; R = 0.92

<table>
<thead>
<tr>
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<th>LowerBound</th>
<th>energy-time</th>
<th>time-energy</th>
<th>randomShuffling</th>
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Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

Graph showing the comparison of different energy-aware strategies on heterogeneous platforms. The graph includes bar charts for various scheduling methods such as deP, deR, and random, with different error values (err_\text{err} = 1, 0.75, 0.5, 0.25) and baseline workloads (\text{bas} \text{work} = 0.5, 0.3, 0.2). The x-axis represents the ratio to the baseline, and the y-axis represents the performance metric with error bars indicating standard deviation.
$\text{cor}_{\text{task}} = 0.5; \text{basicWork} = 0.3; \mathcal{R} = 0.96$

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

\( \text{cor}_{\text{task}} = 0.5; \ \text{basicWork} = 0.3; \ \mathcal{R} = 0.98 \)
Energy-aware strategies on heterogeneous platforms

$\text{cor}_{\text{task}} = 0.75$; $\text{basicWork} = 0.1$; $\mathcal{R} = 0.9$

Ratios to the baseline

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

scheduling

556
Energy-aware strategies on heterogeneous platforms

<table>
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<tr>
<th>corR</th>
<th>corP</th>
<th>corE</th>
<th>corD</th>
<th>corR</th>
<th>corP</th>
<th>corE</th>
<th>corD</th>
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<td>0.00</td>
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</tr>
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</table>

corR: energy-time; corP: energy-energy; corE: time-energy; corD: time-time.
Energy-aware strategies on heterogeneous platforms

cor_{task} = 0.75; basicWork = 0.1; \mathcal{R} = 0.94
energy-aware strategies on heterogeneous platforms

\( \text{corr}_{\text{task}} = 0.75; \ \text{basicWork} = 0.1; \ \mathcal{R} = 0.96 \)

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

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

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

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

\( \text{corr}_{\text{proc}} = 1 \)

\( \text{Ratio to the baseline} \)

\( \text{LowerBound} \)

\( \text{energy-energy} \)

\( \text{time-energy} \)

\( \text{time-time} \)

\( \text{randomShuffling} \)

\( \beta_{\text{bw}} \)
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.75; \text{basicWork} = 0.1; \mathcal{R} = 0.98 \]
$\text{cor}_{\text{task}} = 0.75$; $\text{basicWork} = 0.2$; $\mathcal{R} = 0.9$

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

cor\textsubscript{task} = 0.75; basicWork = 0.2; \R = 0.92
$cor_{task} = 0.75\,; basicWork = 0.2\,; R = 0.94$
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>deP</th>
<th>deR</th>
<th>inE</th>
<th>random</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.10</td>
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<td>20.00</td>
<td>20.00</td>
<td>20.00</td>
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<tr>
<td>cor proc = 0.75;</td>
<td>cor proc = 0.25;</td>
<td>cor proc = 0.5;</td>
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<tr>
<td>cor proc = 0;</td>
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<tr>
<td>cor proc = 1;</td>
<td>cor proc = 1;</td>
<td>cor proc = 1;</td>
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</tr>
</tbody>
</table>

- cor proc: Correlation Proportion
- deP: Delayed Preemption
- deR: Delayed Release
- inE: Inactive Energy
- Random Shuffling

Ratio to the baseline
scheduling
energy-energy
energy-time
time-energy
time-time

β

R = 0.96
### Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>cor proc</th>
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<td>cor proc 0.25</td>
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<tr>
<td>cor proc 0.0</td>
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</table>

**Ratio to the baseline**

- energy-energy
- energy-time
- time-energy
- time-time

- basicWork = 0.2; R = 0.48
- task = 0.75

RR n° 9324
\( \text{cor}_{\text{task}} = 0.75; \text{basicWork} = 0.3; R = 0.9 \)

<table>
<thead>
<tr>
<th>( \text{cor}_{\text{proc}} )</th>
<th>( \text{Ratio to the baseline} )</th>
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</thead>
<tbody>
<tr>
<td>0</td>
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<td>0.25</td>
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<td>0.5</td>
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<td>1.00</td>
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Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

0.10 0.10 0.10 0.10 0.10 0.10
0.20 0.20 0.20 0.20 0.20 0.20
0.30 0.30 0.30 0.30 0.30 0.30
0.40 0.40 0.40 0.40 0.40 0.40
0.50 0.50 0.50 0.50 0.50 0.50
0.60 0.60 0.60 0.60 0.60 0.60
0.70 0.70 0.70 0.70 0.70 0.70
0.80 0.80 0.80 0.80 0.80 0.80
0.90 0.90 0.90 0.90 0.90 0.90
1.00 1.00 1.00 1.00 1.00 1.00

RR n° 9324
Energy-aware strategies on heterogeneous platforms

cor_{task} = 0.75; basicWork = 0.3; R = 0.98
$cor_{task} = 1; \ basicWork = 0.1; \ R = 0.9$

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>deP</th>
<th>deR</th>
<th>iaE</th>
<th>random</th>
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<tr>
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<tr>
<td>deP</td>
<td>deR</td>
<td>iaE</td>
<td>random</td>
</tr>
</tbody>
</table>

**Crowd**

- cor proc = 0
- cor proc = 0.25
- cor proc = 0.5
- cor proc = 0.75
- cor proc = 1

**Benchmark**

- baseline: 0.1; R = 0.94
- baseline: 0.1; R = 0.94
- baseline: 0.1; R = 0.94
- baseline: 0.1; R = 0.94

**Scheduling**

- energy-energy: 0.2, 0.4, 0.6, 0.8, 1.0
- energy-time: 0.2, 0.4, 0.6, 0.8, 1.0
- time-energy: 0.2, 0.4, 0.6, 0.8, 1.0
- time-time: 0.2, 0.4, 0.6, 0.8, 1.0

**Results**

- deP
- deR
- iaE
- random

**Legend**

- deP
- deR
- iaE
- random

<table>
<thead>
<tr>
<th>Ratio to the baseline</th>
<th>deP</th>
<th>deR</th>
<th>iaE</th>
<th>random</th>
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<td>0.8</td>
<td>1.0</td>
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<td>0.8</td>
<td>1.0</td>
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<tr>
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<td>0.8</td>
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<td>1.2</td>
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<tr>
<td>1.0</td>
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<td>1.4</td>
<td>1.6</td>
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RR n° 9324
Energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{task}} = 1; \text{basicWork} = 0.1; R = 0.96 \)
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>ε</th>
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<th>deR</th>
<th>inE</th>
<th>random</th>
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<td>ε cor proc = 1</td>
<td><img src="image1" alt="Graph" /></td>
<td><img src="image2" alt="Graph" /></td>
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<td><img src="image4" alt="Graph" /></td>
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<td>ε cor proc = 0.75</td>
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<td><img src="image14" alt="Graph" /></td>
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<td><img src="image16" alt="Graph" /></td>
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ββ

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<td><img src="image32" alt="Graph" /></td>
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RR n° 9324
\[ \text{cor}_{\text{task}} = 1; \text{cor}_{\text{proc}} = 0.2; \mathcal{R} = 0.9 \]

**Energy-aware strategies on heterogeneous platforms**
Energy-aware strategies on heterogeneous platforms
\[ \text{cor}_{\text{task}} = 1; \text{basicWork} = 0.2; \mathcal{R} = 0.94 \]
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>deP</th>
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<th>mE</th>
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β/bwRatio to the baseline

scheduling: LowerBound

cor: basicWork = 0.2, R = 0.96

RR n° 9324
Energy-aware strategies on heterogeneous platforms

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

cor_{task} = 1; basicWork = 0.3; R = 0.9
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 1; \text{basicWork} = 0.3; R = 0.92 \]

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

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

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

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

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

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

\[ \text{scheduling} \]

\[ \text{LowerBound} \]

\[ \text{energy-time} \]

\[ \text{time-energy} \]

\[ \text{time-time} \]

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

cor\textsubscript{task} = 1; basicWork = 0.3; R = 0.94

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<td>time-time</td>
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\textbf{LowerBound}\hspace{1cm} basicWork = 0.3.3; R = 0.94
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{task}} = 1; \text{basicWork} = 0.3; R = 0.98 \)

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

Ratio to the baseline

\( \beta_{b/w} \)

LowerBound  energy-time  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 $cor_{task}$. 

RR n° 9324
\[ \beta_{b/w} = 0.2; \quad \text{basicWork} = 0.1; \quad R = 0.9 \]

Energy-aware strategies on heterogeneous platforms

Processor correlation vs. mapping

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

- Energy-energy
- Energy-time
- RandomShuffling
- Time-energy
- Time-time

\[ \beta_{\text{hw}} = 0.2, \text{basicWork} = 0.1; R = 0.92 \]

RR n° 9324
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.2; \ basicWork = 0.1; \ R = 0.94 \]

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

$\beta_{b/w} = 0.2; \text{basicWork} = 0.1; \mathcal{R} = 0.96$

Ratio to the baseline

Processor correlation

mapping

LowerBound deP deR inE random

RR n° 9524
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.2; \, basicWork = 0.2; \, R = 0.9 \]
\( \beta_{b/w} = 0.2; \ basicWork = 0.2; \ R = 0.92 \)
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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</table>

### Processor correlation

- Ratio to the baseline

- LowerBound, deP, deR, inE, random

- \( \beta_{h_0} = 0.2 \), \( \text{basicW} \in [0.2; R = 0.94] \)

RR n° 9324
Energy-aware strategies on heterogeneous platforms
$\beta_{b/w} = 0.2; \ basicWork = 0.3; \ R = 0.9$
$\beta_{b/w} = 0.2; \text{basicWork} = 0.3; R = 0.92$

Processor correlation

Ratio to the baseline

mapping

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

$$\beta_{b/\alpha} = 0.2; \text{basicWork} = 0.3; R = 0.96$$

<table>
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Processor correlation

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</tbody>
</table>
Energy-aware strategies on heterogeneous platforms
\( \beta_{b/w} = 0.4; \ basicWork = 0.1; \ R = 0.9 \)
Energy-aware strategies on heterogeneous platforms

\( \beta_{b/w} = 0.4; \) basicWork = 0.1; \( R = 0.92 \)

---

Processor correlation

Ratio to the baseline

\( \text{cor}_{\text{task}} = 0 \)
\( \text{cor}_{\text{task}} = 0.25 \)
\( \text{cor}_{\text{task}} = 0.5 \)
\( \text{cor}_{\text{task}} = 0.75 \)
\( \text{cor}_{\text{task}} = 1 \)

---

Mapping:
- LowerBound
- deP
- deR
- inE
- random

---

Energy-aware strategies on heterogeneous platforms

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Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.4; \quad basicWork = 0.1; \quad R = 0.96 \]

![Graph showing the ratio to the baseline versus processor correlation for different values of \( \text{cor}_{\text{task}} \).](image-url)
\[ \beta_{b/w} = 0.4; \ basicWork = 0.1; \ R = 0.98 \]
Energy-aware strategies on heterogeneous platforms

- Correlation between task and processor correlation
- Ratio to the baseline
- LowerBound
- deP, deR, inE

- Processor correlation
- Correlation between task and processor correlation
- Ratio to the baseline
- LowerBound
- deP, deR, inE

- Processor correlation
- Correlation between task and processor correlation
- Ratio to the baseline
- LowerBound
- deP, deR, inE

- Processor correlation
- Correlation between task and processor correlation
- Ratio to the baseline
- LowerBound
- deP, deR, inE

- Processor correlation
- Correlation between task and processor correlation
- Ratio to the baseline
- LowerBound
- deP, deR, inE
Energy-aware strategies on heterogeneous platforms

$\beta_{b/w} = 0.4; \ basicWork = 0.2; \ R = 0.92$

![Graph showing energy-time and time-energy correlations with processor correlation]
\[ \beta_{b/w} = 0.4; \text{basicWork} = 0.2; \mathcal{R} = 0.94 \]

<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>
<th>0.00</th>
<th>0.25</th>
<th>0.50</th>
<th>0.75</th>
<th>1.00</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>
<td>Ratio to the baseline</td>
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<td>1.00</td>
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<td>0.50</td>
<td>0.25</td>
<td>1.25</td>
<td>1.00</td>
<td>0.75</td>
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<td>1.00</td>
<td>0.75</td>
<td>0.50</td>
<td>0.25</td>
</tr>
</tbody>
</table>

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

Correlation matrix for Processor correlation

Ratio to the baseline

LowerBound

RandomShuffling

Time-energy

Time-time

\[ \beta_{b/w} = 0.4; \text{basicWork} = 0.2; R = 0.96 \]
Energy-aware strategies on heterogeneous platforms

$\beta_{b/w} = 0.4; \ basicWork = 0.2; \ R = 0.98$
Energy-aware strategies on heterogeneous platforms

Verbosity:

\[ \text{Verbosity} = \beta_{\text{W}} = 0.4; \text{basicW} = 0.3; R = 0.9 \]

\[ \text{Processor correlation} = \beta_{\text{R}} \]

\[ \text{Random Shuffling} = \text{random} \]

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

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

\[ \text{Energy-energy} = \text{energy-energy} \]

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

\[ \text{Upper Bound} = \text{Upper Bound} \]

\[ \text{Lower Bound} = \text{Lower Bound} \]

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

\[ \text{deP} = \text{deP} \]

\[ \text{deR} = \text{deR} \]

\[ \text{inE} = \text{inE} \]

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

\( \beta_{b/w} = 0.4; \) basicWork = 0.3; \( R = 0.92 \)

Ratio to the baseline

Processor correlation

mapping

LowerBound \( \delta P \) \( \delta R \) inE random
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>Mapping</th>
<th>Processor correlation</th>
<th>Mapping</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
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<tr>
<td>0.25</td>
<td>0.25</td>
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<tr>
<td>0.50</td>
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<tr>
<td>0.75</td>
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<td>0.75</td>
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<tr>
<td>1.00</td>
<td>1.00</td>
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<tr>
<td>1.25</td>
<td>1.25</td>
<td>1.25</td>
<td>1.25</td>
</tr>
</tbody>
</table>

β_{W_{0}} = 0.4; basicWork = 0.3; R = 0.94

RR n° 9324
Energy-aware strategies on heterogeneous platforms

β_{b/w} = 0.4; basicWork = 0.3; R = 0.96
Energy-aware strategies on heterogeneous platforms

Correlation factors:
- Correlation of energy with energy
- Correlation of energy with time
- Correlation of random to energy
- Correlation of random to time

Ratio to the baseline:
- Basic work
- R

Processor correlation:
- Lower Bound
- deP
- deR
- inE
- random

Reference:
- \( \beta_{\text{tot}} = 0.6 \)
- Basic Work \( c_1 = 0.1 \)
- R = 0.9

Legend:
- Correlation of energy with energy
- Correlation of energy with time
- Correlation of random to energy
- Correlation of random to time

Comparison between correlation factors:
- Correlation of energy with energy
- Correlation of energy with time
- Correlation of random to energy
- Correlation of random to time

RR n° 9324
Energy-aware strategies on heterogeneous platforms

$\beta_{b/w} = 0.6; \text{basicWork} = 0.1; R = 0.92$

<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>$\text{cor}_{\text{task}} = 0$</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>$0.00$</td>
<td>$0.25$</td>
<td>$0.50$</td>
<td>$0.75$</td>
<td>$1.00$</td>
</tr>
</tbody>
</table>

Mapping: LowerBound, deP, deR, mE, random
\( \beta_{b/w} = 0.6; \ basicWork = 0.1; \ R = 0.94 \)
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/u} = 0.6; \text{basicWork} = 0.1; \mathcal{R} = 0.96 \]
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>corr_task = 1</td>
<td>corr_task = 0.1</td>
<td>corr_task = 0.05</td>
<td>corr_task = 0.25</td>
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</tr>
<tr>
<td>corr_task = 0.75</td>
<td>corr_task = 0.5</td>
<td>corr_task = 0.5</td>
<td>corr_task = 0.25</td>
<td>corr_task = 0.0</td>
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<tr>
<td>corr_task = 1</td>
<td>corr_task = 1</td>
<td>corr_task = 1</td>
<td>corr_task = 1</td>
<td>corr_task = 1</td>
</tr>
</tbody>
</table>

Processor correlation

Baseline to the baseline

\( \beta_{W0} = 0.6, \text{ basicWork } h_k = 0.1, \ R = 0.98 \)}

RR n° 9324
Energy-aware strategies on heterogeneous platforms

0.10
0.10
0.10
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$eta_{	ext{bw}} = 0.6$, basicWork/k = 0.2; $R = 0.9$
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>
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<td>Ratio to the baseline</td>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
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<tr>
<td></td>
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<td>0.75</td>
<td>1.00</td>
</tr>
</tbody>
</table>

β \_b/w = 0.6, basicW = 0.2; R = 0.92

RR n° 9324
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>energy-energy</th>
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<th>time-energy</th>
<th>time-time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ratio to the baseline</td>
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<td></td>
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<tr>
<td>deP</td>
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</tbody>
</table>

Processor correlation

\[ \beta_{\text{cor}} = 0.6, \ \text{basicWor} = 0.2; \ R = 0.94 \]

\[ R \approx 0.9324 \]
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>
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<td>corr task 0.50</td>
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<tr>
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<td>corr task 0.20</td>
<td>corr task 0.30</td>
<td>corr task 0.40</td>
<td>corr task 0.50</td>
<td>corr task 0.60</td>
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<tr>
<td>corr task 0.20</td>
<td>corr task 0.30</td>
<td>corr task 0.40</td>
<td>corr task 0.50</td>
<td>corr task 0.60</td>
<td>corr task 0.70</td>
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<tr>
<td>corr task 0.30</td>
<td>corr task 0.40</td>
<td>corr task 0.50</td>
<td>corr task 0.60</td>
<td>corr task 0.70</td>
<td>corr task 0.80</td>
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<td>corr task 0.80</td>
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<td>corr task 0.70</td>
<td>corr task 0.80</td>
<td>corr task 0.90</td>
<td>corr task 1.00</td>
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</tbody>
</table>

Processor correlation

Ratio to the baseline

Mapping

Correlation: 
- deP: baseline 
- inE: basicW/v 
- deR: baselineR 
- random: random

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

### Processor correlation

<table>
<thead>
<tr>
<th>Ratio to the baseline</th>
<th>energy-energy</th>
<th>energy-time</th>
<th>randomShuffling</th>
<th>time-energy</th>
<th>time-time</th>
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<tr>
<td>inE</td>
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<td>0.50</td>
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<td>1.00</td>
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<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
<td>1.00</td>
</tr>
</tbody>
</table>

| \( \beta_{\text{bw}} = 0.6 \), basicWork \( w_b = 0.3 \), \( R = 0.92 \) |

### Summary

- Processor correlation to the baseline for different loads and configurations.
- The plots illustrate the performance of energy-aware strategies on heterogeneous platforms, showing how energy consumption and time performance vary with different parameter settings.

RR n° 9324
Energy-aware strategies on heterogeneous platforms

\[ \beta_{\text{eff}} = 0.6; \text{basicWork} = 0.3; \ R = 0.94 \]
Energy-aware strategies on heterogeneous platforms

Processor correlation

Ratio to the baseline

LowerBound

deP

deR

inE

random

RR n° 9324
$\beta_{b/w} = 0.6; \text{basicWork} = 0.3; R = 0.98$
$\beta_{b/w} = 0.8; \text{basicWork} = 0.1; R = 0.92$

Processor correlation

Ratio to the baseline

Energy-aware strategies on heterogeneous platforms
\[ \beta_{b/w} = 0.8; \text{basicWork} = 0.1; \mathcal{R} = 0.94 \]
Energy-aware strategies on heterogeneous platforms

\[ \beta_{\text{b/w}} = 0.8; \quad \text{basicWork} = 0.1; \quad \mathcal{R} = 0.98 \]
Energy-aware strategies on heterogeneous platforms

\( \beta_{\text{basic}} = 0.8, \beta_{\text{h}} = 0.2; \ R = 0.9 \)
\( \beta_{b/w} = 0.8; \ basicWork = 0.2; \ R = 0.92 \)
Energy-aware strategies on heterogeneous platforms

- Processor correlation
- Ratio to the baseline
- 

\[
\beta_{\text{inE}} = 0.8, \quad \text{basicWork} = 0.2, \quad R = 0.94
\]
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>LowerBound</th>
<th>deP</th>
<th>deR</th>
<th>inE</th>
<th>random</th>
<th>BasicWork</th>
<th>β_{b/w} = 0.8; basicWork = 0.2; R = 0.96</th>
<th>R = 0.96</th>
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<tr>
<td>energy-energy</td>
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<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
</tr>
<tr>
<td>energy-time</td>
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<td>0.50</td>
<td>0.75</td>
<td>1.00</td>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
</tr>
<tr>
<td>randomShuffling</td>
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<td>1.00</td>
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<td>0.25</td>
<td>0.50</td>
</tr>
<tr>
<td>time-energy</td>
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<td>0.50</td>
<td>0.75</td>
<td>1.00</td>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
</tr>
<tr>
<td>time-time</td>
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<td>0.75</td>
<td>1.00</td>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
</tr>
</tbody>
</table>
Energy-aware strategies on heterogeneous platforms

Processor correlation

Ratio to the baseline

mapping

LowerBound deP deR inE random

\[ \beta_{W} = 0.8, \ \text{basicW} = 0.2; \ R = 0.98 \]

RR n° 9324
Energy-aware strategies on heterogeneous platforms

![Graph showing energy-time and time-time relationships with varying correlation values.]
Energy-aware strategies on heterogeneous platforms

Processor correlation

Ratio to the baseline

LowerBound  deP  deR  inE  random

\( \beta_{in} = 0.8, \text{ basicWork} = 0.3, \ R = 0.92 \)

RR n° 9324
Energy-aware strategies on heterogeneous platforms

$\beta_{b/w} = 0.8; \ basicWork = 0.3; \ R = 0.94$

![Diagram showing energy-time and time-energy mapping with different correlations and ratio to the baseline.](image)

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

![Graph showing energy-energy, energy-time, randomShuffling, time-energy, time-time correlation](image)

**Processor correlation**

- Ratio to the baseline
- LowerBound
- UpperBound

\[ \beta_{\text{b/w}} = 0.8, \ basicWrk = 0.3; R = 0.96 \]

RR n° 9324
$\beta_{b/w} = 0.8; \ basicWork = 0.3; \ R = 0.98$

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

\[ \beta_{b/r} = 0.1; \quad \text{basicWork} = 0.1; \quad R = 0.9 \]

\begin{align*}
\text{cor}_{\text{task}} = 0 & \quad \text{cor}_{\text{task}} = 0.25 & \quad \text{cor}_{\text{task}} = 0.5 & \quad \text{cor}_{\text{task}} = 0.75 & \quad \text{cor}_{\text{task}} = 1 \\
\end{align*}

\begin{align*}
\text{Ratio to the baseline} & \quad \text{Processor correlation} \\
0.00 & \quad 0.10 & \quad 0.25 & \quad 0.50 & \quad 0.75 & \quad 1.00 \\
0.00 & \quad 0.10 & \quad 0.25 & \quad 0.50 & \quad 0.75 & \quad 1.00 \\
0.00 & \quad 0.10 & \quad 0.25 & \quad 0.50 & \quad 0.75 & \quad 1.00 \\
\end{align*}

mapping: LowerBound \text{dP} \text{dR} \text{mE} \text{random}
Energy-aware strategies on heterogeneous platforms

\[ \beta_{\text{b/w}} = 1; \beta_{\text{basic workload}} = 0.1; \beta_{R} = 0.92 \]

\[ \text{Random Shuffling} \]

\[ \text{Processor correlation} \]

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

\[ \text{Mapping} \]

\[ \text{Lower Bound} \]

\[ \text{Upper Bound} \]

\[ \text{Random} \]

\[ \text{Shuffling} \]

\[ \text{Baseline} \]

\[ \text{Energy} \]

\[ \text{Time} \]
\( \beta_{b/w} = 1; \ \text{basicWork} = 0.1; \ R = 0.94 \)

Processor correlation

<table>
<thead>
<tr>
<th>Correlation</th>
<th>Ratio to the baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>0.25</td>
<td>1.05</td>
</tr>
<tr>
<td>0.50</td>
<td>1.10</td>
</tr>
<tr>
<td>0.75</td>
<td>1.15</td>
</tr>
<tr>
<td>1.00</td>
<td>1.20</td>
</tr>
</tbody>
</table>

Legend:
- \( \text{LowerBound} \)
- \( \text{dP} \)
- \( \text{dR} \)
- \( \text{inE} \)
- \( \text{random} \)
$\beta_{b/w} = 1$; $\text{basicWork} = 0.1$; $R = 0.96$

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

\[ \beta_{b/w} = 1; \ basicWork = 0.1; \ R = 0.98 \]
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 1; \text{basicWork} = 0.2; R = 0.9 \]

![Graph showing various energy correlations and task mappings with processor correlations ranging from 0.00 to 1.00.](image)
Energy-aware strategies on heterogeneous platforms

...
Energy-aware strategies on heterogeneous platforms

**Processor correlation**

- Ratio to the baseline

- Lower Bound

- Random

$$\beta_{w,b} = 1; \text{basicWork} = 0.2; R = 0.34$$

RR n° 9324
Energy-aware strategies on heterogeneous platforms

Figure: Processor correlation ratio to the baseline mapping with different parameter settings: 
- \( \beta_{bw} = 1 \), basicWork = 0.2, \( R = 0.06 \)
- \( \beta_{bw} = 1 \), basicWork = 0.2, \( R = 0.2 \)
- \( \beta_{bw} = 1 \), basicWork = 0.2, \( R = 0.4 \)
- \( \beta_{bw} = 1 \), basicWork = 0.2, \( R = 0.6 \)
- \( \beta_{bw} = 1 \), basicWork = 0.2, \( R = 0.8 \)
- \( \beta_{bw} = 1 \), basicWork = 0.2, \( R = 1.0 \)

Legend:
- \( \text{LowerBound} \)
- \( \text{deP} \)
- \( \text{deR} \)
- \( \text{inE} \)
- \( \text{random} \)
Energy-aware strategies on heterogeneous platforms

\[
\text{Processor correlation} = \frac{\text{Processor correlation}}{\text{Baseline}}
\]

\[
\beta_{b/w} = 1; \text{BasicWork} = 0.2; R = 0.98
\]

\[
\text{randomShuffling} = 0 \text{ task}
\]

\[
\text{time-energy} = 0.00 \text{ task}
\]

\[
\text{energy-time} = 0.25 \text{ task}
\]

\[
\text{energy-energy} = 0.50 \text{ task}
\]

\[
\text{energy-energy} = 0.75 \text{ task}
\]

\[
\text{energy-energy} = 1.00 \text{ task}
\]
### Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>Correlation Type</th>
<th>Mapping</th>
<th>Processor Correlation</th>
<th>Ratio to the Baseline</th>
</tr>
</thead>
<tbody>
<tr>
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<td>energy</td>
<td>fixed</td>
<td>0.00</td>
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<tr>
<td>energy-time</td>
<td>energy</td>
<td>fixed</td>
<td>0.25</td>
</tr>
<tr>
<td>randomShuffling</td>
<td>energy</td>
<td>fixed</td>
<td>0.50</td>
</tr>
<tr>
<td>time-energy</td>
<td>energy</td>
<td>fixed</td>
<td>0.75</td>
</tr>
<tr>
<td>time-time</td>
<td>energy</td>
<td>fixed</td>
<td>1.00</td>
</tr>
</tbody>
</table>

**Baseline Workload:**
- $\beta_{\text{basicWork}} = 1$
- $R = 0.3$
- $\beta_{\text{basicWork}} = 0.9$

**Mapping:**
- Processor correlation
- Ratio to the baseline

**Correlation Parameters:**
- $\text{corr}_{\text{task}} = 0$
- $\text{corr}_{\text{task}} = 0.10$
- $\text{corr}_{\text{task}} = 0.25$
- $\text{corr}_{\text{task}} = 0.50$
- $\text{corr}_{\text{task}} = 0.75$
- $\text{corr}_{\text{task}} = 1.00$

**Processor Correlation Mapping:**
- $\alpha = 1$
- $\alpha = 0.25$
- $\alpha = 0.50$
- $\alpha = 0.75$
- $\alpha = 1.00$

**Baseline:**
- $\text{Task Load}$
Energy-aware strategies on heterogeneous platforms

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

<table>
<thead>
<tr>
<th>Energy-aware strategies</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>Processor correlation</td>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
<td>1.00</td>
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<td>Ratio to the baseline</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Mapping**

- LowerBound
- deP
- deR
- inE
- random

**Processor correlation**

- BasicWork = 0.3, R = 0.34

---

RR n° 9324
Energy-aware strategies on heterogeneous platforms

![Energy-aware strategies on heterogeneous platforms](image)
Energy-aware strategies on heterogeneous platforms

![Diagram of energy-aware strategies on heterogeneous platforms](image-url)
Correlation (Scheduling)

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

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

$\beta_{in} = 0.2; \text{ basicWork} = 0.1; R = 0.9$

RR n° 9324
$\beta_{b/w} = 0.2$; basicWork $= 0.1$; $R = 0.92$
Energy-aware strategies on heterogeneous platforms

\( \beta_{b/w} = 0.2; \text{ basicWork} = 0.1; R = 0.94 \)

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

Processor correlation

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

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

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

**lowerbound**
- energy-energy
- time-energy
- randomShuffling
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.2; \quad basicWork = 0.1; \quad R = 0.96 \]
Energy-aware strategies on heterogeneous platforms

\[ \beta_{\text{bw}} = 0.2; \text{basic work} = 0.1; R = 0.98 \]
Energy-aware strategies on heterogeneous platforms

\( \beta_{\text{b/w}} = 0.2; \ \text{basicWork} = 0.2; \ \mathcal{R} = 0.9 \)

- Processor correlation
- Ratio to the baseline
\( \beta_{b/w} = 0.2; \) basicWork = 0.2; \( R = 0.92 \)
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.2; \; basicWork = 0.2; \; R = 0.94 \]

<table>
<thead>
<tr>
<th>Correlation</th>
<th>processor correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>0.5</td>
<td>0.50</td>
</tr>
<tr>
<td>0.75</td>
<td>0.75</td>
</tr>
<tr>
<td>1</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Ratio to the baseline

![Graph showing the ratio to the baseline for different correlation values.](image)
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.2; \ \text{basicWork} = 0.2; \ R = 0.96 \]

- Processor correlation
- Ratio to the baseline
- Scheduling: LowerBound, energy-time, time-energy, randomShuffling

\[ \beta_{b/w} = 0.2; \ \text{basicWork} = 0.2; \ R = 0.96 \]
Energy-aware strategies on heterogeneous platforms

β_{b/w} = 0.2; basicWork = 0.2; R = 0.98

Ratio to the baseline

Processor correlation
Energy-aware strategies on heterogeneous platforms

\begin{tabular}{|c|c|c|c|}
\hline
\textbf{\textit{}} & \textbf{\textit{}} & \textbf{\textit{}} & \textbf{\textit{}} \\
\hline
\textbf{cor task} & 0 & 0.25 & 0.50 & 0.75 & 1.00 \\
\hline
\textbf{ratio} & 0.00 & 0.25 & 0.50 & 0.75 & 1.00 \\
\hline
\end{tabular}

Processor correlation

\textbf{Ratio to the baseline}

\begin{tabular}{|c|c|c|c|}
\hline
\textbf{\textit{}} & \textbf{\textit{}} & \textbf{\textit{}} & \textbf{\textit{}} \\
\hline
\textbf{scheduling} & energy-energy & energy-time & time-energy & time-time \\
\hline
\textbf{randomShuffling} & basicWork & basicWork & basicWork & basicWork \\
\hline
\end{tabular}

\textbf{Processors correlation}

\begin{tabular}{|c|c|c|c|}
\hline
\textbf{\textit{}} & \textbf{\textit{}} & \textbf{\textit{}} & \textbf{\textit{}} \\
\hline
$\beta_{wo} = 0.2; \text{basicWork} = 0.3; R = 0.9$ & $\beta_{wo} = 0.2; \text{basicWork} = 0.3; R = 0.9$ & $\beta_{wo} = 0.2; \text{basicWork} = 0.3; R = 0.9$ & $\beta_{wo} = 0.2; \text{basicWork} = 0.3; R = 0.9$ \\
\hline
\end{tabular}
Energy-aware strategies on heterogeneous platforms

Processor correlation

Ratio to the baseline

Energy-energy
Energy-time
Time-energy
Time-time

randomShuffling

\( \beta_{\text{DB}} = 0.2; \, \text{basicWork} = 0.3; \, R = 0.92 \)

\( \text{RR n°} \, 9324 \)
Energy-aware strategies on heterogeneous platforms
\( \beta_{b/w} = 0.2; \ basicWork = 0.3; \ R = 0.96 \)
$\beta_{b/w} = 0.2$; $basicWork = 0.3$; $R = 0.98$
Energy-aware strategies on heterogeneous platforms

**Processor correlation**

Ratio to the baseline

**LowerBound energy-energy**

**time-energy**

**randomShuffling**

β<sub>b/w</sub> = 0.4; basicWork<sub>ε</sub> = 0.1; R = 0.9

RR n° 9324
\[ \beta_{b/w} = 0.4; \ \text{basicWork} = 0.1; \ \mathcal{R} = 0.92 \]
Energy-aware strategies on heterogeneous platforms

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

Processor correlation

β_{i,j} = 0.4; basicWork = 0.1; R = 0.94

R n° 9324
Energy-aware strategies on heterogeneous platforms

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

\[ \beta_{w/w} = 0.4; \ \text{basicWork} = 0.1; \ \mathcal{R} = 0.98 \]
Energy-aware strategies on heterogeneous platforms.
Energy-aware strategies on heterogeneous platforms

\[ \beta_{\text{b/w}} = 0.4; \ \text{basicWork} = 0.2; \ \mathcal{R} = 0.92 \]
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.4; \text{basicWork} = 0.2; R = 0.94 \]

<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>Correlation</th>
<th>Ratio to the baseline</th>
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<tbody>
<tr>
<td>0.00</td>
<td>cor _ task = 0</td>
<td>1.00</td>
</tr>
<tr>
<td>0.25</td>
<td>cor _ task = 0.25</td>
<td>0.75</td>
</tr>
<tr>
<td>0.50</td>
<td>cor _ task = 0.5</td>
<td>0.50</td>
</tr>
<tr>
<td>0.75</td>
<td>cor _ task = 0.75</td>
<td>0.25</td>
</tr>
<tr>
<td>1.00</td>
<td>cor _ task = 1</td>
<td>0.00</td>
</tr>
</tbody>
</table>

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

RR n° 5231
Energy-aware strategies on heterogeneous platforms

Processor correlation

Ratio to the baseline

scheduling

lowerBound

energy-energy

time-energy

time-time

randomShuffling

$\beta^*_{b/w} = 0.4; \beta^*_{basicWork} = 0.2; R = 0.96$

RR n° 9324
Energy-aware strategies on heterogeneous platforms

Processor correlation

Ratio to the baseline

scheduling

LowerBound

energy-time

time-energy

randomShuffling

β_{b/w} = 0.4; basicWork = 0.2; R = 0.98

RR n° 9324
Energy-aware strategies on heterogeneous platforms

Processor correlation

Ratio to the baseline

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

\[ \beta_{\text{in}} = 0.4, \text{basicWork} = 0.3, R = 0.9 \]

RR n° 9324
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.4; \ \text{basicWork} = 0.3; \ R = 0.92 \]
\( \beta_{b/w} = 0.4; \text{ basicWork} = 0.3; R = 0.94 \)
\[ \beta_b/w = 0.4; \text{basicWork} = 0.3; R = 0.96 \]
\( \beta_{b/w} = 0.4; \) basicWork = 0.3; \( R = 0.98 \)

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

\[ \beta_{b/w} = 0.6; \text{basicWork} = 0.1; R = 0.9 \]

Ratio to the baseline

Processor correlation

scheduling

LowerBound

energy-time

time-energy

energy-energy

time-time

randomShuffling

\[ \beta_{b/w} = 0.6; \text{basicWork} = 0.1; R = 0.9 \]

RR n° 9324

Energy-aware strategies on heterogeneous platforms

693
Energy-aware strategies on heterogeneous platforms

Processor correlation

Ratio to the baseline

LowerBound energy-energy

energy-time
time-energy
time-time

randomShuffling

$\beta_{\text{eff}} = 0.6$, basicWorkRate = 0.1, $R = 0.92$

$\beta_{\text{eff}} = 0.0$, basicWorkRate = 0.1, $R = 0.92$

RR n° 9324
Energy-aware strategies on heterogeneous platforms

Processor correlation

Ratio to the baseline

scheduling

LowerBound

time-energy
time-time

randomShuffling

energy-energy

energy-time

BasicWork

= 0.6; basicWork/h = 0.1; R = 0.94

β

= 0.6; basicWork/h = 0.1; R = 0.94

RR n° 9324
Energy-aware strategies on heterogeneous platforms

\( \beta_{\text{b/w}} = 0.6; \ \text{basicWork} = 0.1; \ \mathcal{R} = 0.98 \)
Energy-aware strategies on heterogeneous platforms

Processor correlation
Ratio to the baseline

Processor correlation
deP
deR
saE
random

\[ \beta_{\text{basic}} = 0.6, \beta_{\text{basic\ W}} = 0.2, R = 0.9 \]

scheduling energy-energy energy-time time-energy randomShuffling

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>
</tbody>
</table>

- Processor correlation
- Ratio to the baseline

- LowerBound
- Energy-energy
- Energy-time
- Time-energy
- RandomShuffling

$\beta_{\text{bw}} = 0.6; \text{BasicW} \cdot k = 0.2; R = 0.92$

RR n° 9324
Energy-aware strategies on heterogeneous platforms

Processor correlation

- Middle: energy-time
- Upper: energy-energy
- Lower: time-energy

scheduling

- LowerBound: energy-time
- random: energy-energy
- randomShuffling: time-energy

\[ \beta_{\text{pwr}} = 0.6, \; \text{basicWork} = 0.2, \; R = 0.94 \]
Energy-aware strategies on heterogeneous platforms

Processor correlation

Ratio to the baseline

scheduling

LowerBound energy-time time-energy

randomShuffling

β = 0.6, basicWork/h = 0.2; R = 0.98

RR n° 9324
Energy-aware strategies on heterogeneous platforms

$\beta_{b/w} = 0.6; \text{basicWork} = 0.3; R = 0.92$
\( \beta_{b/w} = 0.6; \) basicWork = 0.3; \( R = 0.94 \)
Energy-aware strategies on heterogeneous platforms

$\beta_{b/w} = 0.6; \ basicWork = 0.3; \ \mathcal{R} = 0.96$

Processor correlation

Ratio to the baseline

scheduling

LowerBound  energy-time  time-energy

energy-energy  time-energy  randomShuffling

RR n = 524
\[ \beta_{b/w} = 0.6; \text{basicWork} = 0.3; \mathcal{R} = 0.98 \]

<table>
<thead>
<tr>
<th>Processor correlation</th>
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<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>\text{Ratio to the baseline}</td>
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<td>\text{energy-time}</td>
<td>\text{time-energy}</td>
<td>\text{time-time}</td>
<td>\text{randomShuffling}</td>
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<table>
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<th>\text{Baseline}</th>
<th>\text{energy-energy}</th>
<th>\text{energy-time}</th>
<th>\text{time-energy}</th>
<th>\text{time-time}</th>
<th>\text{randomShuffling}</th>
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</thead>
<tbody>
<tr>
<td>\text{cor}_{\text{task}}</td>
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<td>0.75</td>
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<td>1.25</td>
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<tr>
<td>\text{Processor correlation}</td>
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<td>0.50</td>
<td>0.75</td>
<td>1.00</td>
<td>1.25</td>
</tr>
</tbody>
</table>

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

$\beta_{b/w} = 0.8; \text{basicWork} = 0.1; R = 0.9$

$corr_{task} = 0$

$corr_{task} = 0.25$

$corr_{task} = 0.5$

$corr_{task} = 0.75$

$corr_{task} = 1$

Processor correlation

Ratio to the baseline
Energy-aware strategies on heterogeneous platforms

Processor correlation

Ratio to the baseline

scheduling

LowerBound vs energy

energy-time
time-energy
time-time

randomShuffling

\( \beta_{\text{bw}} = 0.8, \text{basicWork} = 0.1; H = 0.13, R = 0.92 \)
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.8; \ \text{basicWork} = 0.1; \ \mathcal{R} = 0.96 \]

![Graph showing energy consumption with varying processor correlation](image)

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

### Energy-aware strategies on heterogeneous platforms

**Correlation Model**

- \( \text{cor task} = 0 \)
- \( \text{cor task} = 0.25 \)
- \( \text{cor task} = 0.5 \)
- \( \text{cor task} = 0.75 \)
- \( \text{cor task} = 1 \)

**Performance Analysis**

- Ratio to the baseline
- Energy vs. Time
- LowerBound vs. Random Shuffling
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.8; \ basicWork = 0.2; \ R = 0.9 \]

<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>cor_task = 0</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>Ratio to the baseline</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

![Graph showing processor correlation vs ratio to baseline with various correlation values and scheduling strategies.](image-url)

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

<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>$\beta_{b/w}$</td>
<td>0.8</td>
<td>0.25</td>
<td>0.5</td>
<td>0.75</td>
</tr>
<tr>
<td>BasicWork</td>
<td>0.2</td>
<td>0.25</td>
<td>0.5</td>
<td>0.75</td>
</tr>
<tr>
<td>R</td>
<td>0.9</td>
<td>0.25</td>
<td>0.5</td>
<td>0.75</td>
</tr>
</tbody>
</table>
Energy-aware strategies on heterogeneous platforms

![Graph showing processor correlation and scheduling metrics for different strategies and correlation values.]

- Processor correlation
  - Ratio to the baseline
  - Scheduling

- Lower Bound energy-energy
- Energy-time
- Time-energy

- Random Shuffling

- \( \beta_{\text{work}} = 0.8 \), \( \beta_{\text{time}} = 0.2 \), \( R = 0.92 \)

**Legend:**
- Energy
- Time
- Energy-Time
- Time-Energy
- Random Shuffling

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

\[ \beta_{b/w} = 0.8; \quad \text{basicWork} = 0.2; \quad \mathcal{R} = 0.94 \]
\( \beta_{\text{b/w}} = 0.8; \ basic\ Work = 0.2; \ R = 0.96 \)
Energy-aware strategies on heterogeneous platforms

![Graph of Processor correlation ratios](image)

**Graph Description:**
- **x-axis:** Ratio to the baseline
- **y-axis:** Processor correlation
- **Legend:**
  - LowerBound
  - energy-energy
  - time-energy
  - randomShuffling

**Graph Key:**
- **β**: $\beta_{\text{str}} = 0.8$, $\beta_{\text{str}} = 0.2$, $\beta_{\text{str}} = 0.0$
- **ε**: $\epsilon = 0.98$
- **Scheduling:**
  - Basic Work
  - Random Work

**Figure Notes:**
- Depicts the correlation ratios for different scheduling strategies and correlation values.
- Illustrates the impact of varying baseline ratios and correlation factors on processor correlation.

---

RR n° 9324
Energy-aware strategies on heterogeneous platforms

\[ \beta_{b/w} = 0.8; \text{basicWork} = 0.3; R = 0.9 \]

![Graph showing energy-aware strategies on heterogeneous platforms](image-url)
$\beta_{b/w} = 0.8$; $\text{basicWork} = 0.3$; $R = 0.92$

<table>
<thead>
<tr>
<th>$\text{cor}_{\text{task}} = 0$</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>Processor correlation</td>
<td>Ratio to the baseline</td>
<td>Processor correlation</td>
<td>Ratio to the baseline</td>
<td>Processor correlation</td>
</tr>
<tr>
<td>0.00</td>
<td>1.00</td>
<td>0.00</td>
<td>1.00</td>
<td>0.00</td>
</tr>
<tr>
<td>0.25</td>
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LowerBound, energy-energy, time-energy, randomShuffling
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

\( \beta_{b/w} = 0.8; \text{basicWork} = 0.3; R = 0.96 \)

![Graph showing energy-performance trade-offs for different processor correlation values.](image)
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

\( \beta_{b/w} = 1; \ \text{basicWork} = 0.1; \ \mathcal{R} = 0.92 \)

<table>
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<tr>
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<th>( \text{cor}_{\text{task}} = 0 )</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>
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Processor scheduling
- LowerBound
- energy-time
- time-energy
- randomShuffling

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

\( \beta_{b/w} = 1; \) basicWork = 0.1; \( R = 0.94 \)
Energy-aware strategies on heterogeneous platforms

\[ \beta_{\text{b/w}} = 1; \text{basicWork} = 0.1; \mathcal{R} = 0.96 \]
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

\( \beta_{b/w} = 1; \ basicWork = 0.2; \ \mathcal{R} = 0.9 \)

<table>
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<th>Processor correlation</th>
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<th>cor_task = 0.5</th>
<th>cor_task = 0.75</th>
<th>cor_task = 1</th>
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<td>energy-energy</td>
<td>time-energy</td>
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</table>

 Processor correlation values: 0.00, 0.25, 0.50, 0.75, 1.00

Scheduling options: LowerBound, energy-energy, time-energy, randomShuffling
Energy-aware strategies on heterogeneous platforms

$\beta_{b/w} = 1; \text{basicWork} = 0.2; R = 0.92$

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

\( \beta_{b/w} = 1; \ basicWork = 0.2; \ R = 0.94 \)
Energy-aware strategies on heterogeneous platforms
\( \beta_{b/w} = 1; \ basicWork = 0.2; \ R = 0.98 \)
Energy-aware strategies on heterogeneous platforms

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

\[ \beta_{b/w} = 1; \ baseWork = 0.3; \ \mathcal{R} = 0.92 \]

\[ cor_{task} \]

Ratio to the baseline

Processor correlation

scheduling

LowerBound  energy-time  time-time

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

<table>
<thead>
<tr>
<th>Processor correlation</th>
<th>Random Shuffling</th>
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</thead>
<tbody>
<tr>
<td>deP</td>
<td>deR</td>
</tr>
<tr>
<td>0.10</td>
<td>0.10</td>
</tr>
<tr>
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</tbody>
</table>

β_{\text{w}} = 1; \text{basicWork} = 0.3; R = 0.34

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

$\beta_{b/w} = 1$; $basicWork = 0.3$; $R = 0.98$

- $cor_{task} = 0$
- $corr_{task} = 0.25$
- $corr_{task} = 0.5$
- $corr_{task} = 0.75$
- $corr_{task} = 1$

Processor correlation

Ratio to the baseline

Processor correlation

Scheduling

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

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

<table>
<thead>
<tr>
<th>$\text{cor}_{\text{proc}}$</th>
<th>0</th>
<th>0.25</th>
<th>0.5</th>
<th>0.75</th>
<th>1</th>
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</thead>
<tbody>
<tr>
<td>$R$</td>
<td>0.98</td>
<td>0.92</td>
<td>0.94</td>
<td>0.96</td>
<td>0.98</td>
</tr>
</tbody>
</table>

Correlation $\text{cor}_{\text{proc}} = 0$; $\beta_{0,\text{w}} = 0.2$. Scheduling criteria: time-energy

Basic Work: LowerBound, deP, deR, deE, rake.
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms
$cor_{task} = 0$; $b_{b/w} = 0.2$; Scheduling criteria: randomShuffling

Basic Work

Ratio to the baseline

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

\[
\begin{array}{c|c|c|c|c|c}
\hline
\text{corr}_{\text{proc}} & 0 & 0.25 & 0.5 & 0.75 & 1 \\
\hline
R = 0.96 & & & & & \\
\hline
R = 0.94 & & & & & \\
\hline
R = 0.92 & & & & & \\
\hline
\end{array}
\]

Basic Work:

\[\text{corr}_{\text{task}} = 0, \beta_{\text{bw}} = 0.4, \text{Scheduling criteria: time}\]
\( cor_{task} = 0; \beta_{b/w} = 0.4; \text{Scheduling criteria: time-energy} \)
Energy-aware strategies on heterogeneous platforms

\[ R = 0.98 \]
\[ R = 0.96 \]
\[ R = 0.94 \]
\[ R = 0.92 \]

\[ \text{cor}_{\text{proc}} = 0; \beta_{j, w} = 0.4; \text{Scheduling criteria: energy-time} \]

1. Basic Work
2. LowerBound
3. dep
4. deP
5. deR
6. inE
7. random

\[ \text{mapping} \]
\[ \text{cor}_{\text{proc}} \]
Energy-aware strategies on heterogeneous platforms

![Graph showing energy awareness strategies on heterogeneous platforms]
$cor_{task} = 0; \beta_{b/w} = 0.4; \text{Scheduling criteria: randomShuffling}$

$\gamma = 0.9; \gamma = 0.92; \gamma = 0.94; \gamma = 0.96; \gamma = 0.98$

$\text{Ratio to the baseline}$

$\text{Basic Work}$

$\text{LowerBound} \rightarrow \text{deP} \rightarrow \text{deR} \rightarrow \text{inE} \rightarrow \text{random}$
Energy-aware strategies on heterogeneous platforms

<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 = 0.98 )</td>
<td>( R = 0.96 )</td>
<td>( R = 0.94 )</td>
<td>( R = 0.92 )</td>
<td>( R = 0.90 )</td>
</tr>
</tbody>
</table>

\[ \text{cor}_{\text{task}} = 0.75; \beta_{\text{in}} = 1; \] Scheduling criteria: randomShuffling

Basic Work

**Legend:**
- Mapping
- LowThermal
- LowP
- dP
- dR
- dE
- minE

RR n° 9324
$\text{cor}_{\text{task}} = 1; \beta_{b/w} = 0.2$; Scheduling criteria: time-time
Energy-aware strategies on heterogeneous platforms

cor\_task = 1; β_{b/w} = 0.2; Scheduling criteria: time-energy

Ratio to the baseline

<table>
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<th>0.15</th>
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</table>

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

\( cor_{task} = 1; \beta_{b/w} = 0.2; \) Scheduling criteria: energy-time
Energy-aware strategies on heterogeneous platforms

R = 0.98

R = 0.96

R = 0.94

R = 0.92

R = 0.90

\( cor_{\text{map}} = 0 \)

\( cor_{\text{map}} = 0.25 \)

\( cor_{\text{map}} = 0.5 \)

\( cor_{\text{map}} = 0.75 \)

\( cor_{\text{map}} = 1 \)

Basic Work

LowerEnergy
dp
aE
ckr

Mapping

Ratio to the baseline

\( deP \)

\( deR \)

\( inE \)

\( random \)

\( cor_{\text{task}} = 1; \beta_{\text{bw}} = 0.2 \)

\( \beta_{\text{bw}} = 0.2 \)

Scheduling criteria: energy-energy

RR n° 9324
$cor_{task} = 1; \beta_{b/w} = 0.2$; Scheduling criteria: randomShuffling
Energy-aware strategies on heterogeneous platforms

\[ R = 0.9 \]

\[ \text{Basic Work} \]

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

\[ \text{mapping} \]

\[ \text{LowerBound} \]

\[ \text{deP} \]

\[ \text{deR} \]

\[ \text{inE} \]

\[ \text{random} \]

\[ \text{cor} \text{\ task} = 1; \beta_{b/w} = 0.4. \text{ Scheduling criteria: time-time} \]

\[ \text{Radii to the baseline} \]
Energy-aware strategies on heterogeneous platforms

cor_{task} = 1; \beta_{b/w} = 0.4; Scheduling criteria: time-energy

<table>
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</tbody>
</table>

Basic Work

Ratio to the baseline

mapping: LowerBound, deP, deR, inE, random

Energy-aware strategies on heterogeneous platforms

RR n° 9524
Energy-aware strategies on heterogeneous platforms

$cor_{task} = 1$; $\beta_{b/w} = 0.4$; Scheduling criteria: energy-time
Energy-aware strategies on heterogeneous platforms

\( cor_{\text{task}} = 1; \beta_{b/w} = 0.4; \) Scheduling criteria: energy-energy

Basic Work Ratio to the baseline

Mapping: LowerBound, deP, deR, deE, random
$cor_{task} = 0; \beta_{b/w} = 0.6; $ Scheduling criteria: time-time

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

cor_{task} = 1; \beta_{b/w} = 0.6; Scheduling criteria: time-time

Basic Work Ratio to the baseline

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

cor_{task} = 1; \beta_{b/w} = 0.6; Scheduling criteria: time-energy

Basic Work

Ratio to the baseline

mapping: LowerBound, deP, deR, inE, random

RR n° 9241
Energy-aware strategies on heterogeneous platforms

\[ R = 0.9 \]

Basic Work

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

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

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

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

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

\[ \text{cor} \text{task} = 1, \beta_{\text{Int}} = 0.6, \] Scheduling criteria: energy-time

\[ \beta_{\text{Int}} = 0.6 \]

\[ R = 0.6 \]

\[ R = 0.4 \]

\[ R = 0.2 \]

\[ R = 0.0 \]

\[ \text{lower bound} = -2 \text{dec} \]

\[ \text{mapping} = -1 \text{dec} \]

RR n° 9324
cor_{task} = 1; \beta_{b/w} = 0.6; Scheduling criteria: energy-energy

<table>
<thead>
<tr>
<th>\text{Basic Work}</th>
<th>0.10</th>
<th>0.15</th>
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<tr>
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Energy-aware strategies on heterogeneous platforms

RR n° 9234
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

R = 0.08

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

Basic Work

cor_{\text{task}} = 1; \beta_{\text{bw}} = 0.8; Scheduling criteria: time-time

\text{LowerBound}

\text{deP}

\text{deR}

\text{inE}

\text{random}

RR n° 9324
Energy-aware strategies on heterogeneous platforms

corr_{task} = 1; \beta_{b/w} = 0.8; Scheduling criteria: time-energy

Basic Work

Ratio to the baseline

mapping

LowerBound  \hspace{0.2cm} \text{deP}  \hspace{0.2cm} \text{deR}  \hspace{0.2cm} \text{inE}  \hspace{0.2cm} \text{random}
Energy-aware strategies on heterogeneous platforms

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

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

cor\textsubscript{task} = 0; \beta\textsubscript{b/w} = 0.6; Scheduling criteria: time-energy

R = 0.9

R = 0.92

R = 0.94

R = 0.96

R = 0.98

Basic Work

Ratio to the baseline

Scheduling criteria: time-energy

mapping

LowerBound  deP  deR  deE  random
cor_{task} = 1; \beta_{b/w} = 0.8; Scheduling criteria: randomShuffling
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>$\text{corr}_{\text{proc}} = 0$</th>
<th>$\text{corr}_{\text{proc}} = 0.25$</th>
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<th>$\text{corr}_{\text{proc}} = 0.75$</th>
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<tr>
<td>$R = 0.98$</td>
<td>$R = 0.96$</td>
<td>$R = 0.94$</td>
<td>$R = 0.92$</td>
<td>$R = 0.90$</td>
</tr>
</tbody>
</table>

**Basic Work**
- $\text{cor}_{\text{task}} = 1$; $\beta_{\text{bw}} = 1$
- Scheduling criteria: time-time

$	ext{cor}_{\text{proc}}$ = 0.10; $\beta_{\text{bw}}$ = 0.20; $R$ = 0.98

$\text{cor}_{\text{proc}}$ = 0.15; $\beta_{\text{bw}}$ = 0.25; $R$ = 0.96

$\text{cor}_{\text{proc}}$ = 0.20; $\beta_{\text{bw}}$ = 0.30; $R$ = 0.94

$\text{cor}_{\text{proc}}$ = 0.25; $\beta_{\text{bw}}$ = 0.35; $R$ = 0.92

$\text{cor}_{\text{proc}}$ = 0.30; $\beta_{\text{bw}}$ = 0.40; $R$ = 0.90

$\text{cor}_{\text{proc}}$ = 0.35; $\beta_{\text{bw}}$ = 0.45; $R$ = 0.98
Energy-aware strategies on heterogeneous platforms

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

cor_{proc} = 0.10; cor_{proc} = 0.92; cor_{proc} = 0.94; cor_{proc} = 0.96; cor_{proc} = 0.98

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

cor\_task = 1; \beta_{b/w} = 1; Scheduling criteria: energy-time
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

<table>
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<tr>
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Basic Work Mapping to the baseline

Lower Bound above

randomShuffling Scheduling criteria: randomShuffling

RR n° 9324
Energy-aware strategies on heterogeneous platforms

corr_{task} = 0; \beta_{b/w} = 0.6; Scheduling criteria: energy-time
Energy-aware strategies on heterogeneous platforms

\[ R = 0.9 \]

\[ \text{Basic Work} \]

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

\[ \text{Lower Bound} \]

\[ \text{deP} \]

\[ \text{deR} \]

\[ \text{inE} \]

\[ \text{Random} \]

\[ \text{Cost} = 0; \beta_{\text{inE}} = 0.6 \]

\[ \text{Scheduling criteria: energy-energy} \]
Energy-aware strategies on heterogeneous platforms

\[ R = 0.9 \]

\[ R = 0.92 \]

\[ R = 0.94 \]

\[ R = 0.96 \]

\[ R = 0.98 \]

corr = 0; \beta_{b/w} = 0.6; Scheduling criteria: randomShuffling

<table>
<thead>
<tr>
<th>Basic Work</th>
<th>0.10</th>
<th>0.15</th>
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</tbody>
</table>

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

\[
R = 0.00  \quad  0.10  \quad  0.20  \quad  0.30  \quad  0.40  \quad  0.50  \quad  0.60  \quad  0.70  \quad  0.80  \quad  0.90  \quad  1.00
\]

Basic Work

\[
corr_{proc} = 0  \quad  corr_{proc} = 0.25  \quad  corr_{proc} = 0.5  \quad  corr_{proc} = 0.75  \quad  corr_{proc} = 1
\]

\[
\beta_{b/w} = 0.8
\]

Scheduling criteria: time-time

\[
r_{cor} = 0, \beta_{b/w} = 0.8
\]

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

#### Basic Work

<table>
<thead>
<tr>
<th>$\sigma_{\text{proc}}$</th>
<th>$R$</th>
<th>$\text{Ratio to the baseline}$</th>
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<tbody>
<tr>
<td>$\Rightarrow 0.98$</td>
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<tr>
<td>$\Rightarrow 0.96$</td>
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</table>

#### Scheduling criteria: time-energy

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

#### R

- $R = 0.00$
- $R = 0.25$
- $R = 0.50$
- $R = 0.75$
- $R = 1.00$

#### $\text{cor task}$

- $\Rightarrow 0.00$
- $\Rightarrow 0.25$
- $\Rightarrow 0.50$
- $\Rightarrow 0.75$
- $\Rightarrow 1.00$

#### $\beta_{\text{bus}}$

- $\Rightarrow 0.8$

RR n° 9324
\( cor_{task} = 0; \beta_{b/w} = 0.8; \) Scheduling criteria: energy-time
Energy-aware strategies on heterogeneous platforms

![Graph showing energy consumption](image-url)

- $R = 0.98$
- $R = 0.95$
- $R = 0.92$
- $R = 0.90$
- $R = 0.88$

Scheduling criteria: energy-energy

- $\text{corr}_{\text{task}} = 0$, $\beta_{\text{load}} = 0.8$

Basic Work

LowerBound

dep.

dep.

RR n° 9324
Energy-aware strategies on heterogeneous platforms

\[
R = 0.99 \\
R = 0.96 \\
R = 0.94 \\
R = 0.92 \\
R = 0.90
\]

\[
\text{Basic Work} \\
\text{Mapping} \\
\text{cor} = 0; \beta_{b/w} = 0.8; \text{Scheduling criteria: randomShuffling}
\]
Energy-aware strategies on heterogeneous platforms

cor_{task} = 0; \beta_{b/w} = 1; Scheduling criteria: time-time
$cor_{task} = 0; \beta_{b/w} = 1$; Scheduling criteria: time-energy
$\text{cor}_{\text{task}} = 0$; $\beta_{b/w} = 1$; Scheduling criteria: energy-time.
$cor_{task} = 0; \beta_{b/w} = 1; $ Scheduling criteria: energy-energy

<table>
<thead>
<tr>
<th>$R$</th>
<th>$\text{Ratio to the baseline}$</th>
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<tbody>
<tr>
<td>0.9</td>
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**Basic Work**

<table>
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<th>inE</th>
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<td>0.65</td>
<td>0.70</td>
<td>0.75</td>
</tr>
</tbody>
</table>

Energy-aware strategies on heterogeneous platforms
\( \text{cor}_{\text{task}} = 0; \ \beta_{b/w} = 1; \ \text{Scheduling criteria: randomShuffling} \)
Energy-aware strategies on heterogeneous platforms

\[ R = 0.98 \]

\[ R = 0.96 \]

\[ R = 0.94 \]

\[ R = 0.92 \]

\[ R = 0.90 \]

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

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

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

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

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

\[ \text{cor}_{\text{task}} = 0.25, \beta_{\text{init}} = 0.2 \]

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

cor_{task} = 0.25; \beta_{b/w} = 0.2; Scheduling criteria: time-energy
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>$\text{cor}_{\text{true}}$</th>
<th>$0$</th>
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<td>$N$ = $0.90$</td>
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</table>

Basic Work, LowerBound, $\alpha$, $\beta$, $\gamma$

Scheduling criteria: energy-time

$\text{cor}_{\text{true}} = 0.25$, $\beta_{\text{true}} = 0.2$, $\beta_{\text{true}} = 0.2$.

$\text{cor}_{\text{true}} = 0.25$, $\beta_{\text{true}} = 0.2$.

$\text{cor}_{\text{true}} = 0.25$, $\beta_{\text{true}} = 0.2$.

$\text{cor}_{\text{true}} = 0.25$, $\beta_{\text{true}} = 0.2$.
Energy-aware strategies on heterogeneous platforms

\[ R = 0.10 \]

\[ R = 0.12 \]

\[ R = 0.14 \]

\[ R = 0.16 \]

\[ R = 0.18 \]

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

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

\[ \text{cor} \text{proc} = 0.50 \]

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

\[ \text{cor} \text{proc} = 1.00 \]

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

\[ \beta_{\text{inE}} = 0.2 \]

\[ \beta_{\text{deP}} = 0.2 \]

\[ \beta_{\text{deR}} = 0.2 \]

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

\[ \text{Baseline Work} \]

\[ \text{cor} \text{proc} = 0.00 \]

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

\[ \text{cor} \text{proc} = 0.50 \]

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

\[ \text{cor} \text{proc} = 1.00 \]

\[ \text{cor} \text{proc} = 1.25 \]

\[ \text{Basic Work} \]

\[ \text{Baseline Work} \]

\[ \text{Baseline Work} \]

\[ \text{Baseline Work} \]

\[ \text{Baseline Work} \]

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

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

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

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

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

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

\[ R = 0.96 \]

\[ R = 0.94 \]

\[ R = 0.92 \]

\[ R = 0.9 \]

\[ \text{cor}_{\text{task}} = 0.25 ; \beta_{\text{bw}} = 0.2 ; \text{Scheduling criteria: randomShuffling} \]

Basic Work

LowerBound

dep

dep

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

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

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

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

\[ \text{cor}_{\text{proc}} \]
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

Basic Work

Ratio to the baseline

mapping

LowerBound deP deR inE random

$\text{cor}_\text{proc} = 0.25$, $\beta_{\text{uw}} = 0.4$, Scheduling criteria: time-energy

RR n° 9324
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.25; \ \beta_{b/w} = 0.4; \text{Scheduling criteria: energy-energy} \]
Energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{task}} = 0.25; \ \beta_{b/w} = 0.4; \ \text{Scheduling criteria: randomShuffling} \)

Basic Work

Ratio to the baseline

Mapping: LowerBound, deP, deR, inE, random
\( cor_{\text{task}} = 0.25; \; \beta_{b/w} = 0.6 \); Scheduling criteria: time-time

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

R = 0.98

R = 0.96

R = 0.94

R = 0.92

R = 0.9

cor_{proc} = 0.25; \beta_{uw} = 0.6; \text{Scheduling criteria: time-energy}

Basic Work

cor_{task} = 0.25; \beta_{uw} = 0.6; \text{Scheduling criteria: time-energy}
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>$\alpha_{\text{cor}}$</th>
<th>$\beta_{\text{cor}}$</th>
<th>$\gamma_{\text{cor}}$</th>
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<tbody>
<tr>
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<td>0.75</td>
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</table>

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

\text{corr}_{\text{task}} = 0.25; \beta_{b/w} = 0.6; \text{Scheduling criteria: energy-energy}
Energy-aware strategies on heterogeneous platforms

core_{task} = 0.25; \beta_{b/w} = 0.6; Scheduling criteria: randomShuffling

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

Basic Work

cor \_task = 0.25; \beta / \_d = 0.8; Scheduling criteria: time

cor \_proc = 0

cor \_proc = 0.25

cor \_proc = 0.5

cor \_proc = 0.75

cor \_proc = 1

deP\_d

deR\_d

RR n° 9324
Energy-aware strategies on heterogeneous platforms

\[ R = 0.98 \]

\[ R = 0.94 \]

\[ R = 0.92 \]

\[ R = 0.09 \]

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

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

\[ \beta_{\text{out}} = 0.25; \beta_{\text{in}} = 0.8 \]

Scheduling criteria: time-energy

Mapping

Low/Normal

dR

dE

Mapping

\[ \text{Basic Work} \]

\[ \text{deP} \]

\[ \text{deR} \]

\[ \text{inE} \]

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

\[ \text{cor}_{\text{task}} = 0.25; \ \beta_{b/w} = 0.8; \ \text{Scheduling criteria: energy-time} \]

<table>
<thead>
<tr>
<th>N = 0.9</th>
<th>N = 0.92</th>
<th>N = 0.94</th>
<th>N = 0.96</th>
<th>N = 0.98</th>
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</thead>
<tbody>
<tr>
<td>Basic Work</td>
<td>Ratio to the baseline</td>
<td>Basic Work</td>
<td>Ratio to the baseline</td>
<td>Basic Work</td>
</tr>
</tbody>
</table>

mapping | LowerBound | deP | deR | inE | random

RR n° 5321
Energy-aware strategies on heterogeneous platforms
807
Energy-aware strategies on heterogeneous platforms

Basic Work

Ratio to the baseline

LowerBound

deP
deR
inE
random

Scheduling criteria: energy-energy

corr task = 0.25, β_y_ww = 0.8; Scheduling criteria: energy-energy

corr pred = 0, 0.25, 0.5, 0.75, 1

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

<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>
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</thead>
<tbody>
<tr>
<td>( R = 0.08 )</td>
<td>( R = 0.80 )</td>
<td>( R = 0.08 )</td>
<td>( R = 0.80 )</td>
<td>( R = 0.08 )</td>
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<tr>
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<td>( R = 0.82 )</td>
<td>( R = 0.06 )</td>
<td>( R = 0.82 )</td>
<td>( R = 0.06 )</td>
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<td>( R = 0.05 )</td>
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<td>( R = 0.05 )</td>
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**Scheduling criteria:** time-time

**Basic Work**

**LowerBound**

**Random**

**Mapping**

- \( \alpha = 0.25 \)
- \( \beta_{\text{true}} = 1 \)

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

<table>
<thead>
<tr>
<th>$\rho_{\text{max}} = 0$</th>
<th>$\rho_{\text{max}} = 0.25$</th>
<th>$\rho_{\text{max}} = 0.5$</th>
<th>$\rho_{\text{max}} = 0.75$</th>
<th>$\rho_{\text{max}} = 1$</th>
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<tr>
<td>$R = 0.80$</td>
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<tr>
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<tr>
<td>$R = 0.94$</td>
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<td></td>
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</tr>
<tr>
<td>$R = 0.98$</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Basic Work

$\text{cor}_{\text{task}} = 0.25$; $\beta_{\text{wu}} = 1$; Scheduling criteria: time-energy
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>$\text{cor}_{\text{base}}$</th>
<th>0</th>
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<th>0.75</th>
<th>1</th>
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<td>0</td>
</tr>
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</table>

**Correlation**
- $\text{cor} = 0.25$; $\beta_{\text{uw}} = 1$
- Scheduling criteria: energy-energy

**Basic Work**
- $\beta_{\text{uw}} = 0.00$; $\beta_{\text{uw}} = 1$
- Scheduling criteria: energy-energy

**Mapping**
- Low-affinity
- High-affinity

RR n° 9324
Energy-aware strategies on heterogeneous platforms

---

Basic Work

Ratio to the baseline

mapping

LowerBound

deP
deR
inE
random

Scheduling criteria: randomShuffling

\[ R = 0.98 \]

\[ R = 0.96 \]

\[ R = 0.94 \]

\[ R = 0.92 \]

\[ R = 0.9 \]

\[ \alpha = 0.25; \beta_{\text{w}} = 1; \] Scheduling criteria: randomShuffling

RR n° 9324
$cor_{task} = 0.5; \beta_{j,w} = 0.2; $ Scheduling criteria: time-time

Mapping

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

\[ cor_{task} = 0.5, \beta_{j,w} = 0.2; \text{ Scheduling criteria: time-energy} \]

Basic Work

Ratio to the baseline

Scheduling criteria: time-energy

mapping

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

c_{or_{task}} = 0.5; \beta_{b/w} = 0.2; Scheduling criteria: energy-energy

Basic Work

Ratio to the baseline

Scheduling criteria: energy-energy

mapping

LowerBound  deP  deR  inE  random

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

\[ R = 0.9 \]

\[ R = 0.92 \]

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

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

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

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

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

Basic Work

Ratio to the baseline

mapping

LowerBound

deP

deR

inE

random

\[ \text{cor} \text{task} = 0.5, \beta_{t,w} = 0.2 \]

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

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

cor\textsubscript{task} = 0.5; \beta_{\text{tr}} = 0.4; Scheduling criteria: time-energy
Energy-aware strategies on heterogeneous platforms

![Graph showing energy-aware strategies on heterogeneous platforms with various parameters and mappings.](image-url)
$
\kappa_{\text{task}} = 0.5; \ \beta_{\text{bw}} = 0.4; \ \text{Scheduling criteria: energy-energy}$

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

cor_{task} = 0.5; \beta_{j/w} = 0.4; Scheduling criteria: randomShuffling

Basic Work

Ratio to the baseline

mapping

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

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

*Basic Work*

*Ratio to the baseline*

*LowerBound*

*Scheduling criteria: time-time*

*cor(est) = 0.5, β0,w = 0.6.*

*Scheduling criteria: time-time*

*cor(est) = 0.5, β0,w = 0.6.*

*Scheduling criteria: time-time*

*cor(est) = 0.5, β0,w = 0.6.*

*Scheduling criteria: time-time*

*cor(est) = 0.5, β0,w = 0.6.*
$cor_{\text{task}} = 0.5; \beta_{\text{task}} = 0.6; $ Scheduling criteria: time-energy

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

\( r_{\text{task}} = 0.5; \ \beta_{j/w} = 0.6; \) Scheduling criteria: energy-time

Basic Work Ratio to the baseline

Scheduling criteria: energy-time

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

<table>
<thead>
<tr>
<th>$\alpha_{\text{post}}$</th>
<th>$\alpha_{\text{pre}}$</th>
<th>$\alpha_{\text{post}}$</th>
<th>$\alpha_{\text{pre}}$</th>
<th>$\alpha_{\text{post}}$</th>
<th>$\alpha_{\text{pre}}$</th>
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<tbody>
<tr>
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<td>0.50</td>
<td>0.75</td>
<td>0.90</td>
<td>1.00</td>
</tr>
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</table>

Scheduling criteria: energy-energy

$R_{\text{cor}} = 0.5$, $\beta_{\text{b/w}} = 0.6$
Energy-aware strategies on heterogeneous platforms

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

<table>
<thead>
<tr>
<th>$\text{corr}_{\text{proc}}$ = 0</th>
<th>$\text{corr}_{\text{proc}}$ = 0.25</th>
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<td>$R = 0.96$</td>
<td>$R = 0.96$</td>
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<td>$R = 0.90$</td>
<td>$R = 0.90$</td>
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</tr>
</tbody>
</table>

Basic Work

Ratio to the baseline mapping

$\text{corr}_{\text{task}} = 0.5, \beta_{\text{w}} = 0.8$ Scheduling criteria: time-time

RR n° 9324
Energy-aware strategies on heterogeneous platforms

\[ R = 0.9 \]

\[ \text{Basic Work} \]

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

\[ \text{LowerBound} \]

\[ \text{deP} \]

\[ \text{deR} \]

\[ \text{inE} \]

\[ \text{random} \]

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

\[ \text{cor} = 0, \beta = 0.8 \]

\[ \text{cor} = 0.5, \beta = 0.8 \]

\[ \text{cor} = 0, \beta = 0.5 \]

\[ \text{cor} = 0.5, \beta = 0.5 \]

\[ \text{cor} = 0, \beta = 0.0 \]

\[ \text{cor} = 0.5, \beta = 0.0 \]

RR n° 9324
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.5, \ \beta_{\text{sw}} = 0.8; \text{ Scheduling criteria: energy-time} \]

<table>
<thead>
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<th>( R )</th>
<th>( \text{Ratio to the baseline} )</th>
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<td>0.92</td>
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<td>0.94</td>
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<tr>
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<td><img src="#" alt="Graph" /></td>
</tr>
<tr>
<td>0.98</td>
<td><img src="#" alt="Graph" /></td>
</tr>
</tbody>
</table>

**Mapping:**
- LowerBound
- dE
- deR
- inE
- random
Energy-aware strategies on heterogeneous platforms

Energy-aware strategies on heterogeneous platforms

**Diagram:**

- Corr prev = 0
- Corr prev = 0.25
- Corr prev = 0.5
- Corr prev = 0.75
- Corr prev = 1

- R = 0.98
- R = 0.96
- R = 0.94
- R = 0.92
- R = 0.9

- βw = 0.5, βw = 0.8
- Scheduling criteria: randomShuffling

**Legend:**

- mapping
- Corr
- cor proc
- Basic Work
- RR°
- A:S
- mapping
- cor proc
$\text{cor}_{\text{task}} = 0.5$, $\beta_{j,w} = 1$; Scheduling criteria: time-time
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.5; \beta_{\text{b/w}} = 1; \] Scheduling criteria: time-energy

<table>
<thead>
<tr>
<th>( R )</th>
<th>Ratio to the baseline</th>
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<tbody>
<tr>
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<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>

**Basic Work**

![Graph](image)

**Mapping**

- LowerBound
- deP
- deR
- inE
- random

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

Basic Work
Ratio to the baseline
mapping
LowerBound
dep
deP
inE
random

cor
 task = 0.5, \beta_0 = 1. Scheduling criteria: energy-time

RR n°9324
Energy-aware strategies on heterogeneous platforms

$cor_{task} = 0.5; \beta_{h/w} = 1$; Scheduling criteria: energy-energy

Basic Work

Ratio to the baseline
Energy-aware strategies on heterogeneous platforms

<table>
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<th>$c_{\text{pre}}$</th>
<th>$R$</th>
<th>$\beta_0$</th>
<th>$\beta_0$</th>
<th>$\beta_0$</th>
<th>$\beta_0$</th>
<th>$\beta_0$</th>
<th>$\beta_0$</th>
<th>$\beta_0$</th>
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<td>0.75</td>
<td>1.00</td>
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<tr>
<td>1.00</td>
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<td>0.75</td>
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</table>

Basic Work: Correlation $= 0.5$, $\beta_0 = 1$; Scheduling criteria: randomShuffling

RR n° 9324
Energy-aware strategies on heterogeneous platforms

cor_{task} = 0.75; \beta_{b/w} = 0.2; Scheduling criteria: time-time
$\text{cor}_{\text{task}} = 0.75; \ \beta_{b/w} = 0.2$; Scheduling criteria: time-energy
Energy-aware strategies on heterogeneous platforms

$R = 0.98$

$R = 0.96$

$R = 0.94$

$R = 0.92$

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

$\text{Basic Work}$

$\text{Ratio to the baseline}$

$\text{mapping}$

$\text{LowerBound}$

$\text{deP}$

$\text{deR}$

$\text{inE}$

$\text{random}$

$\beta_{\text{ww}} = 0.75$, $\beta_{\text{ww}} = 0.2$, Scheduling criteria: energy-time

RR n° 9324
$cor_{task} = 0.75; \beta_{b/w} = 0.2; \text{ Scheduling criteria: energy-energy}$
energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

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

Basic Work

Ratio to the baseline

mapping LowerBound deP deR inE random
\[ \text{cor}_{\text{task}} = 0.75; \quad \beta_{b/w} = 0.4; \quad \text{Scheduling criteria: time-energy} \]
Energy-aware strategies on heterogeneous platforms

\[ R = 0.98 \]

\[ R = 0.96 \]

\[ R = 0.94 \]

\[ R = 0.92 \]

\[ R = 0.90 \]

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

Scheduling criteria: energy-time

Basic Work

LowestEnergy

\[ \text{Basic Work} \]

\[ \text{LowestEnergy} \]

[Graph and chart data not transcribed]
Energy-aware strategies on heterogeneous platforms

\[ R = 0.9 \]

\[ corr_{\text{task}} = 0.75, \beta_{\text{uw}} = 0.4 \]

Scheduling criteria: energy-energy

Basic Work

LowerBound
deP
deR
inE
random

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

RR n° 9324
$cor_{task} = 0.75$; $\beta_{b/w} = 0.4$; Scheduling criteria: randomShuffling

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

cor_{task} = 0.75; \beta_{b/w} = 0.6; Scheduling criteria: time-time

Basic Work

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

<table>
<thead>
<tr>
<th>cos(\theta) = \theta</th>
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<th>cos(\theta) = 0.75</th>
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<tr>
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</tbody>
</table>

Scheduling criteria: time-energy

Basic Work: \( \beta \) = 0.00, 0.75. Workload: \( \beta \) = 0.6. Scheduling criteria: time-energy.
Energy-aware strategies on heterogeneous platforms

corr_{task} = 0.75; \beta_{b/w} = 0.6; \text{Scheduling criteria: energy-time}
$\rho_{\text{task}} = 0.75$; $\beta_{b/w} = 0.6$; Scheduling criteria: energy-energy
Energy-aware strategies on heterogeneous platforms

\( cor_{\text{task}} = 0.75; \beta_{b/w} = 0.6; \) Scheduling criteria: randomShuffling
Energy-aware strategies on heterogeneous platforms
$cor_{task} = 0.75; \beta_{b/w} = 0.8; \text{Scheduling criteria: time-energy}$

$\mathbb{R} = 0.9; \mathbb{R} = 0.92; \mathbb{R} = 0.94; \mathbb{R} = 0.96; \mathbb{R} = 0.98$

$cor_{proc} = 0.10; cor_{proc} = 0.15; cor_{proc} = 0.20; cor_{proc} = 0.25; cor_{proc} = 0.30$

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

c_{0.75}; \beta_{b/w} = 0.8; Scheduling criteria: energy-time

Basic Work

Ratio to the baseline

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

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

<table>
<thead>
<tr>
<th>( \mathcal{R} )</th>
<th>LowerBound</th>
<th>deP</th>
<th>deR</th>
<th>inE</th>
<th>random</th>
</tr>
</thead>
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<td><img src="image2" alt="Graph" /></td>
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<td><img src="image4" alt="Graph" /></td>
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</tr>
<tr>
<td>( \mathcal{R} = 0.92 )</td>
<td><img src="image6" alt="Graph" /></td>
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<tr>
<td>( \mathcal{R} = 0.94 )</td>
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<td>( \mathcal{R} = 0.96 )</td>
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<tr>
<td>( \mathcal{R} = 0.98 )</td>
<td><img src="image21" alt="Graph" /></td>
<td><img src="image22" alt="Graph" /></td>
<td><img src="image23" alt="Graph" /></td>
<td><img src="image24" alt="Graph" /></td>
<td><img src="image25" alt="Graph" /></td>
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</table>
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
<th>$\text{corr}_{\text{pre}}$</th>
<th>0.00</th>
<th>0.25</th>
<th>0.50</th>
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<tbody>
<tr>
<td>$R = 0.98$</td>
<td></td>
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<tr>
<td>$R = 0.96$</td>
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<tr>
<td>$R = 0.94$</td>
<td></td>
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<td></td>
<td></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>$R = 0.90$</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Basic Work: $\alpha \beta = 0.75$, $\beta_{\text{bw}} = 0.8$; Scheduling criterion: randomShuffling

RR n° 9324
Energy-aware strategies on heterogeneous platforms

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

\( \text{cor}_{\text{task}} = 0.75; \ \beta_{\text{b/w}} = 1; \ \text{Scheduling criteria: time-energy} \)
Energy-aware strategies on heterogeneous platforms

\[ R = 0.9, \quad \beta = 0.75, \quad \beta_{\text{in}} = 1; \quad \text{Scheduling criteria: energy-time} \]
Energy-aware strategies on heterogeneous platforms

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

\( \text{cor}_{\text{task}} = 0; \ \beta_{b/w} = 0.2; \ \text{Mapping criteria: inE} \)

<table>
<thead>
<tr>
<th>N</th>
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</tr>
</thead>
<tbody>
<tr>
<td>0.9</td>
<td>1.00</td>
</tr>
<tr>
<td>0.92</td>
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</tr>
<tr>
<td>0.94</td>
<td>1.00</td>
</tr>
<tr>
<td>0.96</td>
<td>1.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Basic Work</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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<td>0.10</td>
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<td>0.15</td>
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<table>
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<th>time-energy</th>
<th>randomShuffling</th>
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Energy-aware strategies on heterogeneous platforms

RR n° 5231

S05
$c_{rtask} = 0; \beta_{b/w} = 0.2; \text{Mapping criteria: deR}$
\( \text{corr}_{\text{task}} = 0; \beta_{b/w} = 0.2; \text{Mapping criteria: deP} \)

<table>
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<tr>
<th>( \mathcal{N} )</th>
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<tbody>
<tr>
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<table>
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<td>0.75</td>
</tr>
<tr>
<td>1.00</td>
<td>0.50</td>
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</tbody>
</table>

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

\[ \text{cor}_{\text{task}} = 0; \beta_{b/w} = 0.2; \text{Mapping criteria: random} \]
Energy-aware strategies on heterogeneous platforms

\[ R = 0.9 \]

\[ R = 0.92 \]

\[ R = 0.94 \]

\[ R = 0.96 \]

\[ R = 0.98 \]

\[ cor_{task} = 0; \beta_{b/w} = 0.4; \text{Mapping criteria: inE} \]

<table>
<thead>
<tr>
<th>Basic Work</th>
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<th>0.15</th>
<th>0.20</th>
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<th>0.30</th>
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<td>1.25</td>
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<td>1.25</td>
<td>1.00</td>
<td>0.75</td>
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- LowerBound
- energy-time
- time-energy
- randomShuffling
Energy-aware strategies on heterogeneous platforms

cor_{task} = 0; \beta_{b/w} = 0.4; Mapping criteria: deR

Basic Work

Ratio to the baseline

0.00 0.25 0.50 0.75 1.00 1.25

0.10 0.15 0.20 0.25 0.30 0.35

scheduling: LowerBound, energy-time, time-energy, randomShuffling
$R = 0.9$; $\beta_{b/w} = 0.4$; Mapping criteria: deP

<table>
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<tr>
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<th>$\beta$</th>
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<tr>
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<td>0.10</td>
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</table>

Energy-aware strategies on heterogeneous platforms
$\text{R} = 0.9$, $\beta_{b/w} = 0.4$; Mapping criteria: random

energy-aware strategies on heterogeneous platforms
\( \text{cor}_{\text{task}} = 0; \ \beta_{b/w} = 0.6; \ \text{Mapping criteria: inE} \)
Energy-aware strategies on heterogeneous platforms

\[ c_{\text{task}} = 0; \beta_{b/w} = 0.6; \text{Mapping criteria: deR} \]
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 1; \ \beta_{b/w} = 1; \ \text{Mapping criteria: random} \]
$cor_{task} = 0; \beta_{b/w} = 0.6; $ 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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<tbody>
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Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{task}} = 0; \ \beta_{b/w} = 0.6; \ \text{Mapping criteria: random} \)

<table>
<thead>
<tr>
<th>( R )</th>
<th>( \text{Baseline} )</th>
<th>LowerBound</th>
<th>energy-energy</th>
<th>time-energy</th>
<th>randomShuffling</th>
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</thead>
<tbody>
<tr>
<td>0.9</td>
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<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
</tr>
<tr>
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<td>0.10</td>
</tr>
<tr>
<td>0.94</td>
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<td>0.10</td>
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<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
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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

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

<table>
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<th>$cor_{prev}$</th>
<th>$R_{corr}$</th>
<th>$\beta_{bw}$</th>
<th>Mapping criteria: inE</th>
<th>Ratio to the baseline</th>
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<tbody>
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<td>0</td>
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<td>basic work</td>
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<td>0.96</td>
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</tr>
<tr>
<td>0.5</td>
<td>0.94</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.75</td>
<td>0.92</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0.90</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Energy-aware strategies on heterogeneous platforms

\[ R = 0.9 \]

\[ R = 0.92 \]

\[ R = 0.94 \]

\[ R = 0.96 \]

\[ R = 0.98 \]

cor \[ task \] = 0; \[ \beta_{b/w} \] = 0.8; Mapping criteria: deR

Basic Work

Ratio to the baseline

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

\[ R = 0.9 \]

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

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

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

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

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

\[ \text{cor}_{\text{task}} = 0; \beta_{\text{uw}} = 0.8; \text{Mapping criteria: deP} \]

\[ \text{cor}_{\text{task}} = 0; \beta_{\text{uw}} = 0.8; \text{Mapping criteria: deP} \]

\[ \text{cor}_{\text{task}} = 0; \beta_{\text{uw}} = 0.8; \text{Mapping criteria: deP} \]

\[ \text{cor}_{\text{task}} = 0; \beta_{\text{uw}} = 0.8; \text{Mapping criteria: deP} \]

\[ \text{cor}_{\text{task}} = 0; \beta_{\text{uw}} = 0.8; \text{Mapping criteria: deP} \]
Energy-aware strategies on heterogeneous platforms

\[ R = 0.98 \]

\[ R = 0.96 \]

\[ R = 0.94 \]

\[ R = 0.92 \]

\[ R = 0.90 \]

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

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

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

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

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

Basic Work

Ratio to the baseline

scheduling

LowerBound

energy-energy

time-energy

time-time

cor_{\text{proc}} = 0; \beta_{b/w} = 0.8; Mapping criteria: random

RR n° 9324
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms
\( r_{\text{task}} = 0; \beta_{b/w} = 1; \) Mapping criteria: deP
Energy-aware strategies on heterogeneous platforms

corr tasked = 0; $\beta_{b/w} = 1$; Mapping criteria: random

- $R = 0.9$
- $R = 0.92$
- $R = 0.94$
- $R = 0.96$
- $R = 0.98$

Basic Work

Ratio to the baseline

Energy-aware strategies on heterogeneous platforms

scheduling

- LowerBound
- energy-energy
- time-time
- randomShuffling
0.00

0.25

0.50

0.75

1.00

0.00
1.25

0.25

0.50

0.75

1.00

0.00
1.25

0.25

0.50

Ratio to the baseline
0.75

20.00
0.10

20.00
0.10

20.00
0.10

20.00
0.10

R = 0.9

20.00
0.10

0.25
0.30 0.10

20.00
0.10

20.00
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20.00
0.10

20.00
0.10

20.00
0.10

0.15
0.20

20.00
0.10

20.00
0.10

R = 0.92

20.00
0.10

0.25
20.00
0.10

20.00
0.10

20.00
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20.00
0.10

20.00
0.10

20.00
0.10

0.20

Basic Work

0.15
20.00
0.10

20.00
0.10

20.00
0.10

0.25

energy-time
time-energy

R = 0.94

LowerBound
energy-energy

0.30 0.10

scheduling

0.20

0.10

20.00
0.10

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20.00
0.10

20.00
0.10

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20.00
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20.00
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20.00
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0.75

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1.00

20.00
0.10

20.00
0.10

1.25

20.00
0.10

20.00
0.10

cortask = 0.25; βb/w = 0.2; Mapping criteria: inE

20.00
0.10

20.00
0.10

RR n° 9324
20.00
0.10

20.00
0.10

20.00
0.10

20.00
0.10

0.15
0.20

20.00
0.10

R = 0.96

time-time
randomShuffling

0.30 0.10

20.00
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20.00
0.10

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0.30 0.10

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20.00
0.10

0.15
0.20

20.00
0.10

R = 0.98

20.00
0.10

20.00
0.10

0.25
corproc = 0.75

corproc = 1

0.30

20.00
0.10

20.00
0.10

20.00
0.10

corproc = 0.5

corproc = 0.25

20.00
0.10

20.00
0.10

corproc = 0

886

Energy-aware strategies on heterogeneous platforms


\( cor_{\text{task}} = 0.25; \ \beta_{b/w} = 0.2; \) Mapping criteria: deR

<table>
<thead>
<tr>
<th>Basic Work</th>
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<th>( \mathcal{R} = 0.92 )</th>
<th>( \mathcal{R} = 0.94 )</th>
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</table>

Legend: LowerBound, energy-time, time-energy, randomShuffling, basic work.
Energy-aware strategies on heterogeneous platforms

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

\[ R = 0.9 \]

\[ R = 0.92 \]

\[ R = 0.94 \]

\[ R = 0.96 \]

\[ cor_{port} = 0 \]

\[ cor_{port} = 0.25 \]

\[ cor_{port} = 0.5 \]

\[ cor_{port} = 0.75 \]

\[ cor_{port} = 1 \]

Basic Work

Ratio to the baseline

scheduling

LowerBound

energy-energy

time-energy

time-time

randomShuffling

\[ cor_{task} = 0.25 \]

\[ \beta_{low} = 0.4 \]

Mapping criteria: inE

RR n° 9324
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.25; \beta_{b/w} = 0.4; \text{Mapping criteria: deR} \]
cor_{task} = 0.25; \beta_{b/w} = 0.4; Mapping criteria: deP

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

cor\text{task} = 0.25; \beta_{b/w} = 0.4; Mapping criteria: random

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
randomShuffling

LowerBound
energy-energy
time-time
randomShuffling
$\text{cor}_{\text{task}} = 0.25; \beta_{b/w} = 0.6; \text{Mapping criteria: inE}$
\( \text{cor}_{\text{task}} = 0.25; \ \beta_{b/w} = 0.6; \text{Mapping criteria: deR} \)
$\text{cor}_{\text{task}} = 0.25$; $\beta_{b/w} = 0.6$; Mapping criteria: deP

Basic Work

Ratio to the baseline

Energy-aware strategies on heterogeneous platforms
cor\textsubscript{task} = 0.25; \beta_{b/w} = 0.6; Mapping criteria: random
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.25; \beta_{b/w} = 0.8; \text{Mapping criteria: inE} \]

<table>
<thead>
<tr>
<th>( R )</th>
<th>( \text{Basic Work} )</th>
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</thead>
<tbody>
<tr>
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<tr>
<td>0.94</td>
<td>0.75</td>
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<tr>
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</tr>
<tr>
<td>0.98</td>
<td>1.25</td>
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</tbody>
</table>

\[ \text{scheduling: LowerBound, energy-time, time-energy, randomShuffling} \]
Energy-aware strategies on heterogeneous platforms

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

- \begin{array}{l}
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R = 0.92 \\
R = 0.94 \\
R = 0.96 \\
R = 0.98 \\
\end{array}

- \begin{array}{l}
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cor\text{proc} = 0.25 \\
cor\text{proc} = 0.5 \\
cor\text{proc} = 0.75 \\
cor\text{proc} = 1 \\
\end{array}

Ratio to the baseline

Basic Work

- \begin{array}{l}
lowerBound \\
energy-energy \\
energy-time \\
time-energy \\
time-time \\
randomShuffling \\
\end{array}
Energy-aware strategies on heterogeneous platforms

\( cor_{\text{task}} = 0.25; \ \beta_{b/w} = 0.8; \) Mapping criteria: deP

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

$c_{\text{task}} = 0.25$; $\beta_{b/w} = 1$; Mapping criteria: inE

Ratio to the baseline

Basic Work

scheduling

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

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

\( \text{cor}_{\text{task}} = 0.5; \beta_{b/w} = 0.2; \text{Mapping criteria: inE} \)
Energy-aware strategies on heterogeneous platforms

c_{\text{task}} = 0.5; \beta_{j,w} = 0.2; Mapping criteria: deR

Basic Work

Ratio to the baseline

0.00 0.25 0.50 0.75 1.00 1.25 0.00 0.25 0.50 0.75 1.00 1.25 0.00 0.25 0.50 0.75 1.00 1.25
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

0.00 0.25 0.50 0.75 1.00 1.25 0.00 0.25 0.50 0.75 1.00 1.25 0.00 0.25 0.50 0.75 1.00 1.25
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

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

\[ \text{cor}_{\text{task}} = 0.5; \beta_{\text{f,w}} = 0.2; \] Mapping criteria: deP

<table>
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Energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{task}} = 0.5 \), \( \beta_{\text{bw}} = 0.2 \); Mapping criteria: random
Energy-aware strategies on heterogeneous platforms

cor\textsubscript{task} = 0.5; \beta_{\text{b/w}} = 0.4; Mapping criteria: inE

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Basic Work

Ratio to the baseline

scheduling

LowerBound - energy-time

energy-energy - time-energy

randomShuffling
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.5; \beta_{\text{beta}} = 0.4; \text{Mapping criteria: deR} \]
Energy-aware strategies on heterogeneous platforms

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<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><img src="image7" alt="Graph" /></td>
<td><img src="image8" alt="Graph" /></td>
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<td>cor_\text{prox} = 0.5</td>
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<td><img src="image12" alt="Graph" /></td>
<td><img src="image13" alt="Graph" /></td>
<td><img src="image14" alt="Graph" /></td>
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<tr>
<td>cor_\text{prox} = 0.75</td>
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<td><img src="image17" alt="Graph" /></td>
<td><img src="image18" alt="Graph" /></td>
<td><img src="image19" alt="Graph" /></td>
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<tr>
<td>cor_\text{prox} = 1</td>
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<td><img src="image22" alt="Graph" /></td>
<td><img src="image23" alt="Graph" /></td>
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Basic Work: \( \text{Ratio to the baseline} \)

**scheduling**

| cor\_\text{task} = 0.5, \( \beta\_v = 0.4 \), Mapping criteria: deP |
|-----------------|--------|--------|--------|--------|--------|
| cor\_\text{prox} = 0 | ![Graph](image26) | ![Graph](image27) | ![Graph](image28) | ![Graph](image29) | ![Graph](image30) |
| cor\_\text{prox} = 0.25 | ![Graph](image31) | ![Graph](image32) | ![Graph](image33) | ![Graph](image34) | ![Graph](image35) |
| cor\_\text{prox} = 0.5 | ![Graph](image36) | ![Graph](image37) | ![Graph](image38) | ![Graph](image39) | ![Graph](image40) |
| cor\_\text{prox} = 0.75 | ![Graph](image41) | ![Graph](image42) | ![Graph](image43) | ![Graph](image44) | ![Graph](image45) |
| cor\_\text{prox} = 1 | ![Graph](image46) | ![Graph](image47) | ![Graph](image48) | ![Graph](image49) | ![Graph](image50) |

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

#### Basic Work

<table>
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<tr>
<th>cor wastewater</th>
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<tr>
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<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
<td>1.00</td>
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</table>

#### Correlation between energy and task ratio

- cor wastewater = 0.5, cor proc = 0.4, Mapping criteria: random

#### LowerBound energy-time

The LowerBound energy-time is calculated based on the energy consumption and task ratio. It helps in optimizing the energy efficiency of tasks on heterogeneous platforms.

#### UpperBound energy-energy

The UpperBound energy-energy is determined by the energy consumption and task ratio, ensuring optimal energy use.

#### Energy-time

Energy-time ratio is a crucial factor in determining the efficiency of energy consumption across different platforms.

#### RandomShuffling

RandomShuffling is a technique used to distribute tasks randomly across different platforms, optimizing the energy consumption.

---

**RR n° 9324**
$R_{\text{cor}} = 0.9$, $R_{\text{proc}} = 0.25$, $R_{\text{task}} = 0.5$, $\beta_{b/w} = 0.6$; Mapping criteria: inE

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

\[ \text{cor}_{\text{task}} = 0.5; \beta_{b/w} = 0.6; \] Mapping criteria: deR

<table>
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<tr>
<th>( \mathcal{N} )</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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<td>0.20</td>
<td>0.25</td>
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Basic Work

Ratio to the baseline

Energy aware strategies on heterogeneous platforms
$cor_{task} = 0.5; \beta_{j/w} = 0.6; \text{Mapping criteria: deP}$
$\text{cor}_{\text{task}} = 0.5$; $\beta_{b/w} = 0.6$; Mapping criteria: random
Energy-aware strategies on heterogeneous platforms

<table>
<thead>
<tr>
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<th>$\text{corr}_{\text{task}} = 0.25$</th>
<th>$\text{corr}_{\text{task}} = 0.5$</th>
<th>$\text{corr}_{\text{task}} = 0.75$</th>
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Basic Work

Ratio to the baseline

$scheduling$
$cor_{\text{task}} = 0.5; \beta_{j,w} = 0.8$; Mapping criteria: deR
Energy-aware strategies on heterogeneous platforms

cor_{\text{task}} = 0.5; \beta_{b/w} = 0.8; \text{Mapping criteria: deP}
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.5; \ \beta_{j/w} = 0.8; \ \text{Mapping criteria: random} \]
Energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{task}} = 0.5, \beta_{b/w} = 1; \text{Mapping criteria: inE} \)

<table>
<thead>
<tr>
<th>( N = 0.9 )</th>
<th>( N = 0.92 )</th>
<th>( N = 0.94 )</th>
<th>( N = 0.96 )</th>
<th>( N = 0.98 )</th>
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<tbody>
<tr>
<td>LowerBound</td>
<td>energy-energy</td>
<td>time-time</td>
<td>randomShuffling</td>
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Basic Work

Ratio to the baseline vs. Basic Work

scheduling

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

cor\textsubscript{task} = 0.5; \beta_{b/w} = 1; Mapping criteria: deR
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{task} = 0.5; \beta_{b/w} = 1; \text{Mapping criteria: deP} \]
Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms

cor_{task} = 0.75; \beta_{b/w} = 0.2; Mapping criteria: inE

<table>
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<tr>
<th>cor_{task}</th>
<th>cor_{proc}</th>
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Ratio to the baseline

Basic Work

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

cor_{task} = 0.75; \beta_{b/w} = 0.2; Mapping criteria: deR
\(\text{cor}_{\text{task}} = 0.75; \beta_{b/w} = 0.2; \) Mapping criteria: deP
$cor_{task} = 0.75$; $\beta_{b/w} = 0.2$; Mapping criteria: random

$R = 0.9$

$R = 0.92$

$R = 0.94$

$R = 0.96$

$R = 0.98$

Basic Work

Ratio to the baseline

$cor_{proc} = 0.75$; $\beta_{b/w} = 0.2$; Mapping criteria: random

scheduling

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

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

\[ r_{\text{task}} = 0.75; \; \beta_{b/w} = 0.4; \text{Mapping criteria: inE} \]
$\text{cor}_{\text{task}} = 0.75; \ \beta_{b/w} = 0.4; \ \text{Mapping criteria: deR}$
\( \text{cor}_{\text{task}} = 0.75; \ \beta_{b/w} = 0.4 \); Mapping criteria: deP
cor_{task} = 0.75; \beta_{b/w} = 0.4; Mapping criteria: random

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Basic Work

Ratio to the baseline

Energy-aware strategies on heterogeneous platforms
$cor_{task} = 0.75$; $\beta_{b/w} = 0.6$; Mapping criteria: inE
$\text{cor}_{\text{task}} = 0.75; \beta_{b/w} = 0.6$; Mapping criteria: deR
$\text{corr}_{\text{task}} = 0.75; \beta_{b/w} = 0.6; \text{Mapping criteria: deP}$
Energy-aware strategies on heterogeneous platforms

\( \text{cor}_{\text{task}} = 0.75; \ \beta_{b/w} = 0.6; \ \text{Mapping criteria: random} \)

**Basic Work**

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

---

**Energy-aware strategies on heterogeneous platforms**

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

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Basic Work

- $\text{cor}_{\text{task}} = 0.75, \beta_{\text{bw}} = 0.8$
- Mapping criteria: inEI

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LowerBound

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

**References**

R = 0.98
Energy-aware strategies on heterogeneous platforms

cor_{task} = 0.75; \beta_{b/w} = 0.8; Mapping criteria: deR

Basic Work

Ratio to the baseline
$\text{cor}_{\text{task}} = 0.75$; $\beta_{b/w} = 0.8$; Mapping criteria: deP
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 0.75; \; \beta_{b/w} = 0.8; \] Mapping criteria: random
\( \text{ratio} = 0.75; \; \beta = 1; \) Mapping criteria: inE

Basic Work

Ratio to the baseline

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

Basic Work

Ratio to the baseline
cor\textsubscript{task} = 0.75; \beta_{b/w} = 1; Mapping criteria: random
cor_{task} = 1; \beta_{b/w} = 0.2; Mapping criteria: inE
$cor_{task} = 1$; $\beta_{b/w} = 0.2$; Mapping criteria: deR

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Basic Work

Ratio to the baseline

scheduling

LowerBound, energy-time, time-time

energy-energy, time-energy, randomShuffling

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

\( cor_{task} = 1; \beta_{b/w} = 0.2; \) Mapping criteria: deP

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</table>

**Scheduling:**
- LowerBound
- energy-energy
- energy-time
- time-energy
- randomShuffling

**LowerBound**

**energy-energy**

**energy-time**

**time-energy**

**randomShuffling**
$cor_{task} = 1; \beta_{b/w} = 0.2; \text{Mapping criteria: random}$
Energy-aware strategies on heterogeneous platforms

cor_{task} = 1; \beta_{b/w} = 0.4; Mapping criteria: inE

<table>
<thead>
<tr>
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<tbody>
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<td>time-energy</td>
</tr>
<tr>
<td>0.96</td>
<td>time-time</td>
</tr>
<tr>
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<td>randomShuffling</td>
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Basic Work
Energy-aware strategies on heterogeneous platforms

\[ \text{corr}_{\text{task}} = 1; \ \beta_{b/w} = 0.4; \ \text{Mapping criteria: deR} \]
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 1; \beta_{h/w} = 0.4; \text{Mapping criteria: deP} \]

\[ \text{cor}_{\text{proc}} = 0.9 \]

\[ \text{cor}_{\text{proc}} = 0.92 \]

\[ \text{cor}_{\text{proc}} = 0.94 \]

\[ \text{cor}_{\text{proc}} = 0.96 \]

\[ \text{cor}_{\text{proc}} = 0.98 \]

Basic Work

Ratio to the baseline

Energy-aware strategies on heterogeneous platforms

scheduling
\( R_{\text{cor proc}} = 0 \).25 \( R_{\text{cor proc}} = 0 \).5 \( R_{\text{cor proc}} = 1 \)

\( cor_{\text{task}} = 1 \); \( \beta_{b/w} = 0.4 \); Mapping criteria: random

<table>
<thead>
<tr>
<th>Basic Work</th>
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<th>time-time</th>
<th>randomShuffling</th>
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Energy-aware strategies on heterogeneous platforms

```
RR n 923
```
Energy-aware strategies on heterogeneous platforms

\( cor_{task} = 1; \beta_{b/w} = 0.6; \) Mapping criteria: inE

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scheduling
LowerBound | energy-time | time-time
energy-energy | time-energy | randomShuffling
cor_{task} = 1; \beta_{b/w} = 0.6; Mapping criteria: deR
Energy-aware strategies on heterogeneous platforms

\[ \text{cor}_{\text{task}} = 1; \quad \beta_{b/w} = 0.6; \quad \text{Mapping criteria: deP} \]

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<table>
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<th>( \text{randomShuffling} )</th>
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RR n° 9234

Energy-aware strategies on heterogeneous platforms

906
Energy-aware strategies on heterogeneous platforms

cor\textsubscript{task} = 1; \beta_{b/w} = 0.6; Mapping criteria: random

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**Basic Work**

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**Scheduling**

- LowerBound
- energy-time
- time-energy
- RandomShuffling

**Lower Bound energy-energy, time-time**
$\text{cor}_{\text{task}} = 1; \beta_{b/w} = 0.8; \text{Mapping criteria: inE}$

<table>
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<th>Basic Work</th>
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<th>time-energy</th>
<th>randomShuffling</th>
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Energy-aware strategies on heterogeneous platforms
Energy-aware strategies on heterogeneous platforms
$cor_{task} = 1; \beta_{b/w} = 0.8; \text{Mapping criteria: deP}$

$R = 0.9$
$R = 0.92$
$R = 0.94$
$R = 0.96$
$R = 0.98$

Basic Work

Ratio to the baseline

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

$cor_{task} = 1; \beta_{b/w} = 0.8; $ Mapping criteria: random
Energy-aware strategies on heterogeneous platforms

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

cor\_{\text{task}} = 1; \beta_{b/w} = 1; \text{Mapping criteria: deR}

<table>
<thead>
<tr>
<th>N</th>
<th>\text{Ratio to the baseline}</th>
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Basic Work

scheduling: LowerBound, energy-energy, time-time, randomShuffling
\( cor_{task} = 1; \beta_{b/w} = 1; \) Mapping criteria: deP

<table>
<thead>
<tr>
<th>( R )</th>
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RR n: 9321

Energy-aware strategies on heterogeneous platforms