This article presents execution time and energy data collected from modern multicore systems running shared-memory applications, analyzed using our analytic models. While the full data sets and source code are available on Github, this data-in-brief article includes some samples and describes the experimental setup.

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1. Data

In this article we present the time-energy data measured for shared-memory applications running on modern multicore systems [1,2]. We provide two main data sets for each system and application, (i) measured, or raw, time-energy values as shown in Tables 3–7 and (ii) model output as shown in Tables 8 and 9. Table 3 presents measured data on homogeneous multicores with static OpenMP scheduling when big, little and all cores, respectively, are...
used. Table 7 presents measured data on heterogeneous multicores with dynamic OpenMP scheduling when all cores are used. Table 8 shows model’s output per system and application, while Table 9 presents a summary of model accuracy per system for all applications and speedup laws used, with respect to the sequential fraction and energy savings. The data in Table 8, corresponding to Amdahl’s law [3], is plotted in Fig. 2. The corresponding data derived with Gustafson’s law [4] is plotted in Fig. 3.

2. Experimental design, materials and methods

2.1. Setup

The experimental setup is depicted in Fig. 1. To collect power and energy, we use a Yokogawa WT201 power meter connected to the 240V AC power line. A controller system is used to start the experiments and collect execution and energy data from the target system. The power and energy samples are collected once per second. Table 1 summarizes the characteristics of the target systems used in our measurements.

Table 2 summarizes the shared-memory applications with their input parameters, as used for collecting the measurements. These applications are selected from well-known benchmarking suites, such as NPB [5], Rodinia [6], Parsec [7] and Mantevo [8]. In addition to the first seven applications presented in our research work [1,2], we provide data for CloverLeaf (CL), miniFE (FE) and miniGhost (GH) benchmarks from Mantevo suite [8], running on Xeon, i7 and Pi3.

2.2. Measured data

Measured time-energy data consists of seven columns, as shown in Table 3 for EP execution on Xeon. Each row represents the execution on a number of cores of the given application on the given system. The columns represent the number of nodes, number of cores per node, the core clock frequency of the cores, the execution time in seconds (s), the energy in Watts-hour (Wh) and Joules (J), and the average power consumption in Watts (W). The number of nodes is always one because these
experiments are run on single-node shared-memory multicore systems. To apply our models \cite{1,2}, the key columns to consider are Cores, Time and Energy.

For heterogeneous systems, such as XU3 and TX2, we provide four measured data sets per application, as exemplified in Tables 4–7 for EP on XU3. The first two data sets represent the execution with

Table 1

Systems.

| System | CPU | Cores | Frequency [GHz] | Memory [GB] |
|--------|-----|-------|-----------------|-------------|
| AMD    | AMD Opteron K10 | 48 | 2.10 | 64 (NUMA) |
| ARM    | Cavium ThunderX (64-bit ARM) | 48 | 2.00 | 128 (UMA) |
| Xeon   | Intel Xeon E5-2630 v4 | 10 (20 HT) | 2.20 | 64 (UMA) |
| i7     | Intel Core i7-6700 | 4 (8 HT) | 3.40 | 16 |
| Pi3    | ARM Cortex-A53 | 4 | 1.20 | 1 |
| XU3    | ARM big.LITTLE HMP (ARM Cortex-A15 + ARM Cortex-A7) | 8 (4 + 4) | 2.00 | 2 |
| TX2    | HMP (Denver + ARM Cortex-A57) | 6 (2 + 4) | 2.04 | 8 |

Table 2

Applications.

| Application | Benchmark Suite | Input Size | OpenMP Scheduling |
|-------------|-----------------|------------|-------------------|
| EP (Embarrassingly Parallel) | NPB \cite{5} | Class C (Random-number pairs: $2^{32}$) | default |
| BT (Block Tri-diagonal Solver) | NPB \cite{5} | Class C (Grid size: $162 \times 162 \times 162$, Iterations: 200) | static |
| SP (Scalar Penta-Diagonal solver) | NPB \cite{5} | Class C (Grid size: $162 \times 162 \times 162$, Iterations: 400) | Static |
| LV (LavaMD) | Rodinia \cite{6} | Boxes1d: 24 | default |
| KM (Kmeans) | Rodinia \cite{6} | $n = 1,000,000 \times m = 34 \times k = 5$ | static |
| PF (Pathfinder) | Rodinia \cite{6} | Width (rows): 900,000, Steps (columns): 500 | default |
| BS (BlackScholes) | Parsec \cite{7} | 4,000,000 options | default |
| CL (CloverLeaf) | Mantevo \cite{8} | Grid size 10000, end_time = 30.0 | default |
| FE (miniFE) | Mantevo \cite{8} | nx = 150 | default |
| GH (miniGhost) | Mantevo \cite{8} | nx = 100, num_tsteps = 1000 | default |
Table 3
Raw time-energy measurements (EP on Xeon).

| Procs | Cores | Freq       | Time [s] | Energy [Wh] | Energy [J] | AvgPower [W] |
|-------|-------|------------|----------|-------------|------------|--------------|
| 1     | 1     | 2.20GHz    | 384.14   | 8.46        | 30,456     | 79.48        |
| 1     | 2     | 2.20GHz    | 195.63   | 4.60        | 16,560     | 84.93        |
| 1     | 3     | 2.20GHz    | 138.33   | 3.36        | 12,096     | 88.32        |
| 1     | 4     | 2.20GHz    | 106.39   | 2.71        | 9756       | 92.10        |
| 1     | 5     | 2.20GHz    | 89.29    | 2.31        | 8316       | 94.73        |
| 1     | 6     | 2.20GHz    | 77.76    | 2.08        | 7488       | 97.18        |
| 1     | 7     | 2.20GHz    | 69.07    | 1.87        | 6732       | 99.04        |
| 1     | 8     | 2.20GHz    | 62.09    | 1.73        | 6228       | 100.73       |
| 1     | 9     | 2.20GHz    | 55.23    | 1.58        | 5688       | 103.89       |
| 1     | 10    | 2.20GHz    | 49.65    | 1.46        | 5256       | 107.49       |
| 1     | 11    | 2.20GHz    | 49.64    | 1.46        | 5256       | 107.85       |
| 1     | 12    | 2.20GHz    | 45.94    | 1.37        | 4932       | 110.92       |
| 1     | 13    | 2.20GHz    | 42.85    | 1.28        | 4608       | 110.22       |
| 1     | 14    | 2.20GHz    | 40.12    | 1.20        | 4320       | 110.81       |
| 1     | 15    | 2.20GHz    | 37.48    | 1.14        | 4104       | 112.08       |
| 1     | 16    | 2.20GHz    | 35.42    | 1.10        | 3960       | 112.34       |
| 1     | 17    | 2.20GHz    | 34.02    | 1.06        | 3816       | 112.98       |
| 1     | 18    | 2.20GHz    | 31.58    | 0.97        | 3492       | 113.88       |
| 1     | 19    | 2.20GHz    | 29.93    | 0.92        | 3312       | 114.54       |
| 1     | 20    | 2.20GHz    | 28.83    | 0.89        | 3204       | 115.21       |

Table 4
Raw time-energy measurements on big cores with static scheduling (EP on XU3).

| #Procs | Cores | Freq       | Time [s] | Energy [Wh] | Energy [J] | AvgPower [W] |
|--------|-------|------------|----------|-------------|------------|--------------|
| 1      | 1     | 2.00GHz    | 710.81   | 0.02        | 60.12      | 9.27         |
| 1      | 2     | 2.00GHz    | 363.58   | 0.01        | 42.12      | 12.51        |
| 1      | 3     | 2.00GHz    | 250.09   | 0.01        | 36.00      | 15.03        |
| 1      | 4     | 2.00GHz    | 197.88   | 0.01        | 29.52      | 15.56        |

Table 5
Raw time-energy measurements on little cores with static scheduling (EP on XU3).

| #Procs | Cores | Freq       | Time [s] | Energy [Wh] | Energy [J] | AvgPower [W] |
|--------|-------|------------|----------|-------------|------------|--------------|
| 1      | 1     | 2.00GHz    | 1607.79  | 0.03        | 99.00      | 6.65         |
| 1      | 2     | 2.00GHz    | 820.67   | 0.01        | 53.28      | 7.10         |
| 1      | 3     | 2.00GHz    | 548.60   | 0.01        | 37.80      | 7.51         |
| 1      | 4     | 2.00GHz    | 413.19   | 0.01        | 29.88      | 7.89         |

Table 6
Raw time-energy measurements on all cores with static scheduling (EP on XU3).

| #Procs | Cores | Freq       | Time [s] | Energy [Wh] | Energy [J] | AvgPower [W] |
|--------|-------|------------|----------|-------------|------------|--------------|
| 1      | 1     | 2.00GHz    | 714.61   | 0.017       | 61.2       | 9.24         |
| 1      | 2     | 2.00GHz    | 363.75   | 0.012       | 43.2       | 12.45        |
| 1      | 3     | 2.00GHz    | 250.87   | 0.01        | 36         | 14.69        |
| 1      | 4     | 2.00GHz    | 198.74   | 0.008       | 28.8       | 15.32        |
| 1      | 5     | 2.00GHz    | 321.7    | 0.01        | 36         | 10.94        |
| 1      | 6     | 2.00GHz    | 273.5    | 0.008       | 28.8       | 11.10        |
| 1      | 7     | 2.00GHz    | 235.14   | 0.007       | 25.2       | 11.35        |
| 1      | 8     | 2.00GHz    | 206.75   | 0.007       | 25.2       | 11.67        |
Table 7
Raw time-energy measurements on all cores with dynamic scheduling (EP on XU3).

| #Procs | Cores | Freq   | Time [s] | Energy [Wh] | Energy [J] | AvgPower [W] |
|--------|-------|--------|----------|-------------|------------|--------------|
| 1      | 1     | 2.00GHz| 709.82   | 0.017       | 61.2       | 9.25         |
| 1      | 2     | 2.00GHz| 364.94   | 0.012       | 43.2       | 12.47        |
| 1      | 3     | 2.00GHz| 248.67   | 0.01        | 36         | 15.11        |
| 1      | 4     | 2.00GHz| 198.96   | 0.008       | 28.8       | 15.31        |
| 1      | 5     | 2.00GHz| 179.27   | 0.007       | 25.2       | 15.32        |
| 1      | 6     | 2.00GHz| 162.8    | 0.007       | 25.2       | 15.41        |
| 1      | 7     | 2.00GHz| 149.53   | 0.006       | 21.6       | 15.54        |
| 1      | 8     | 2.00GHz| 137.73   | 0.006       | 21.6       | 15.67        |

Table 8
Model output data (EP on Xeon, Amdahl's law).

| Cores | Measured Speedup | Predicted Speedup | Measured Energy Savings | Predicted Energy Savings | Measured Time | Predicted Time | Measured Energy | Predicted Energy |
|-------|------------------|-------------------|-------------------------|-------------------------|--------------|----------------|----------------|-----------------|
| 1     | 1                | 0                 | 0                       | 0                       | 384.1        | 384.1          | 30,530          | 24,233.8        |
| 2     | 1.96             | 1.94              | 0.456                   | 0.466                   | 195.6        | 198            | 16,615.1        | 13,024.5        |
| 3     | 2.78             | 2.82              | 0.6                     | 0.619                   | 138.3        | 136            | 12,217.2        | 9288            |
| 4     | 3.61             | 3.66              | 0.679                   | 0.696                   | 106.4        | 105            | 9798.4          | 7419.8          |
| 5     | 4.3              | 4.45              | 0.723                   | 0.744                   | 89.3         | 86.4           | 8458.3          | 6298.9          |
| 6     | 4.94             | 5.19              | 0.752                   | 0.773                   | 77.8         | 73.9           | 7556.8          | 5551.6          |
| 7     | 5.56             | 5.9               | 0.776                   | 0.796                   | 69.1         | 65.1           | 6841            | 5017.8          |
| 8     | 6.19             | 6.57              | 0.795                   | 0.812                   | 62.1         | 58.4           | 6254.2          | 4617.5          |
| 9     | 6.96             | 7.21              | 0.812                   | 0.825                   | 55.2         | 53.3           | 5737.6          | 4306.1          |
| 10    | 7.74             | 7.82              | 0.825                   | 0.835                   | 49.6         | 49.1           | 5336.9          | 4057            |
| 11    | 7.74             | 8.4               | 0.825                   | 0.844                   | 49.6         | 45.7           | 5353.9          | 3853.2          |
| 12    | 8.36             | 8.95              | 0.835                   | 0.851                   | 45.9         | 42.9           | 5026.8          | 3683.4          |
| 13    | 8.96             | 9.47              | 0.845                   | 0.857                   | 42.9         | 40.5           | 4723            | 3539.7          |
| 14    | 9.57             | 9.98              | 0.854                   | 0.862                   | 40.1         | 38.5           | 4445.6          | 3416.5          |
| 15    | 10.25            | 10.46             | 0.862                   | 0.866                   | 37.5         | 36.7           | 4200.6          | 3309.7          |
| 16    | 10.85            | 10.92             | 0.869                   | 0.87                    | 35.4         | 35.2           | 3989.6          | 3216.3          |
| 17    | 11.29            | 11.36             | 0.874                   | 0.874                   | 34           | 33.8           | 3843.4          | 3133.9          |
| 18    | 12.16            | 11.79             | 0.882                   | 0.877                   | 31.6         | 32.6           | 3596.3          | 3060.6          |
| 19    | 12.83            | 12.19             | 0.888                   | 0.879                   | 29.9         | 31.5           | 3428.1          | 2995.1          |
| 20    | 13.32            | 12.59             | 0.891                   | 0.882                   | 28.8         | 30.5           | 3321.6          | 2936.1          |

Table 9
Model accuracy output (on Xeon).

| #Val | #App | Amdahl | Gustafson | RMSD(f) | RMSD (es) |
|------|------|--------|-----------|---------|-----------|
|      |      |        |           | Amdahl  | Gustafson |
| EP   | 0.03 | 0.33   | 0.373     | 0.406   | 1.3       | 2.3       |
| LV   | 0.05 | 0.42   | 0.26      | 0.664   | 1.4       | 3.3       |
| BT   | 0.1  | 0.62   | 0.512     | 1.09    | 3.1       | 7.5       |
| SP   | 0.22 | 0.81   | 0.583     | 1.142   | 10.3      | 16.6      |
| BS   | 0.06 | 0.5    | 0.249     | 0.594   | 1.2       | 4.5       |
| KM   | 0.38 | 0.89   | 0.168     | 0.306   | 9.5       | 11.3      |
| PF   | 0.46 | 0.93   | 0.036     | 0.305   | 2.2       | 11.8      |
| CL   | 0.2  | 0.79   | 0.456     | 1.011   | 8.5       | 13.9      |
| FE   | 0.19 | 0.78   | 0.284     | 0.902   | 7.4       | 11.5      |
| GH   | 0.99 | 0.9999 | 0.028     | 0.029   | 2.6       | 2.5       |
OpenMP static scheduling on big and little cores, respectively. The last two data sets represent the execution on all cores using static and dynamic OpenMP execution, respectively.

2.3. Model output data

Our analytic models [1,2] are implemented in Python and can be run on a Linux system using the provided bash scripts. There are two wrapper scripts corresponding to homogeneous and heterogeneous systems, respectively. Besides speedup and energy data, these scripts take as parameters the number of cores, the active power fraction (APF) [1,2] and the idle power of the system. By tweaking these parameters, users can explore new system designs and estimate their time-energy efficiency.

Fig. 2. Amdahl speedup on Xeon.

Fig. 3. Gustafson speedup on Xeon.
Model output data consists of nine columns, as shown in Table 8 for EP running on Xeon when Amdahl’s law [3] for speedup is used. The first column represents the number of cores used for execution, while the other eight columns represent measured and predicted speedup, energy savings, execution time and energy, respectively.

In addition, the source code implementing the model reports the sequential fraction and the Root-Mean-Square Deviation (RMSD) between measured and predicted values across all core counts. A summary consisting of the sequential fraction (f), RMSD of the sequential fraction (RMSD(f)) and RMSD of energy savings (RMSD(es)) for each workload and for both Amdahl’s and Gustafson’s laws, is written in a stats.csv file for each system. Table 9 exemplifies such data for the Xeon system.

The speedup values in Table 8 correspond to Amdahl’s law [3] and are used to plot Fig. 2. On the other hand, Fig. 3 represents the same measurements, while the predicted speedup is determined using Gustafson’s law [4]. The results for other systems are presented in our research papers [1,2].

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Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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