A METHOD FOR EVALUATION OF INFORMATIONAL SERVICES - STEP 2: COMPUTING THE INFORMATIONAL SERVICES' PERFORMANCE PROPORTIONALITY CONSTANTS

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***Abstract**: Enhancing the hardware power does not cause linear enhancing of the informational services' performance. To discover the value of growth one has to test both source and enhanced systems running equal or similar services. If we need to discover the growth of services' performance for different computers' configurations we have to have common basis for comparing one software service with those of other systems which are tested on different computer configurations. In paper [Ivanova et al 2016] the first step of a method for solving such problem was presented. In this paper we outline the second step of the method. This step consists of computing the informational services' performance proportionality constants. Further paper will present the last step of the method. All examples in the paper are based on results from real experiments presented in the [Markov et al, 2015].*

***Keywords**: Evaluation of informational services; computing the software systems' performance proportionality constants.*

***ACM Classification Keywords**: H.3.4 Systems and Software - Performance evaluation (efficiency and effectiveness); H.3.5 Online Information Services.*

Introduction

In series of three papers we present a method for evaluation of informational services. It consists of three steps:

1. Computing the hardware proportionality constants;
2. Computing the software systems' performance and proportionality constants;
3. Analysis of experiments: Rank-based multiple comparison.

In the paper [Ivanova et al, 2016] we outlined the first step of the method - computing the hardware proportionality constants. This step is important due to differences in the hardware and corresponding operational systems. Further paper will present the third step of the method. Now we will discuss the second step of the method: computing the informational services' performance proportionality constants. All examples in the paper are based on results from real experiments presented in the [Markov et al, 2015].

Let remember the main problem to be solved.

Enhancing the hardware power does not cause linear enhancing of the informational services' performance. To discover the value of growth one has to test both source and enhanced systems running equal or similar software.

In our case we have the same problem. In [Ivanova et al, 2016] we show that computer configurations A, K, B, and C, may be ordered by their Average CPU Marks as well as their General scores. In all cases we need to discover the growth of software performance for different configurations. This is needed because we want to have common basis for comparing our load time with those of other systems which are tested on different computer configurations.

For this purpose we will follow simple algorithm.

Let informational service **X** is tested on two computer configurations: **U** and **W**, where **W** is enhanced configuration; and informational service **Y** is tested on different computer configuration **V** of the same class and similar characteristics as **U**. We have couples (**X**,**U**), (**X**,**W**), and (**Y**,**V**).

Computer configurations **U** and **W** are not available for testing and all work has to be done on computer configuration **V**.

Computer configurations' global scores are respectively:

$$\mathbf{E_U} = 0.3,\ \mathbf{E_V} = 1,\ \text{and}\ \mathbf{E_W} = 3.$$

X is tested on **U** by dataset **S1** with 200 instances and on **W** with similar dataset **S2** with 250 instances.

Y is tested on configuration **V** by datasets **S1** and **S2**.

Loading times are respectively:

$$\mathbf{L_{(X,U,S1)}}=1000 \text{ sec.},\ \mathbf{L_{(X,W,S2)}}=5 \text{ sec.};$$

$$\mathbf{L_{(Y,V,S1)}}=400 \text{ sec.},\ \mathbf{L_{(Y,V,S2)}}=500 \text{ sec.}$$

The problem we have to solve is:

"What will be the loading time of informational service **Y** if it will be run on computer configuration **W** with dataset **S2**?" i.e. $\mathbf{L_{(Y,W,S2)} = ?}$.

The algorithm

Firstly we will illustrate the algorithm and after that we will give it in details.

We have the diagram (Figure 1):

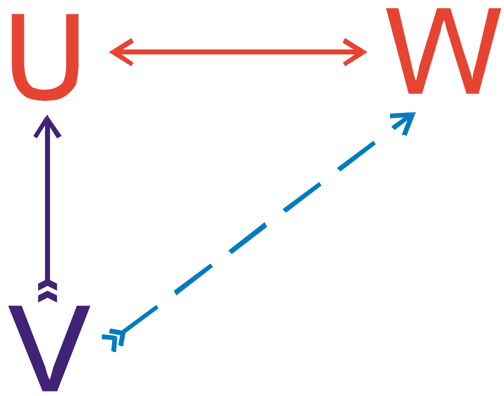

Figure 1. Interrelations between computer configurations

Using published data we may estimate interrelations between computer configurations **U** and **W** as well as between two versions of informational service **X** run on **U** and **W**. We have to use hardware proportionality constants (given in [Ivanova et al, 2016]) to make data comparable and to compute the ratio coefficient of software growth by dividing the loading time on **W** by one on **U**.

To make data from experiments on **V** comparable with these on **U** and **W** we assume that **V** and **U** are from the same class of computer power and there is no software growth for a informational service **Y** in the transition from **V** to **U**. In other words, to estimate interrelations between computer configurations **V** and **U** we need only hardware proportionality constants. After this step we will have data from experiments on **V** transferred for the **U**, i.e. we will have results from informational service **Y** as if the informational service **Y** is tested on configuration **U**.

We assume that the possible software growth of informational service **Y** from computer **U** to **W** is the same as for the informational service **X**, i.e. we can use the same coefficient for software growth for systems **X** and **Y**. This way we will have comparable data for computer configuration **W**.

Below the algorithm is given in details:

1. Reduce loading time $L_{(X,W,S2)}$ of informational service **X**, run on computer configuration **W** and dataset **S2** with |**S2**|=250 instances, to loading time $L_{(X,W,S2')}$ of **X** for hypothetical dataset **S2'** with |**S2'**|=|**S1**|=200 instances, using the formula

$$L_{(X,W,S2')} = |S2'| * (L_{(X,W,S2)} / |S2|) =$$
$$= |S1| * (L_{(X,W,S2)} / |S2|) = 200*(5/250) = \mathbf{4}$$

2. Compute ratio coefficient of growth G_{UW} from (**X**,**U**) to (**X**,**W**) by equation:

$$G_{UW} = L_{(X,U,S1)} / L_{(X,W,S2')} = 1000/4 = \mathbf{250}$$

3. Compute loading time $\mathbf{L_{(Y,U,S2)}}$ of informational service **Y** with dataset **S2** if it is hypothetically ran on configuration **U**, using hardware proportionality constant $\mathbf{H_{VU}}$:

$$\mathbf{V \propto U:} \quad \mathbf{H_{VU} =} \quad \mathbf{E_V/E_U =} \quad 1 / 0.3 \quad = \mathbf{3.33}$$

and formula:

$$\mathbf{L_{(Y,U,S2)}} = \mathbf{H_{VU}}*\mathbf{L_{(Y,V,S2)}} = 3.33*\mathbf{L_{(Y,V,S2)}} = 3.33*500 = \mathbf{1665}$$

4. Compute loading time $\mathbf{L_{(Y,W,S2)}}$ of informational service **Y** with dataset **S2** if it is hypothetically ran on configuration **W,** using ratio coefficient of growth $\mathbf{G_{UW}}$, hypothetical loading time $\mathbf{L_{(Y,U,S2)}}$, and formula:

$$\mathbf{L_{(Y,W,S2)}} = \mathbf{L_{(Y,U,S2)}}/\mathbf{G_{UW}} = \mathbf{L_{(Y,U,S2)}} / 250 = 1665/250 = \mathbf{6.66}$$

This way we have received comparable value of loading time of informational service **Y** with informational service **X** for computer configuration **W**, i.e.

$$\mathbf{L_{(X,W,S2)}}=5 \text{ sec. and } \mathbf{L_{(Y,W,S2)}} = 6.66 \text{ sec.}$$

and we may conclude that informational service **X** will have a little better loading time than informational service **Y** if both are run on computer configuration **W** with dataset **S2**.

One may suppose that we may use directly proportionality constant $\mathbf{H_{WV}}$:

$$\mathbf{W \propto V:} \quad \mathbf{H_{WV}} = \quad \mathbf{E_W/E_V =} \quad 3 / 1 \quad = \mathbf{3}$$

and to reduce $\mathbf{L_{(Y,V,S2)}}$=500 sec. three times, i.e. 500/3 = 166.66.

This is not correct because the ***software growth*** is not taken in account.

We have to calculate possible software growth from **V** to **W** again going through **U** and using $\mathbf{G_{UW}}$ to calculate possible $\mathbf{G_{VW}}$. This may be done by using the proportionality constant $\mathbf{H_{VU}}$ because we need to calibrate growth from **U** to **W** by hardware proportionality of **V** and **U**. In other words, to receive value of growth $\mathbf{G_{VW}}$ from **V** to **W** we have to compute:

$$\mathbf{G_{VW}} = \mathbf{G_{UW}}/\mathbf{H_{VU}}$$

Finally:

$$\mathbf{L_{(Y,W,S2)}} = \mathbf{L_{(Y,V,S2)}}/\mathbf{G_{VW}}$$

Let see it for concrete values:

$$\mathbf{G_{UW}} = \mathbf{L_{(X,U,S1)}}/\mathbf{L_{(X,W,S2')}} = 1000/4 = \mathbf{250}$$

$$\mathbf{H_{VU} = E_V/E_U =} \quad 1 / 0.3 \quad = \mathbf{3.33}$$

$$\mathbf{G_{VW}} = (\mathbf{G_{UW}}/\mathbf{H_{VU}}) = (250/3.33) = \mathbf{75.07}$$

$$\mathbf{L_{(Y,W,S2)}} = \mathbf{L_{(Y,V,S2)}}/\mathbf{G_{VW}} = 500 / 75.07 = \mathbf{6.66}$$

We received the same result as algorithm above. This proves that we have equivalent approaches.

The algorithm may be presented by a formula:

$$L_{(Y,W,S2)} = R_{YVW} * L_{(Y,V,S2)}$$

where

$$R_{YVW} = \frac{E_v * | S1 | * L_{(X,W,S2)}}{E_U * | S2 | * L_{(X,U,S1)}}$$

i.e.

$$L_{(Y,W,S2)} = \frac{E_v * | S1 | * L_{(X,W,S2)}}{E_U * | S2 | * L_{(X,U,S1)}} * L_{(Y,V,S2)}$$

where:

- **X**, **Y** - informational services;
- **U**, **V**, **W** – computer configurations;
- (**X**,**U**), (**X**,**W**), (**Y**,**V**) – couples “informational service – computer configuration”;
- E_U, E_V, E_W - computer configurations’ global scores;
- **S1**, **S2** – datasets;
- $L_{(X,U,S1)}$, $L_{(X,W,S2)}$, $L_{(Y,V,S1)}$, $L_{(Y,V,S2)}$, $L_{(Y,W,S2)}$ - loading times of given informational service, computer configuration, and dataset;
- H_{VU} – computer configurations’ proportionality constant;
- G_{UW} – ratio coefficient of growth of informational service during migration from a computer configuration to enhanced one.

Experimental environment

Our experimental environment includes informational services, computer configurations, datasets and experimental data like published benchmark results, different constants, ratio coefficients, etc.

The main elements of our experimental environment (for concrete names see [Markov et al, 2015]) are:

- Informational services to be compared are: **R**, **V**, **J**, and **S**.

  V, **J** and **S** have several variants depending of databases used. These variants have different loading times on the same computer configurations. In our comparisons we will take the best result from the all benchmarks on given configuration.

- Computer configurations used for benchmarking are **A**, **K**, **B**, **C**;
- Couples "informational service – computer configuration" are:

  (**R**, **K**);

  (**V**, **A**), (**V**, **B**), (**V**, **C**);

  (**J**, **A**), (**J**, **B**), (**J**, **C**);

  (**S**, **A**), (**S**, **B**), (**S**, **C**).

- Computer configurations' global scores are $\mathbf{E_A}$, $\mathbf{E_K}$, $\mathbf{E_B}$, and $\mathbf{E_C}$;
- Middle-size datasets are: **B50K**; **H.nt**; **B250K**; **G.nt**; **B1M**; **B5M**.
- Large size datasets are: **I.nt**; **B25M**; **B100M**.
- Proportionality constant between computer configurations **K** and **A** is $\mathbf{H_{KA}}$ [Ivanova et al, 2016];
- Ratio coefficient of growth of informational services during migration from computer configuration **A** to enhanced ones **B** and **C** are $\mathbf{G_{AB}}$ and $\mathbf{G_{AC}}$;

Corresponded loading times **L** will be presented at the places where they will be used.

Software proportionality constants

To provide concrete comparisons of our experimental loading time data, we have to compute $\mathbf{H_{KA}}$, $\mathbf{G_{AB}}$, and $\mathbf{G_{AC}}$.

For purposes of this discussion, it is enough to compute average constants $\mathbf{H_{KA}}$, $\mathbf{G_{AB}}$, and $\mathbf{G_{AC}}$ based on average loading data for all chosen systems. We will use published benchmark results (done by Freie Universität Berlin, Web-based Systems Group (BSBM team)) and available both as printed publication and free accessible data in the Internet.

Software proportionality for configurations K, A, and B

Benchmark results for dataset **S1** (**H.nt**; 200 036 instances) used for benchmarks on **Configuration A** are published in [Becker, 2008] and reproduced in Table 1.

Table 1. Benchmark results for dataset S1 (**H.nt**)

<table>
<tr><th>system</th><th>loading time in seconds</th><th>the best time in seconds</th></tr>
<tr><td>V</td><td>1327</td><td>1327</td></tr>
<tr><td>J Variant 1</td><td>5245</td><td rowspan="3">3557</td></tr>
<tr><td>J Variant 2</td><td>3557</td></tr>
<tr><td>J Variant 3</td><td>9681</td></tr>
<tr><td>S</td><td>2404</td><td>2404</td></tr>
<tr><td colspan="2">Total average time in seconds:</td><td>2429.333</td></tr>
</table>

Benchmark results for dataset **S2** (***B250K***; 250 030 instances) used for benchmarks on **Configuration B** are published in [BSBMv2, 2008] and reproduced in Table 2.

Table 2. Benchmark results for dataset S2 (***B250K***)

system	loading time in seconds
V	33
J	24
S	18
Total average time in seconds:	25

Due to equal informational services and range of their loading times on the same computer configuration, we will use total average times as loading times of virtual informational service **X**, i.e. $L_{(X,A,S1)}$ = **2429.333** and $L_{(X,B,S2)}$ = **25**.

Following our algorithm, we reduce loading time $L_{(X,B,S2)}$ of virtual informational service **X**, run on computer configuration **B** and dataset **S2** with |**S2**|=250 030 instances, to loading time $L_{(X,B,S2')}$ of **X** for hypothetical dataset **S2'** with |**S2'**|=|**S1**|=200 036 instances, using the formula

$$L_{(X,B,S2')} = |S1| * (L_{(X,B,S2)} / |S2|) = 200036*(25/250030) = \mathbf{20.00}.$$

We compute ratio coefficient of growth G_{AB} from (**X**,**A**) to (**X**,**B**) by equation:

$$G_{AB} = L_{(X,A,S1)}/L_{(X,B,S2')} = 2429.333/20 = \mathbf{121.46665}.$$

Hardware proportionality constant H_{AK} is:

$$A \propto K: \quad H_{AK} = E_K/E_A = 1 / 0.32 = \mathbf{3.125}$$

Really measured **R** loading time on Configuration **K** for dataset **S2** is **575.069** sec. We compute loading time $L_{(R,A,S2)}$ using formula:

$$L_{(R,A,S2)} = H_{AK}*L_{(R,K,S2)} = 3.125*575.069 = 1797.09.$$

At the end, we compute loading time $L_{(R,B,S2)}$ of informational service **R** with dataset **S2** if it is hypothetically run on configuration **B,** using ratio coefficient of growth G_{AB}, hypothetical loading time $L_{(R,A,S2)}$, and formula:

$$L_{(R,B,S2)} = L_{(R,A,S2)}/G_{AB} = 1797.09 / 121.46665 = \mathbf{14.796}$$

To **verify** our computations and to show *the easiest way* to find $L_{(R,B,S2)}$, we will use our formula

$$L_{(RDFArM,B,S2)} = R_{RDFArM,K,B} * L_{(RDFArM,K,S2)}$$

i.e. we have to compute $R_{R,K,B}$ one time and to use it in benchmarks for all datasets. $R_{R,K,B}$ may be computed by formula:

$$R_{RDFArM,A,B} = \frac{E_K * | S1 | * L_{(X,B,S2)}}{E_A * | S2 | * L_{(X,A,S1)}}$$

or in linear view:

$$R_{R,K,B} = (E_K * |S1| * L_{(X,B,S2)}) / (E_A * |S2| * L_{(X,A,S1)}) =$$
$$= (1 * 200036 * 25) / (0.32 * 250030 * 2429.333) =$$
$$= 5000900 / 194369961.5968 = \mathbf{0.025729}.$$

We compute loading time $\mathbf{L_{(R,B,S2)}}$ of informational service **R** with dataset **S2** if it is hypothetically run on configuration **B,** using ratio coefficient $\mathbf{R_{R,K,B}}$:

$$\mathbf{L_{(R,B,S2)}} = \mathbf{L_{(R,K,S2)}} * \mathbf{R_{R,K,B}} = 575.069 * 0.025729 = \mathbf{14.796}.$$

We receive the same result.

Software proportionality for configurations K, A, and C

Software proportionality for configurations **K**, **A**, and **C** will be computed based on the performance of systems **V** and **J** because missing information about **S** in the benchmark publications.

Benchmark results for dataset **S1** (***I.nt***; 15,472,624 instances) used for benchmarks on **Configuration A** are published in [Becker, 2008] and reproduced in Table 3.

Table 3. Benchmark results for dataset S1 (**I.nt**)

system	**loading time in seconds**	**the best time in seconds**
V	**7017**	**7017**
J Variant 1	**70851**	**70851**
J Variant 2	**73199**	
J Variant 3	**734285**	
Total average time:		**38934**

Benchmark results for dataset **S2** (***B100M***; 100 000 748 instances) used for benchmarks on **Configuration C** are published in [BSBMv6, 2011] and reproduced in Table 4.

Table 4. Benchmark results for dataset S2 (***B100M***)

system	loading time in seconds
V	6566
J	4488
Total average time:	5527

Following our algorithm, we reduce loading time $L_{(X,C,S2)}$ of virtual informational service **X**, run on computer configuration **C** and dataset **S2** with **|S2|**=100 000 748 instances, to loading time $L_{(X,C,S2')}$ of **X** for hypothetical dataset **S2'** with **|S2'|**=**|S1|**=15 472 624 instances, using the formula:

$$L_{(X,C,S2')} = |S1| * (L_{(X,C,S2)} / |S2|) =$$
$$= 15472624*(5527/100000748) = \mathbf{855.166}.$$

We compute ratio coefficient of growth G_{AC} from (**X**,**A**) to (**X**,**C**) by equation:

$$G_{AC} = L_{(X,A,S1)}/L_{(X,C,S2')} = 38934/855.166 = \mathbf{45.528}.$$

Hardware proportionality constant H_{AK} is:

$$A \propto K: \quad H_{AK} = E_K/E_A = 1 / 0.32 = \mathbf{3.125}.$$

Really measured **R** loading time on Configuration **K** for dataset **S2** is 43652.528 sec. We compute loading time $L_{(R,A,S2)}$ using formula:

$$L_{(R,A,S2)} = H_{AK}*L_{(R,K,S2)} = 3.125*43652.528 = \mathbf{136414.15}.$$

At the end, we compute loading time $L_{(R,C,S2)}$ of system **R** with dataset **S2** if it is hypothetically run on configuration **C,** using ratio coefficient of growth G_{AC}, hypothetical loading time $L_{(R,A,S2)}$, and formula:

$$L_{(R,C,S2)} = L_{(R,A,S2)}/G_{AC} = 136414.15/45.528 = \mathbf{2996.27} \text{ sec.}$$

To **verify** our computations and to show *the easiest way* to find $\mathbf{L_{(R,C,S2)}}$, we will use our formula

$$L_{(RDFArM,C,S2)} = R_{RDFArM,K,C} * L_{(RDFArM,K,S2)}$$

i.e. we have to compute $\mathbf{R_{R,K,C}}$ one time and to use it in benchmarks for all datasets. $\mathbf{R_{R,K,C}}$ may be computed by formula:

$$R_{RDFArM,A,C} = \frac{E_K * |S1| * L_{(X,C,S2)}}{E_A * |S2| * L_{(X,A,S1)}}$$

or in linear view:

$$\mathbf{R_{R,K,C}} = (\mathbf{E_K} * \mathbf{|S1|} * \mathbf{L_{(X,C,S2)}}) / (\mathbf{E_A} * \mathbf{|S2|} * \mathbf{L_{(X,A,S1)}}) =$$

$$= (1 * 15472624 * 5527) / (0.32 * 100000748 * 38934) =$$

$$= 85517192848 / 1245897319242.24 = \mathbf{0.068639}.$$

We compute loading time $\mathbf{L_{(R,C,S2)}}$ of informational service **R** with dataset **S2** if it is hypothetically run on configuration **C,** using ratio coefficient $\mathbf{R_{R,K,C}}$:

$$\mathbf{L_{(R,C,S2)}} = \mathbf{L_{(R,K,S2)}} * \mathbf{R_{R,K,C}} = 43652.528 * 0.068639 = \mathbf{2996.27}.$$

We receive same result.

Ratio coefficients

To compare our results from experiments on computer configuration **K** we will use ratio coefficients:

For published results received on computer configuration **A**:

$$\mathbf{L_{(R,A,S2)} = L_{(R,K,S2)} * 3.125;}$$

For published results received on computer configuration **B**:

$$\mathbf{L_{(R,B,S2)} = L_{(R,K,S2)} * 0.025729;}$$

For published results received on computer configuration **C**:

$$\mathbf{L_{(R,C,S2)} = L_{(R,K,S2)} * 0.068639.}$$

Conclusion

The goal of this work was to outline the second step of a method for estimating further development of any informational service. This step consists of computing the software proportionality constants and ratio coefficients.

We assumed that the “software growth” will be done in the same grade as one of the known systems. Estimation of experimental systems was provided to make different configurations comparable. Using proportionality formula, experiments become comparable. We have provided series of experiments which were needed to estimate the storing time of a concrete informational services for middle-size and very large datasets. Our experimental environment included program systems, computer configurations, datasets and experimental data like published benchmark results, different constants, ratio coefficients, etc. All examples in the paper were based on results from real experiments presented in the [Markov et al, 2015].

A further paper will present the last steps of the method.

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