Modular Microserver Data Centre

# Total Cost of Ownership

This document provides a summary of the TCO analysis for M2DC appliances. It is highly promising that even for pilot production; we can see a break-even point for the TCO of the M2DC server when compared to state-of-the-art servers. To make the fair comparison we estimate values of the high-volume sales. This approach provides us with a realistic scenario for the market entry and the initial sales, supporting the business opportunities with essential information for the pitch with potential customers. An extended version of this document can be found in deliverable D6.4.

**Energy Efficiency.** It is worth highlighting the large difference in energy saving between infrastructure based on standard and the M2DC servers across all the M2DC appliances. The energy-efficiency gains prove the usefulness of the architecture and technology introduced by M2DC, reducing energy usage overhead. When analysing the energy efficiency of each appliance against the results of the standard infrastructure over 10 years, we get a gain of:

- factor x1.1 for the HPC appliance with the Intel Xeon E3-1505 microservers, and factor x1.3 for the same appliance with M2DC Hi1616 microservers, both measured in MCUPJ using the EULAG metrics specific to, e.g., numerical weather forecast simulations;
- factor x5.9 for the IMG appliance, measured in operations per Joule;
- factor x2 for the Cloud appliance, measured in requests per Joule;
- factor x1.7 for the IoT appliance, measured in tasks per Joule.

Additional gains, on top of those above, can potentially be achieved by the use of power capping, workload management and the usage of specific SEEs.

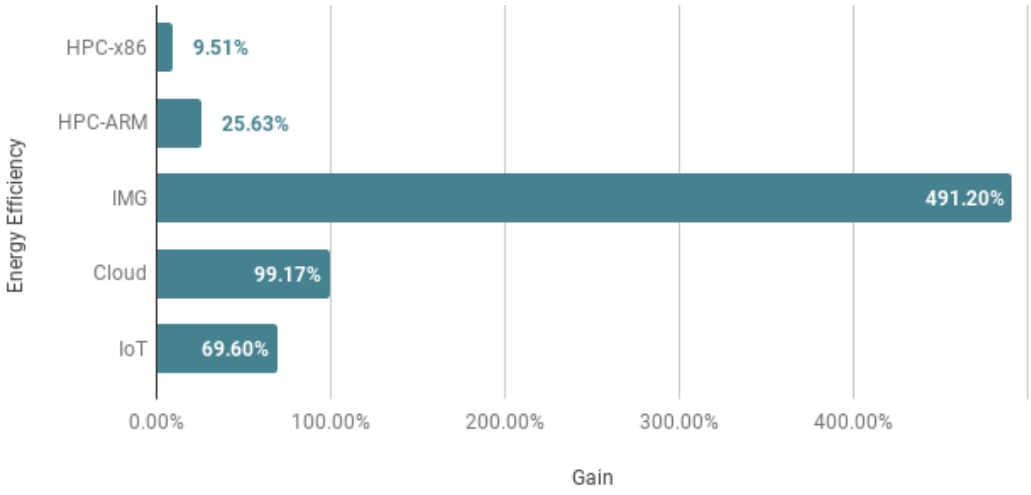


*Figure 1 - Energy-efficiency gains throughout the M2DC appliances*

The gains in energy efficiency. impact the costs in the energy consumption of the infrastructure. This is part of the total costs of the infrastructure, can reach above 9% in the case of the HPC-ARM appliance (see Table 1 for details). The energy efficiency gains are of factor 6 in the case of the image appliance, which is directly connected with the impact of the image processing System Efficiency Enhancement (SEE).

*Table 1: Electricity costs comparison between the standard and the M2DC infrastructures*

| Electricity | HPC-x86 | HPC-ARM | IMG | Cloud | IoT |
|---|---|---|---|---|---|
| Std 1 | 4,599.79€ | 4,599.79€ | 5,584.50€ | 6,417.50€ | 8,672.40€ |
| Std 2 | 3,950.13€ | 3,950.13€ | **4,204.80€** | 8,669.73€ | 10,643.40€ |
| Std 3 | **2,505.97€** | **2,505.97€** | 13,140.00€ | **6,136.94€** | **5,124.60€** |
| M2DC | 2,288.33€ | 1,994.75€ | 1,229.90€ | 3,081.26€ | 2,177.96€ |
| Gain | 8.68% | 20.40% | 70.75% | 49.79% | 57.50% |

**Data Centre space.** Another highlight of the improved cost-efficiency is the reduction of required space in the data centre thanks to the adoption of M2DC. This is due to the high density of the M2DC server compared to standard hardware in DCs. In fact, the estimates show that, the difference of space required comparing with the standard infrastructure is between 26% and 65% lower for the HPC appliance, while the highest savings are reached by the IMG appliance above 87% (see Table 2 for details).

*Table 2: Space costs comparison between the standard and the M2DC infrastructures*

| Space | HPC-x86 | HPC-ARM | IMG | Cloud | IoT |
|---|---|---|---|---|---|
| Std 1 | 1,914.22€ | 1,914.22€ | 6,500.00€ | 2,992.61€ | **3,000.00€** |
| Std 2 | **1,017.72€** | **1,017.72€** | **2,250.00€** | **2,627.87€** | 4,750.00€ |
| Std 3 | 3,377.21€ | 3,377.21€ | 10,250.00€ | 6,751.46€ | 6,750.00€ |
| M2DC | 750.00€ | 353.17€ | 750.00€ | 750.00€ | 750.00€ |
| Gain | 26.31% | 65.30% | 66.67% | 71.46% | 75.00% |

As we shall analyse later in this section, the migration and training costs implied by the change to the M2DC systems in some cases (as for image processing appliance) are compensated by the high energy efficiency gain in the long run (at least two-fold). Intelligent monitoring and DC integration highly contribute to these gains. Additionally, the relatively high cost for the basic infrastructure of the M2DC server is compensated by the large amount of microservers that can be integrated into one chassis combined with the embedded communication infrastructure.

**Operation and upgrade costs.** The operation and upgrade expenses are highlights in the TCO optimisation. The modular nature of the platform permits significant gains in both of these aspects. In particular, the upgrade is a substantial part of the overall investment, usually impacting the infrastructure after 3 to 4 years. The gains in the upgrade costs vary throughout the appliances, from 37% to 73% (see Table 3). On the other hand, the operation costs reach

30% up to 49% gains by using the M2DC infrastructure with a loss of 16% in the case of HPC x86 due to the low operation prices of the Taishan case (see Table 4).

*Table 3: Upgrade costs comparison between the standard and the M2DC infrastructures*

| Upgrade | HPC-x86 | HPC-ARM | IMG | Cloud | IoT |
|---|---|---|---|---|---|
| Std 1 | 53,536.81€ | 53,536.81€ | **55,660.00€** | **83,697.32€** | 110,220.00€ |
| Std 2 | 41,059.48€ | 41,059.48€ | 60,300.00€ | 106,020.27€ | 74,880.00€ |
| Std 3 | **40,494.70€** | **40,494.70€** | 144,560.00€ | 97,475.24€ | **55,120.00€** |
| M2DC | 22,918.80€ | 11,082.82€ | 15,046.80€ | 26,515.20€ | 32,275.20€ |
| Gain | 43.40% | 72.63% | 72.97% | 68.32% | 41.45% |

*Table 4: Operation costs comparison between the standard and the M2DC infrastructures*

| Operation | HPC-x86 | HPC-ARM | IMG | Cloud | IoT |
|---|---|---|---|---|---|
| Std 1 | 2,511.45€ | 2,511.45€ | **3,300.00€** | **3,926.30€** | 5,500.00€ |
| Std 2 | 2,004.12€ | 2,004.12€ | 3,600.00€ | 5,174.88€ | 3,735.00€ |
| Std 3 | **1,875.34€** | **1,875.34€** | 8,640.00€ | 4,702.20€ | **2,730.00€** |
| M2DC | 1,853.75€ | 884.62€ | 1,399.37€ | 2,033.57€ | 2,327.57€ |
| Gain | 1.15% | 52.83% | 57.59% | 48.21% | 14.74% |

In general, when confronting the electricity, operation and space average costs, against their average gains, we see that the most significant cost optimisation refers to electricity. The average electricity costs are about 41% and the overall gains are above 6% of the total costs. Then, the average operation costs are also heavy on the overall infrastructure costs (about 4%), and their average gains are about 35%. Finally, the space costs, being 2% of the overall average infrastructure, are optimised with M2DC to up to 61%. These results are represented in the bubble diagram of Figure 2, where: the x axis represents the average % of gain by adopting the M2DC infrastructure; and the y axis represents the weight in EUR of each of the cost classes in comparison with the overall costs of the infrastructure.

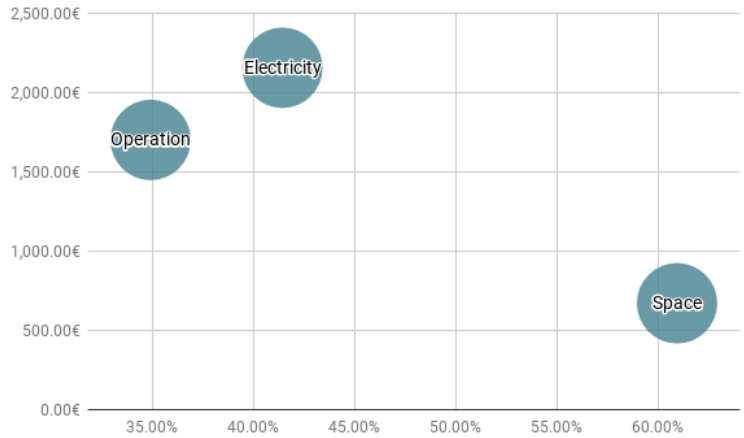


*Figure 2: Representation of the positioning of operation, space and electricity costs in the size of investment*

The final TCO estimations show that the use of M2DC appliances can bring significant savings of TCO. These gains are shown in Table 5 for the case where an upgrade is performed at least after four years, and in Table 6: when this upgrade does not take place. These tables consider the size of the initial investment and show values for five and ten years to provide a mid and long term perspective on the overall costs in analysis. These tables provide a comparison between the highlights of the total values of the M2DC TCO, showcasing the results for the cases with and without upgrade in the low and high demand scenarios. The percentages highlighted in green show the gains with the adoption of the M2DC infrastructure.

*Table 5: Global TCO gain between standard and M2DC infrastructure (with upgrade)*

| TCO gain after year | HPC-x86 | HPC-ARM | IMG | Cloud | IoT |
|---|---|---|---|---|---|
| Y1 | 20.55% | 55.02% | 43.43% | 53.42% | 23.82% |
| Y5 | 33.17% | 61.72% | 59.35% | 58.96% | 41.88% |
| Y10 | 38.70% | 65.16% | 63.86% | 62.58% | 46.16% |

*Table 6: Global TCO gain between standard and M2DC infrastructure (without upgrade)*

| TCO gain after year | HPC-x86 | HPC-ARM | IMG | Cloud | IoT |
|---|---|---|---|---|---|
| Y1 | 20.55% | 55.02% | 43.43% | 53.42% | 23.82% |
| Y5 | 28.17% | 56.59% | 51.29% | 54.05% | 42.07% |
| Y10 | 33.89% | 58.27% | 55.82% | 56.69% | 50.02% |

According to the summary provided by Table 5, for the scenario where an upgrade to the infrastructure is considered, and by Table 6, where it is not, the overall gains in year ten range between 39% (HPC-x86 without upgrade) and 65% (IMG with upgrade). Upgrading the M2DC system multiple times through the barebone's lifetime increases the TCO gains throughout all of the appliances in all of the three cut-offs considered (i.e., Y1, Y5 and Y10). Figure 3 shows the increase in the percentage gains for each of the appliances through time. There is a considerable difference between the two HPC appliance configurations (i.e., HPC-x86 and HPC-ARM). Both the IoT appliance and the HPC-ARM seem to show the best results regarding such overall gains.

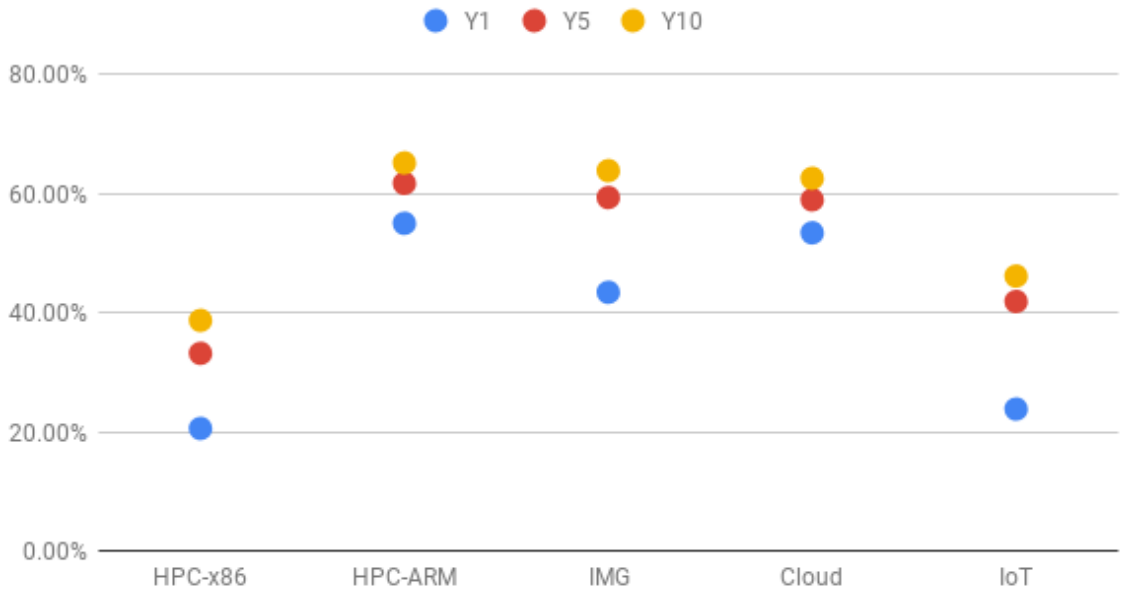


*Figure 3: Representation of the global gains comparison between standard and M2DC infrastructure (considering an upgrade before the fifth year)*

As can be observed in Figure 4, the analysis of specific costs in the TCO shows that the gains are not homogeneous throughout the appliances. While the IoT appliance has the best gain in the space category, it has the smallest gain in the upfront investment in the needed infrastructure. In all of the cases the HPC-x86 appliance has lower gains than the HPC-ARM instance. Note that the values between specific costs are not comparable. For example, 25% of space costs are much lower than 25% of electricity costs.

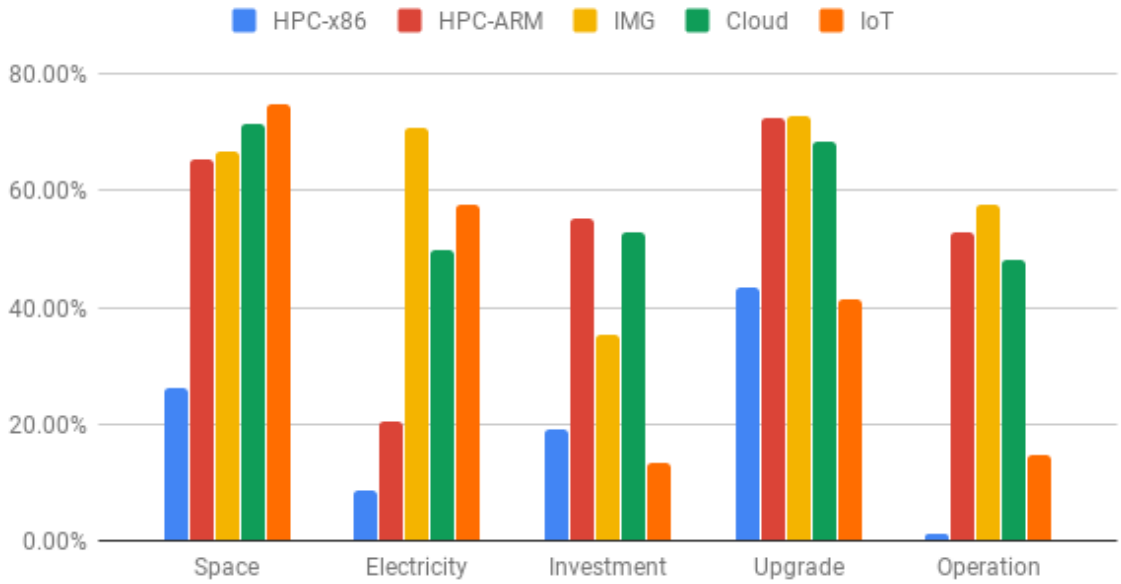


*Figure 4: Gains at some of the specific costs for each of the M2DC appliances*

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