

APPENDIX B

B: On-Demand/Reserved Price Versus Hardware Costs

B.1 Introduction

An interesting research concerns the relation between the price reductions in EC2 and the expected hardware cost reduction that happens over time. In this appendix, that focusses on the CPU cost, we have a look at what underlying hardware Amazon is using for instances of a certain instance type and how this has evolved over time.

B.2 Hardware Evolution

According to sources on the internet the following are the processors that were used in the hardware of Amazon on which certain instance types were ran at the moment of introduction of the instances.

Type Subtype \ Region	US-East	Others
Standard Small	AMD Opteron 2218	Xeon E5430
Standard Large	Xeon E5430	Xeon E5430
Standard Extra Large	Xeon E5430	Xeon E5430
Micro Micro	Xeon E5430	Xeon E5430
High-Memory Extra Large	Xeon X5550	Xeon X5550
High-Memory Double Extra Large	Xeon X5550	Xeon X5550
High-Memory Quadruple Extra Large	Xeon X5550	Xeon X5550
High-CPU Medium	Xeon E5410	Xeon E5410
High-CPU Extra Large	Xeon E5410	Xeon E5410

After finding this information, we decided to test whether these are still the microprocessors that are used by Amazon. This was done using the following pseudocode:

```

for  $i = 0$  to  $x$  do
  for all  $type$  in instanceTypes do
    instance=startInstanceUSRegion( $type$ )
    procInfo=instance.execute("more /proc/cpuinfo")
    output.append(procInfo)
  end for
end for

```

The command used in this algorithm "more /proc/cpuinfo" returns a lot of CPU related characteristics of the system.

```

[ec2-user@ip-10-212-101-159 ~]$ more /proc/cpuinfo
processor       : 0
vendor_id     : GenuineIntel
cpu family    : 6
model        : 23
model name    : Intel(R) Xeon(R) CPU           E5430  @ 2.66GHz
stepping     : 10
cpu MHz      : 2659.994
cache size   : 6144 KB
...

```

This experiment, that tested what type of processor the machine on which your requested instance (of a certain type) was running, resulted in the following table showing the used microprocessors by instances of a certain type.

Type Subtype \ Region	US-East
Standard Small	Xeon E5507/E5430
Standard Large	Xeon E5507/E5430
Standard Extra Large	Xeon E5507/E5430
Micro Micro	Xeon E5430
High-Memory Extra Large	Xeon X5550
High-Memory Double Extra Large	Xeon X5550
High-Memory Quadruple Extra Large	Xeon X5550
High-CPU Medium	Xeon E5507/E5410
High-CPU Extra Large	Xeon E5507/E5410

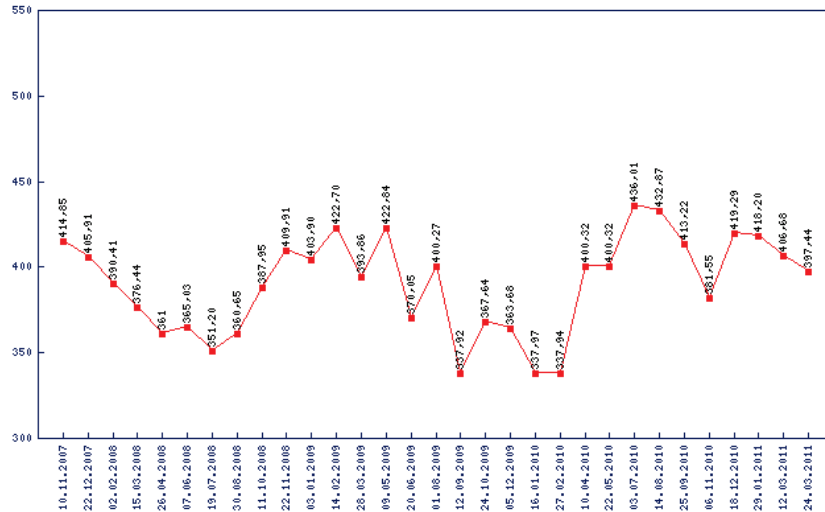
These results show that Amazon started using newer microprocessors for a number of 'older' instance types. It seems like they did not replace the old processors but added more machines with a newer processor in their datacenters. The one that has been around the longest however, namely the AMD Opteron 2218 that was used in the US East Region for Standard Small instances in the early days of EC2 seems to be disappeared or it at least became rare to get a machine with this processor. The following table gives a bit more information about the microprocessors that are in

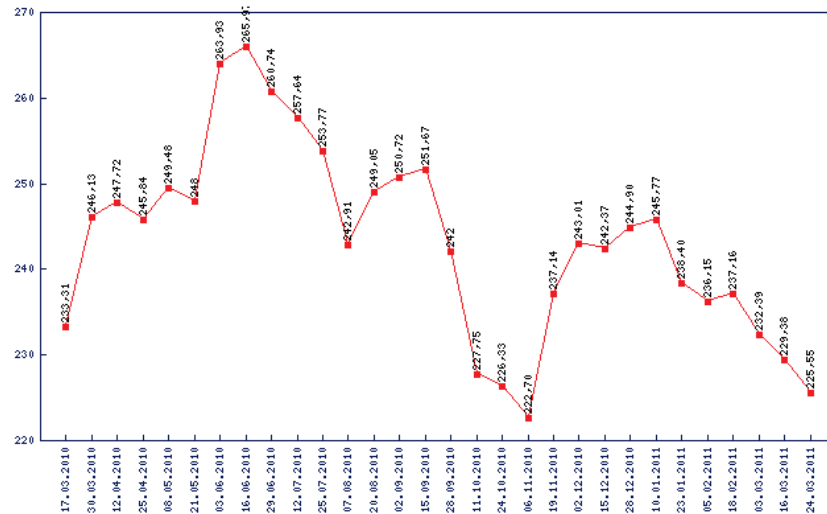
use in EC2, such as their official launch date and their original price (when they are sold in bulk per thousand units).

Processors	Launch Date	Price 1ku
Xeon E5410 "Harpertown" 4x2.33 GHz	Q4'07	\$256.00
Xeon E5430 "Harpertown" 4x2.66 GHz	Q4'07	\$455.00
Xeon X5550 "Nehalem" 4x2.66 GHz	Q1'09	\$958.00
Xeon E5507 "Nehalem" 4x2.26 GHz	Q1'10	\$276.00
AMD Opteron 2218 2x2.6 GHz	Q3'06	\$873.00

B.3 Price Evolution

Now we have a look at the evolution of the price the mentioned microprocessors. In the following consumer market price evolution graphs taken from a german price watch site that averages the price of the processor across a number of popular electronics online merchant sites over time, we notice that the price, of for example the Intel Xeon E5430 and E5507, did not change that much on the consumer market. Note that the start price on these graphs mirrors the introduction price mentioned in the table above.





That the CPU price didn't seem to decrease, does not mean that the hardware cost for Amazon did not decrease. They started using newer processor models over time, which can reduce the hardware cost for a certain amount of compute power, that a certain instance type needs to offer the advertised amount of Elastic Compute Units (ECU), considerably. We'll now discuss what processors have been used for Standard Small instances on EC2 over time and what price reduction this evolution is accompanied by. The AMD Opteron 2218, which was used in the early days of EC2 in the US East region, was a dual core 2.6GHz processor and costed 873 dollars at the time of its introduction. If we express this in price per GHz, it had a price of 167 dollar per GHz. The microprocessors that are used today for this kind of instances are the Intel Xeon E5430 (quad core at 2.66GHz for 455 dollars) and the Intel Xeon E5507 (quad core at 2.26GHz for 276 dollars). They have a corresponding price per GHz of 42.76 and 30.53 dollars. So, substituting the AMD Opteron by the newer E5430 processor comes with a price reduction of about 75%. This reduction happened in a bit over a year, since the E5430 was launched in the fourth quarter of 2007 and the AMD Opteron 2218 was introduced in the third quarter of 2006. The newer Intel Xeon E5507, launched in the first quarter of 2010, signifies a reduction of about 82% compared to the AMD Opteron processor and a decrease of about 29 percents compared to the Intel Xeon E5430. The instance price of a standard small instance on the other hand has only decreased 15 percents during the last 5 years of its existence, so there is a large gap between the fall in value of the hardware and the price reduction Amazon carried out for its customers.

B.4 Conclusion

We conclude that not much data about hardware costs and what hardware Amazon is using is publicly available. We've shown however that during the last 5 years,

in which Amazon EC2 has been active, they put newer microprocessors in use to provide certain instances to his customers. This evolution was accompanied by a noteworthy price decrease of up to 80 percents. The hourly rate for EC2 instances on the other hand have only, as shown before, had a price reduction of up to 15 percents. This divergence has as a consequence, if we assume operational costs to have remained the same, that Amazon is making more and more money and that they have room for price reductions, if tougher competition would become reality.