Upgrading MacBook Pro (15-inch, late 2011)

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Abstract

In this article we present a ready–to–implement plan for upgrading MacBook Pro (15-inch, late 2011). We cover all aspects of the process so that there are no surprise during execution. We discuss how memory and storage can be replaced without any support from Apple Inc.

CONTENTS

I. Introduction

In this article we will explore various options to improve our computer — MacBook Pro (15-inch, late 2011). We can sell our computer for about 4000 hkd at dcfever [1] and buy a second hand for about 6-7000 hkd [2, 3]. However as there are risks involved, we prefer to just upgrade the system for about 2000hkd. When the system breaks, we can buy a cheap CPU temporarily and when time is right we will buy a new one. Care must be taken that the logic board doesn't overheat in future and the GPU problems that causes catastrophic trouble doesn't get repeated.

We consider upgrading memory, storage and other peripherals. Memory up-gradation is straight forward where we will replace the two RAM in their slots. For storage, we will transfer the current Toshiba HDD to the optical bay and install a new SDD in the main bay. We will consider the most valuable peripherals for up-gradation.

The important aspects We will explore in this report are:

- *Feasibility* of the new hardware. We will state the best—value models of hardware that are compatible with the motherboard so that it can be purchased for being mounted.
- *Heating* of the system after up-gradation. The GPU is vulnerable and has crashed leading to days of blackouts even in Hong Kong which has excellent Apple service. The replacement is not free now and the charge for new motherboard would be more than 4000 hkd. We will frame the cautions that must be taken so that the risk is ameliorated.

II. Survey

We will survey the existing hardware and their features below. We will also discuss technical recommendations for up-gradation. We discuss the memory, storage and external peripherals below.

We will consider the advice from Crucial [4]and OWC [5]seriously as they offer memory and storage options often with lifetime warranty for our specific Mac model.

A. Basic Survey of Memory

Opening many tabs in Google Chrome leads to computer hang or slowdown due to RAM limitations [6]. Even in 16GB RAM computers, many tabs of chrome alone may consume 48% memory.

The model of the computer is MacBook Pro (15-inch, late 2011)also known as MacBook Pro 8.2. We refer to the official site for details [7]. The existing memory is 4GB (two 2GB SO-DIMMs) of 1333MHz DDR3 SDRAM. It is of Double Data Rate Small Outline Dual Inline Memory Module (DDR3) format and is a 204-pin model. The dimensions are 30mm(1.18 inch). The type of RAM is PC3-10600 DDR3 1333 MHz. The format PC**X**-**Y** implies RAM of DDR **X** and maximum data transfer rate of **Y** (MB/s). The processor type is Intel® Core™ i7-2675QM Processor as returned by terminal command "sysctl -n machdep.cpu.brand_string" and detailed in 'everymac' website [8].

DDR is not backward compatible so we cannot substitute DDR with DDR2/3 [9]. DIMM are desktop full sized modules and SO-DIMM are 'notebook' size modules. The number of pins of RAM must match. For best performance, it is recommended that we fill both memory slots, installing an equal memory module in each slot. Although the official Apple website [7] seems to recommend 8GB as maximum memory upgrade, it could be because 8GB was maximum available memory at that time. According to the processor details in the official Intel® website [10], memory can be upgraded to a maximum of 16GB with 1333 MHz. There are several online websites recommending compatible upgrade of 16GB [11–14]. Upgrade for RAM beyond 16GB in the current model is rare to find online, probably much more expensive and outright denied by Intel® , OWC [5], etc. Therefore, *we will not consider a memory upgrade beyond 16GB*.

The current model is 1333 MHz. This speed is safe in terms of compatibility. Online, there are some recommendations for upgrade to higher memory at same speed of 1333 MHz for our model [12]. There are some forums where the speed choice of 1600 MHz is mentioned (not with high clarity) [13–16]. It must be noted that online [16] it may be recommended to get a RAM for a similar MacBook Pro model that has Intel® Core™ i7-2760QM processor which allows 1600 MHz RAM [17] unlike our model. The official Intel® specs about the processor states that it does not support speed higher that 1333 MHz. There are warnings that even Intel® Core™ i7-2760QM processor may not support 1600 MHz [18]. Some claim that if a newly installed

RAM with higher speed is not supported, the 'about this mac' pane will show the effective speed at which the RAM is running [16]. Others claim that even though 'about this mac' pane shows some speed, a newly installed RAM may not even work or pass tests [18]. The many screenshot proof online may not mean the 1600 MHz RAM actually runs at 1600MHz – the processor may still communicate with a 1600MHz RAM at 1333 MHz speed or less depending on capability in the best case. In the worst, the RAM may not work. There are strong reservation against 1600 MHz RAM for our model in some places [9, 15]. Therefore, *we will not consider a RAM beyond 1333 MHz speed.*

Comparison between RAMs should take into account speed and CAS latency – CL which is the time between accessing the memory and reading the output. Lower the CL and higher the frequency, better the RAM. It has been mentioned [9] that a wrong CL RAM can cause fatal problems like not being able to boot or being frequently unstable. The only suggested way to reliably check the current CL of RAM in MacBook Pro is to open the case and check the label of the RAM hardware [9]. Some claim that early 2011 models use 9-9-9-24 RAM timing; CL 9 seems to be mostly in use for models released around 2011 [19]. It is further mentioned that for MacBook Pro 2011 model, RAM with CL greater than 10 or less than 8 will cause incompatibility [9]. RAM with CL 8 is rare and therefore RAM with CL 9 is ideal. Some places recommend CL=9 for the current model [20]. The term tRas is the active to precharge delay which is the time taken by the memory to allow next access to be initiated [21]. The timing of RAM is given as 9-9-9-**X** (for CL 9) where **X** is the tRas. If not given, for CL 9 RAM 9-9-9, the tRas is 9*3 which is 27. The lower the tRas the better the RAM. Therefore *we will consider CL 9 or 8 for new memory with tRas 27, 24 or lower.*

DDR4 (better version than DDR3) is not recommended by OWC [5]or Crucial [4]for our model. It is also not necessarily found to be interchangeable with DDR3 — the processor must support it, number of pins must match, etc [22, 23]. As our model is also older *we will not investigate further about DDR4 compatibility and only consider DDR3 for memory upgrade.*

The current model supports RAM at 1.5V [24–26]. The processor type for our model is also called Sandy Bridge [27]. It supports 1.5V RAM. For other later models of processors like Ivy Bridge [28] the memory is 1.35V. Crucial suggests 1.35V [20] where as OWC [5]suggests both 1.5V and 1.35V [13]. Macmemory website recommends 1.5V only for the processor [29]. My **hypothesis** is that if the processor specifies 1.5V, it must imply that the processor will divert 1.5V to the RAM. If we use 1.35V, it means more volts is applied to RAM than it needs - may lead to heating, etc. So it may be better to use 1.5V RAM as even if lower volts is applied to a RAM that needs higher volts, it may not cause as much serious issue — except that it may not work. Therefore *we will prefer 1.5V rated RAM.*

Crucial [4]and OWC [5]have many recommendations, yet many of them are DDR3L model, the low voltage (1.35V) model for Ivy bridge processor. As these are trusted sites that offer lifetime limited warranty, it makes sense that these RAM may work in our model. Yet the best choice is 1.5V DDR3 model for Sandy bridge processor. There is one on OWC [5]that seems ideal [30]. However we will visit Sham Sui Poto survey there first.

It must be noted that the current 4GB RAM is worth 60 hkd if traded in to OWC [5] [31]. However given international shipping that is not included, the execution is nonviable. We may consider trading it in the local Sham Sui Po.

B. Memory Options to Consider

The tools required [32] are:

- Phillips #00 Screwdriver [33]
- Spudger [34] or Nylon Pry tool [35, 36] (not necessary [37] for execution of our goal)

OWC [5]has all of them in one set for 118 hkd [38].

The RAM specifications are: [30, 39]:

- Technology: DDR3 SO-DIMM
- Density: 8GB (8192MB)
- RoHS: Yes
- Pin Count: 204-pin
- Op. Temp.: 0C to +85C
- Data Rate: DDR3-1333
- Speed: PC3-10600
- CL: CAS 9-9-9-24
- Cycle Time: 1.875ns
- Voltage: 1.5V
- ECC: Non ECC

- Module Ranks: Dual Rank
- Register: Non Parity
- Low Noise 8-Layer PCB
- Price : 1000-1100 hkd [20, 30, 39]

Top brands for RAM based on preliminary survey are: OWC [5], Crucial [4], Samsung, Kingston, Corsair.

There are not many mentions of bad RAMs online. *Apacer and other cheap brands are said to be bad at some places.* We must keep this in mind. However as long as we buy from the well known brands listed above, we must be fine.

C. Basic Survey of Storage

In our model both the optical bay and main bay have link speed of 6 Gbits/s. The negotiated speed are lower because the devices have their own SATA models of lower speed [40, 41]. My hard disk (Toshiba MK5065GSX) currently located in the main bay is SATA II [42]. According to current HDD specs [43], the main bay is 9.5 mm but it will support 7mm through the use of specs [44].

There are three hardware options for storage: SSD, SSHD and traditional hard drives [45, 46]. As our goal is to get high speed, SSD is the best option. SSHD (hybrid SSD) is a compromise such that for same money as SSD one gets more storage by compromising some speed. For the same money, traditional HD is slower and has more storage. As we intend to keep our traditional HD, storage space is not our main concern. *For the best speed, we will consider buying SSD.*

The optical bay for our model is compatible with SATA III(6 Gbits/s link speed), yet there are some reports online that the optical bay for MacBook Pro (15-inch, late 2011)may not actually work properly with a SATA III device [47–51],everymacreplaceguide. Especially if the optical bay for our model has SATA III and the drive installed there is SATA III capable, the bay will negotiate a high 6 Gbits/s speed but that leads to severe problems. So it is better if the bay is SATA II 3Gbits/s or if the hardware installed there is 3Gbits/s. *For our model, SATA III device must be installed in main bay and SATA II device in the optical bay.*

Previously there were some problems in our model in the main bay with 6 Gbits/s drive. That has been resolved with software update. *For normal functioning of SATA III device in main bay for our model, the software must be updated to EFI Firmware Update 2.3 [49, 52, 53].*

SATA III in the main bay and drive working at negotiated speed of 6 Gbits/s is superior to hard disk operation at negotiated speed of SATA II [54]. So although in real-world scenarios where the computing is not intense, there may not be much difference between SATA II and SATA III, for SSDs the operation speed in SATA III is found higher in practice [55, 56]. *Therefore, we will consider SATA III device for our main bay storage.*

Note that optical bay does not have motion sensors so the hard drive, when installed there, is not protected from bumps and drops. The hard drive in optical bay is also noisier [57, 58].Yet some hard drive have inbuilt protection [50]. Toshiba website seems to have removed older products details [59]. According to a lot of websites, MKxx65GSXF family of HDD (our model being Toshiba MK5065GSXF) from Toshiba has an embedded motion sensor to detect if the hard disk drive is in free fall. In such cases, the HDD quickly and immediately moves the read/write heads away from the spinning to prevent them damaging any data upon impact. One website [43] seems to have the full details of the HDD model and specifies that it has reliable motion sensor. As multiple websites have reported the fact that our current HDD model has motion sensor [58, 60–63], one of them [63] also claiming that it was on Toshiba website at the time of its reporting, we will believe it. For all other factors, HDD in optical bay seems fine [64]. We also find that there are not many reports of HDD failure or severe issues when installed in optical bay; most reported issues are about SATA which we addressed [65–67]. There are some claims that we should disable sudden motion sensor in the OS as the HDD has its own [68]. Yet it is not very popular or logically compelling argument, so we will avoid it for now. The concerns about noise is not a big issue for now. The battery life can be improved by using HDD wisely. The most important concern is heating [58]. Some claim its not that bad [64] and generally this issue is not widely reported online for now. Nonetheless, given its potential to fatally affect the logic board and cause complete damage which is very expensive to repair, we will take care and be sensitive to it. *Therefore, we conclude that installing our current Toshiba HDD into the optical*

bay (from the main bay) is safe.

D. Options for Optical Bay Enclosures

We need to consider how we will use our superdrive externally after removing it from the optical bay.

The **OWC [5]Data Doubler** with the superdrive enscloser will cost around 44 usd (345 hkd) [69]. It is a well known brand with great reviews, warranty etc. It also includes complete set of tools that are necessary for both memory and storage replacement [70]. After purchasing this we need nothing more than an SSD to execute the whole operation of putting SSD in main bay, HDD in optical bay, using Superdrive externally. *The warranty for data doubler and superdrive enclosure is 1 year by OWC [5]. Total cost : 345 hkd.*

The **MCE Optibay** for Unibody Macs together with the optical drive case will be around 49.99 usd (391 hkd) [71, 72]. It also includes all the tools like OWC [5]. The brand is well known and discussed online, but OWC [5]reputation, popularity and expertise is superior. *The warranty for Optibay is lifetime and for the Superdrive enclosure is 1 year.* The difference from OWC [5]seems to be excess of 50 hkd in exchange for lifetime warranty on Optibay (against 1 year). *Total cost : 391 hkd.*

The **Unibody Laptop Dual Drive** by ifixit comes at 34.95 usd (274 hkd) [73]. This includes tools and also the cable for superdrive connection and probably a bag-enclosure. The price is cheaper than other well known brands. *It has lifetime warranty on all items*. It is around 70 hkd cheaper than OWC [5]and has lifetime warranty against 1 year for OWC [5]. The downside may be that the superdrive enclosure is not as good or specified (though it has cables) and that the brand is not as popular, etc as OWC [5]. *Total cost : 274 hkd.*

Generic Bays available online are reported as good and much cheaper [74–77]. There are also cautions that there may be annoying but non-severe issues.

Note that this is just a tool and not the actual device. Yet its malfunction can be irritating. Based on the above analysis we will visit Sham Sui Poand purchase a good generic alternative or else the ones from ifixit or OWC [5]. *The cost-benefit analysis must be done on the spot to see if the total price of tools, bay etc when bought separately is really much cheaper.*

E. Storage Options to Consider

The tools required [78] are:

- Phillips #00 Screwdriver [33]
- Spudger [34] or Nylon Pry tool [35, 36] (not necessary [37] for execution of our goal)
- TR6 Torx Security Screwdriver [79]

OWC [5]has all of them in one set for 118 hkd [38].

For OWC [5]the price of bundled SSD with DIY Data Doubler offers no substantial discount [80, 81]. Further the super drive needs to be bought together again so as to get discount on it.*Therefore we will consider buying SSDs and Data Doubler with Superdrive separately, if at all.*

Below we discuss several SDD products and their important features.

OWC [5]Mercury Electra 6G SSD

- 119.99 usd (938 hkd)
- 250 GB
- 3 year warranty
- 4ch controller
- Sequential Reads (Compressible Data)up to 522MB/s
- Sequential Writes (Compressible Data)up to 463MB/s
- Sequential Reads (Incompressible Data)up to 506MB/s
- Sequential Writes (Incompressible Data)up to 443MB/s
- Random 4K Readup to 90,000 IOPS
- Random 4K Writeup to 60,000 IOPS * IOPS means Input Output operations per Minute

OWC [5]Mercury Extreme Pro 6G SSD

- 149.99 usd (1172 hkd)
- 240 GB
- 5 year warranty
- controller: SandForce 228x Series Processor with 7% Over Provisioning
- Sustained Reads 6Gb/s (up to)559MB/s
- Sustained Writes 6Gb/s (up to)527MB/s
- Sustained Reads 3Gb/s (up to)284MB/s
- Sustained Writes 3Gb/s (up to)266MB/s
- Read Incompressible Data Rate (up to)479MB/s
- Write Incompressible Data Rate (up to)282MB/s
- Random 4K Read4Up to 60,000 IOPS
- Random 4K Write4Up to 60,000 IOPS
- Read Latencyless than 0.1ms

- Write Latencyless than 0.1ms

Note that OWC [5]Mercury Extreme is said to be better performing and more reliable than Electra. The controller is different which accounts for the difference. However for our purpose Electra may be enough. There is not much online discussions about problems with Electra or how Extreme is way better. There is reasonable cost difference between the two.

Samsung 850 PRO 6G

- 129 usd (1008 hkd)
- 256 GB
- 10 year warranty
- Max Sequential Reads (Compressible Data)up to 550MB/s
- Max Sequential Writes (Compressible Data)up to 520MB/s

Samsung 850 EVO 6G

- 99.99 usd (781 hkd)
- 250 GB
- 5 year warranty
- Max Sequential Reads (Compressible Data)up to 540MB/s
- Max Sequential Writes (Compressible Data)up to 520MB/s

Intel 520 SSD 6G

- 154 usd (1203 hkd)
- 240 GB
- 5 year warranty
- Reads (Compressible Data)up to 550MB/s
- Writes (Compressible Data)up to 520MB/s

Corsair CSSD-N240GBGTX-BK 6G

- 269 usd (2102 hkd)
- 240 GB

Samsung 850 Pro Series 6G

- 167.99 usd (1313 hkd)
- 256 GB
- 10 year warranty
- Sequential Reads up to 550MB/s
- Sequential Writes up to 520MB/s
- Random 4K Readup to 100,000 IOPS
- Random 4K Writeup to 90,000 IOPS

Crucial BX300 6G

- 87.99 usd (688 hkd)
- 240 GB
- 3 year warranty
- Sequential Reads up to 550MB/s
- Sequential Writes up to 510MB/s

Crucial mX300 6G

- 92.99 usd (727 hkd)
- 275 GB
- 3 year warranty
- Sequential Reads up to 530MB/s
- Sequential Writes up to 500MB/s

Crucial mX300 6G

- 149.99 usd (1172 hkd)
- 525 GB
- 3 year warranty
- Sequential Reads up to 530MB/s
- Sequential Writes up to 510MB/s

ifixit(Toshiba) OCZ TL100 SSD 6G

- 79.95 usd (625 hkd)
- 240 GB
- 2 year warranty
- Sequential Reads up to 550MB/s
- Sequential Writes up to 530MB/s

ifixit(Toshiba) OCZ TR150 SSD 6G

- 149.95 usd (1172 hkd)
- 480 GB
- 2 year warranty
- Sequential Reads up to 550MB/s
- Sequential Writes up to 520MB/s

According to some online ratings sites [82, 83] that tested the drives the bests brands are (in similar but not exact order):

- **Samsung 830(470) 256GB**
- **OCZ Vertex(3, 4, Agility 2, etc.) 240 GB**
- **Intel SSD 520(330, X25-M G2, X25-V) 240 GB**
- **Corsair Performance Pro(Nova , Force F100)**
- **Crucial M4(C300) 256 GB**
- **Kingston SSDNow V+**

F. Keyboard, Mouse and VGA Adapter

We also need to purchase a Keyboard, Mouse and VGA adapter for our MacBook Pro (15-inch, late 2011). As the Apple original ones are very expensive ($\geq$ 500 hkd for Keyboard and Mice, $\geq$ 200 hkd for VGA adapter) [84, 85], we will look for reasonable ones in Sham Sui Po.

III. Methodology, Maintenance and Future Considerations

A. Methodology for Memory

We must refer to [32, 86, 87] for installation.

B. Methodology for Storage

Some well known guides for setting up dual storage (main bay and optical bay) are [88–90]. There are also some guides for optical bay superdrive replacement with SDD [91, 92]. Some guides for HDD/SDD replacement are [93, 94].

C. Post Installation verification

According to [95] memtest [96] should be done after installation. We plan to download the free version and run it. We also need to download mac os (.iso) to a pendrive and boot from it so full memory can be tested as advised [95]. We must also follow up with these sites [97, 98] to have a full test of RAM.

For SSD storage devices there is not much details about testing online. However there are some solutions for standard problems, which are rare. To test the actual speed an app can be downloaded from Mac App Store [99]. We may also follow some advice from this site [100]. *In particular, we must check whether we need to enable TRIM depending on which device we have bought.*

D. Care-taking in Future

We have to take care of logic board burnout, its causes and precautions. Heating issue has to be dealt with rigorously. Some battery saving tips must also be read [101]. For RAM we must follow the instructions to reduce memory usage by applications like Chrome [102].

E. Further Replacements for Consideration

[103] has a good list of feasible replacements for our MacBook Pro model. Some important ones are [104, 105]. We have to take care of logic board burnout, its causes and precautions. Heating issue has to be dealt with rigorously. Some battery saving tips must also be read [101].

IV. Conclusion

We need to purchase the following:

- **Memory (1000-1100 hkd)**
  The details of memory can be found in Section II-B. Most of the good brands cost similar at 1000 hkd for 16GB.
- **Storage (1350 hkd)**
  For storage, we need to purchase optical bay enclosure , superdrive enclosure and SSD. For details, refer to Section II-D and Section II-E.The cost of optical bay enclosure with superdrive from a good brand must be around 350 hkd. The lower brands could cost 65 hkd. The cost of SSD varies more; we fix our expectation to 1000 hkd.
- **Tools**[1] **(120 hkd)**
  The tools required for storage include all those that are required for memory. The details are mentioned in Section II-E. If a set is purchased from a good brand, the cost will be around 120 hkd.
- **Keyboard, Mice and VGA adapter (700 hkd)**
  The details about the peripherals are mentioned in Section II-F. The price of originals is 700 hkd. We fix our expectation to this price, but *we will rigorously try to minimize the cost of peripherals of reasonable value when purchased from Sham Sui Po.*

After the purchasing ordeal is over, we need to install the products by following the information in the links discussed in Sections III-A and III-B. We must also test the products to verify that they are functioning as they should according to the information in the links discussed in Section III-C.

We must also keep in mind the information discussed in Section III-D. Heating of the logic board leading to fatal problems has happened before. We must never use our computer in a manner to aggravate the heating risks. There are some concerns that the battery may be fast depleted after installation of higher memory and SSD. We must keep the battery saving tips in mind. Further even after 16 GB RAM, memory can be exhausted by poor use of some applications. We must understand and follow the information on how to optimize memory use by applications.

We may also read and keep in mind other replacements of our MacBook Pro (15-inch, late 2011), that may help in improving our experience. In future we may need to do them. Some of them are discussed in Section III-E

[1]The price of tools is included in most packages that offer optical bay and superdrive enclosures. Our expected price for Storage is based on the price of some products, most of which include tools. The expected price of tools listed here is such when they are bought solely. One must be mindful of *double counting* here.

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