

# Broadwell (microarchitecture)

**Broadwell** is Intel's codename for the 14 nanometer die shrink of its Haswell microarchitecture. It is a "tick" in Intel's tick-tock principle as the next step in semiconductor fabrication.<sup>[1][2][3]</sup> Like some of the previous tick-tock iterations, Broadwell did not completely replace the full range of CPUs from the previous microarchitecture (Haswell), as there were no low-end desktop CPUs based on Broadwell.<sup>[4]</sup>

Some of the processors based on the Broadwell microarchitecture are marketed as "5th-generation Core" i3, i5 and i7 processors. This moniker is however not used for marketing of the Broadwell-based Celeron, Pentium or Xeon chips. This microarchitecture also introduced the Core M processor branding.

Broadwell's H and C variants will be used in conjunction with Intel 9 Series chipsets (Z97, H97 and HM97), in addition to retaining backward compatibility with some of the Intel 8 Series chipsets.<sup>[5]</sup>

## 1 Design and variants

Broadwell has been launched in three major variants:<sup>[6]</sup>

- **BGA** package:
  - *Broadwell-Y*: system on a chip (SoC); 4.5 W and 3.5 W thermal design power (TDP) classes, for tablets and certain ultrabook-class implementations. GT2 GPU will be used, while maximum supported memory is 8 GB of LPDDR3-1600.<sup>[7]</sup> These will be the first chips to roll out, and are expected for Q3/Q4 2014. At Computex 2014, Intel announced that these chips will be branded as *Core M*.<sup>[8]</sup> TSX instructions are disabled in this series of processors because a bug that cannot be fixed with a microcode update exists.<sup>[9]</sup>
  - *Broadwell-U*: SoC; two TDP classes – 15 W for 2+2 and 2+3 configurations (two cores with a GT2 or GT3 GPU) as well as 28 W for 2+3 configurations.<sup>[10]</sup> Designed to be used on motherboards with the PCH-LP chipset for Intel's ultrabook and NUC platforms. Maximum supported is up to 16 GB of DDR3 or LPDDR3 memory, with DDR3-1600 and LPDDR3-1867 as the maximum memory speeds. The 2+2 configuration is scheduled for Q4 2014, while the 2+3 is estimated for Q1 2015.<sup>[6]</sup> For Broadwell-U models with integrated 5x00 GPUs, die size is 82 mm<sup>2</sup> with a total of 1.3 billion transistors, while for the models with 6100 and 6200 GPUs the die size is 133 mm<sup>2</sup> with a total of 1.9 billion transistors.
- *Broadwell-H*: 37 W and 47 W TDP classes, for motherboards with HM86, HM87, QM87 and the new HM97 chipsets for "all-in-one" systems, mini-ITX form-factor motherboards, and other small footprint formats. It may come in two different variants, as single and dual chips; the dual chips (4 cores, 8 threads) will have GT3e and GT2 GPU, while a single chip (SoC; two cores, four threads) will have GT3e GPU. Maximum supported memory is 32 GB of DDR3-1600.<sup>[7]</sup> These are scheduled for Q2 2015.<sup>[6]</sup>
- **LGA 1150** socket:
  - *Broadwell-DT*: quad-core unlocked desktop version with GT3e integrated graphics (Iris Pro 6200) and 128 MB of eDRAM L4 cache, in a 65 W TDP class. Announced to be backward compatible with the LGA 1150 motherboards designed for Haswell processors.<sup>[11]</sup>
- **LGA 2011-v3** socket:
  - *Broadwell-EP*: to be marketed as Xeon E5-2600 v4 etc., while using the C610 Wellsburg chipset platform. Up to 22 cores and 44 threads, up to 55 MB of total cache and 40 PCI Express 3.0 lanes, with 55–160 W TDP classes. Maximum supported memory speed is quad-channel DDR4–2400.<sup>[12]</sup>
  - *Broadwell-EX*: Brickland platform, for mission-critical servers. Intel QuickPath Interconnect (QPI) is expected to be updated to version 1.1, enabling seamless scaling beyond eight-socket systems. Maximum supported memory speeds are expected to be DDR3-1600 and DDR4-1866.<sup>[13][14]</sup> Up to 24 core and 48 threads, up to 60 MB of L3 cache and 32 PCI Express 3.0 lanes, with 115–165 W TDP.
  - *Broadwell-E*: HEDT platform, for enthusiasts. With a maximum of 10 cores it is said to be released during computex, and subsequently was

released in July 2016. Consisting of four processors: the 6800K, 6850K, 6900K, and the deca-core 6950X with clock speeds ranging from 3 GHz to 3.9 GHz as well as up to 25 mb of L3 cache, however over clocking these processors has seen a max overclock headroom of 4.3 GHz stable.<sup>[15]</sup>

## 2 Instruction set extensions

Broadwell introduces some instruction set architecture extensions:<sup>[16][17]</sup>

- **Intel ADX:** ADOX and ADCX for improving performance of arbitrary-precision integer operations<sup>[18]</sup>
- **RDSEED** for generating 16-, 32- or 64-bit random numbers from a thermal noise entropy stream, according to NIST SP 800-90B and 800-90C<sup>[19]</sup>
- **PREFETCHW** instruction<sup>[19]</sup>
- **Supervisor Mode Access Prevention (SMAP)** – optionally disallows access from kernel-space memory to user-space memory, a feature aimed at making it harder to exploit software bugs.
- **Transactional Synchronization Extensions:** This instruction set is reintroduced for all versions of Broadwell except for Broadwell-Y because a bug that cannot be fixed via microcode update in Broadwell-Y and all versions of Haswell except for the Haswell-EX variants has been fixed with a new CPU stepping level.<sup>[9]</sup>

## 3 New features

Broadwell's Intel Quick Sync Video hardware video decoder adds VP8 hardware decoding<sup>[20]</sup> and encoding<sup>[21]</sup> support. It adds VP9 and HEVC 10-bit decoding support through the integrated GPU.<sup>[22]</sup> Also, it will have two independent bit stream decoder (BSD) rings to process video commands on GT3 GPUs; this will allow one BSD ring to process decoding and the other BSD ring to process encoding at the same time.<sup>[23]</sup>

Broadwell's integrated GPU supports on Windows Direct3D 11.2, OpenGL 4.4 (OpenGL 4.5 on Linux<sup>[24]</sup>) and OpenCL 2.0.<sup>[25][26][27]</sup> However, it is marketed as Direct3D-12-ready.<sup>[28]</sup> Broadwell-E introduced Intel Turbo Boost Max Technology 3.0.<sup>[29]</sup>

## 4 List of Broadwell processors

### 4.1 Desktop processors

#### 4.1.1 “Broadwell-E” (14 nm)

### 4.2 Embedded processors

### 4.3 Mobile processors

1. When a cooler or quieter mode of operation is desired, this mode specifies a lower TDP and lower guaranteed frequency versus the nominal mode.<sup>[32]:71–72</sup>
2. This is the processor's rated frequency and TDP.<sup>[32]:71–72</sup>
3. When extra cooling is available, this mode specifies a higher TDP and higher guaranteed frequency versus the nominal mode.<sup>[32]:71–72</sup>

### 4.4 Server processors

## 5 Roadmap and history

Main article: Intel Tick-Tock

On September 10, 2013, Intel showcased the Broadwell 14 nm processor in a demonstration at IDF. Intel CEO Brian Krzanich claimed that the chip would allow systems to provide a 30 percent improvement in power use over the Haswell chips released in mid-2013. Krzanich also claimed that the chips would ship by the end of 2013;<sup>[38]</sup> however, the shipment was delayed due to low yields from Intel's 14 nm process.<sup>[39]</sup>

On October 21, 2013, a leaked Intel roadmap indicated a late 2014 or early 2015 release of the K-series Broadwell on the LGA 1150 platform, in parallel with the previously announced Haswell refresh. This will coincide with the release of Intel's 9-series chipset, which may be required for Broadwell processors due to a change in power specifications for its LGA 1150 socket.<sup>[40][41]</sup>

On May 18, 2014, *Reuters* quoted Intel's CEO promising that Broadwell-based PCs will be on shelves for the holiday season, but probably not for the back-to-school shopping.<sup>[42]</sup>

Mobile CPUs are expected in Q4 2014 and high-performance quad-core CPUs in 2015. The mobile CPUs will benefit from the reduced energy consumption of the die shrink.<sup>[43][44]</sup>

On June 18, 2014, Intel told *CNET* that while some specialized Broadwell-based products would be out in Q4 2014, “broader availability” (including mobile CPUs) would only happen in 2015.<sup>[45]</sup>

As of July 2014, Broadwell CPUs are available to Intel's hardware partners in sample quantities.<sup>[46]</sup> Intel is

expected to release 17 Broadwell U series family microprocessors at CES 2015.<sup>[47]</sup> Also, according to a leak posted on vr-zone, Broadwell-E chips will be available in 2016.<sup>[48]</sup>

On August 11, 2014, Intel unveiled formally its 14 nm manufacturing process, which is used for Broadwell, and indicated that mobile variants of the process will be known as *Core M* products. Additionally, Core M products were announced to be shipping during the end of 2014, with desktop variants shipping shortly after.<sup>[49]</sup>

With Broadwell, Intel focused mainly on laptops, miniature desktops, and all-in-one systems.<sup>[50]</sup> This left traditional desktop users with no new socketed CPU options beyond fourth-generation Haswell, which first arrived in 2013. Even though the company finally introduced two Broadwell desktop chips in the summer of 2015, it launched its high-end sixth-generation Skylake CPUs very shortly thereafter. In September 2015, Kirk Skaugen, senior vice president and general manager of Intel's Client Computing Group, admitted that skipping desktops with Broadwell was a poor decision. Between the end-of-life for Windows XP in 2014 and the lack of new desktop chips, Intel has not given desktop PC users any good reasons to upgrade in 2015.<sup>[50]</sup>

## 5.1 Releases

On September 5, 2014, Intel launched the first three Broadwell-based processors that belong to the low-TDP Core M family, Core M 5Y10, Core M 5Y10a and Core M 5Y70.<sup>[51]</sup>

On October 9, 2014, the first laptop with Broadwell Intel Core M 5Y70 CPU, Lenovo Yoga 3 Pro, was launched.<sup>[52]</sup>

On October 31, 2014, four more Broadwell based CPUs were launched belonging to Core M Family, increasing the number of launched Broadwell CPUs to seven.<sup>[53]</sup>

On January 5, 2015, 17 additional Broadwell laptop CPUs were launched for the Celeron, Pentium and Core i3, i5 and i7 series.<sup>[54]</sup>

On March 31, 2016, Intel officially launched 14 nm Broadwell-EP Xeon E5 V4 CPUs.<sup>[55]</sup>

On May 30, 2016, Intel officially launched 14 nm Broadwell-E Core i7 69xx/68xx processor family.

## 6 See also

- List of Intel CPU microarchitectures
- List of Intel Core M microprocessors

## 7 Notes

- [1] Implemented as **eDRAM** and serving primarily to increase the performance of integrated **GPU**, while being shared with the CPU.

## 8 References

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- [18] New Instructions Supporting Large Integer Arithmetic on Intel Architecture Processors (Document number 327831–001) // Intel, August 2012
- [19] Intel C++ Composer XE 2013 for Windows\* Installation Guide and Release Notes (Document number: 321414-004US) // Intel, October 4, 2012; section “3.2.4 Inline assembly and intrinsic support for Intel architecture code named Broadwell added to Composer XE 2013 Update 1”, page 13
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- [32] “4th Generation Intel Core processor based on Mobile M-Processor and H-Processor Lines Datasheet, Volume 1 of 2” (PDF). [intel.com](http://intel.com). December 2013. Retrieved December 22, 2013. Configurable TDP (cTDP) and Low-Power Mode (LPM) form a design vector where the processor behavior and package TDP are dynamically adjusted to a desired system performance and power envelope. [...] With cTDP, the processor is now capable of altering the maximum sustained power with an alternate guaranteed frequency. Configurable TDP allows operation in situations where extra cooling is available or situations where a cooler and quieter mode of operation is desired.
- [33] “The technical details behind Intel’s 7 Watt Ivy Bridge CPUs”. [arstechnica.com](http://arstechnica.com). January 14, 2013. Retrieved December 22, 2013. If the CPU needs to work hard for an extended period of time and the laptop gets warmer, it will slowly ramp down its speed until it’s operating at its stated TDP. [...] There are two OEM-configurable “power level” states that define how quick the CPU can be in these situations: PL2 tells the processor how much power it’s allowed to use when it needs a short burst of speed, and PL1 defines how quickly the processor can run under sustained load. [...] This is at the heart of what Intel is doing with the Y-series processors: their maximum TDP has been lowered four watts, from 17 to 13. Intel is also validating them for use at two lower PL1 values: 10 watts and 7 watts. This is where the marketing we discussed earlier comes in—rather than keeping these values under the covers as it has so far been content to do, Intel has taken that lowest value, put it on its product pages, and called it SDP.
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## 9 External links

- Intel to launch Broadwell “U” series CPUs at CES 2015

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