Bringing Laptops Into the 2020s

Lattice Enables Critical Functionality

A Lattice Semiconductor White Paper

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The laptop market is seeing a resurgence due to changing work situations brought on by COVID-19. Even before the pandemic spread globally, in January 2020 industry analyst firm Gartner noted, “The PC market experienced growth for the first time since 2011, driven by vibrant business demand for Windows 10 upgrades, particularly in the U.S., EMEA and Japan.[1]” To be competitive in this growing market, laptop OEMs are looking to differentiate their products by adopting new technologies and applications to boost productivity. While many of these technologies found initial traction in smartphones or other devices, they can be brought together in laptops in a way that combines the power of a full-fledged computer with the convenience and the security of a mobile device that can adapt to its surroundings.

Many of the new capabilities being added to laptops can be implemented in software, but would reduce the laptop’s battery life. To address this, Lattice Semiconductor is developing hardware implementations that provide better performance at much lower power levels, while maintaining the ability to provide future updates using Lattice’s field programmable gate array (FPGA) devices. As FPGAs can be reprogramed in the field, laptop OEMs can implement new applications in hardware via downloadable software and firmware updates, instead of redesigning the hardware.

Laptop Use Increasing

Once predicted to be supplanted by smartphones and tablets, laptop use is growing due to changing work conditions and emerging technologies. Technology trends like cloud computing and ubiquitous broadband connectivity mean employees can stay productive when working off-campus. Thanks to their full-sized keyboard and high resolution displays and cameras, laptops are generally considered to be the form factor of choice for business productivity applications like email, word processing, and video conferencing.

While many of the latest technical innovations around power savings and artificial intelligence (AI) have been focused on the smartphone platform, those same innovations can now be applied to laptops without a significant impact on the laptop’s power consumption. For example, as the display is one of the main contributors to power consumption in a laptop, battery life can be significantly improved by applying intelligent user monitoring to determine when a user is looking at their laptop so it can automatically lower display brightness when the user’s attention is focused elsewhere. This application is already widely adopted by smartphones, and the same experience can now be implemented on laptops.

AI Acceptance Increasing

While AI remains a nascent field with immeasurable potential, its value is still being proven to consumers. But there are AI applications that have achieved mainstream success, and users are comfortable with using them. One is facial recognition, in particular as a security feature in a smartphone. It is also now widely used in airports worldwide to track travelers entering or leaving a country as they pass an immigration desk. In each case, a camera recognizing a face has strengthened confidence that a computer user – or someone entering the country – is who they say they are. Now that consumers are growing comfortable with AI-enabled experiences, expect smart vision applications like facial recognition to be more widely implemented on laptops.

Security and Privacy

While both security and privacy are critical for desktop computers, they are even more important for mobile laptops. Whether used for work or for personal business, security and privacy – technically different concepts – merge as a requirement. The need for security to protect sensitive data overlaps with the desire to keep that data private.

We're all too familiar with the fact that security and privacy often come at a cost to convenience. While burdensome security measures clearly protect a laptop that's out in public, they can become more annoying (and even unnecessary) when the laptop is in a known, controlled environment like a work or home office.

One of the benefits of a laptop that leverages AI for situational awareness is that it can adjust the security behaviors according to where the laptop is. At home, convenience can be enhanced, since there is less physical risk. In a café, by contrast, security can be tightened due to the unfamiliar surroundings and people.

And it's not just about deciding where the laptop is. The same camera that scans the environment can make note of when the user leaves the computer to get more coffee or go to the restroom. The computer can then lock itself down without the user having to remember to do so. In a similar vein, the camera may notice that another pair of eyes is looking at the screen over the user's shoulder, causing the laptop to take action to thwart possible viewing by an unauthorized user. Given the multitude of well-publicized computer hacks, AI can also help monitor internal behaviors and activity to alert the user to anything suspicious.

These are a few examples of the ways laptops are evolving to meet the needs and expectations of the modern workforce. For the balance of the paper, we will focus on two specific laptop trends:

- Always-on and instant-on behaviors. The name of the game here is saving energy.
- New laptop form factors. This could mean detaching the screen from the rest of the machine, experimenting with new laptop shapes, or folding the laptop in the middle of a larger screen.

Lattice FPGAs – the iCE40 UltraPlus™ and the CrossLink-NX™ FPGAs, in particular – and Lattice's sensAI™ solutions stack for always-on Edge AI applications provide a particularly effective way of enabling these new capabilities within future laptops. And they do so in a way that requires far lower power than an ASIC-based approach would need.

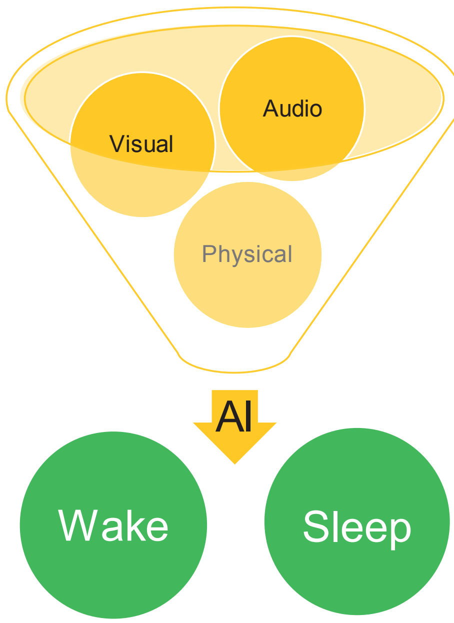
Always-On and Instant-On

Today there are only three ways to put a laptop to sleep or wake it up: push a button (maybe with the mouse), close the lid, or wait for the laptop to time-out. Newer laptops might also be awakened by a voice command.

The challenge with a laptop is its central system-on-chip (SoC). The SoC is in charge of what happens in the laptop, and, for that reason, it's involved in most tasks that the laptop performs. It contains the CPU cores, and it may include other processing and peripheral circuits as well. And it burns a lot of energy in doing its work.

Because the SoC is involved in so many of the laptop's activities, there is little that the laptop can do while the system – and the SoC in particular – sleeps. The only capabilities available during sleep relate to the few options for waking the system back up. No other tasks can run on a sleeping system. In some cases, if they do (download email, network monitoring), they consume 100s of milliwatts of energy; a significant drain on battery life.

There are many tasks that a laptop can perform even while the SoC sleeps, if it is enhanced by an AI layer that responds to sensor signals. The AI capabilities can do work or make decisions while the SoC is asleep, ultimately determining whether the SoC should wake up for further work or whether it can remain asleep and let the AI layer handle the required task. Low-power FPGAs make an ideal hardware platform for the AI layer. They provide enough processing power to handle basic AI tasks (presence detection, for example), but do so while consuming much less power than the SoC. If the AI layer determines the SoC needs to be involved with the task, it can then wake it to supplement the AI layer's processing capabilities or take other action.



Lattice provides this AI capability today through the Lattice sensAI solutions stack, which layers AI functionality over the iCE40 UltraPlus, ECP5™, and CrossLink-NX FPGAs. But such AI has so far mostly been adopted by Internet-of-things (IoT) devices. For example, a smart doorbell might have the following features:

- Detecting the presence of a human and other objects like packages.
- Detecting and/or recognizing a specific face or person. These can be specific people registered as authorized users (like the house's residents) or people who routinely pass by the doorbell camera, like a uniformed delivery person or gardener.
- Interpreting a few hand gestures, or understanding a few verbal commands. Combining facial recognition with a spoken key phrase or password enables dual authentication log-ins for heightened security.
- Leveraging a sensor-agnostic inference engine to minimize sensor data being sent over Cloud.

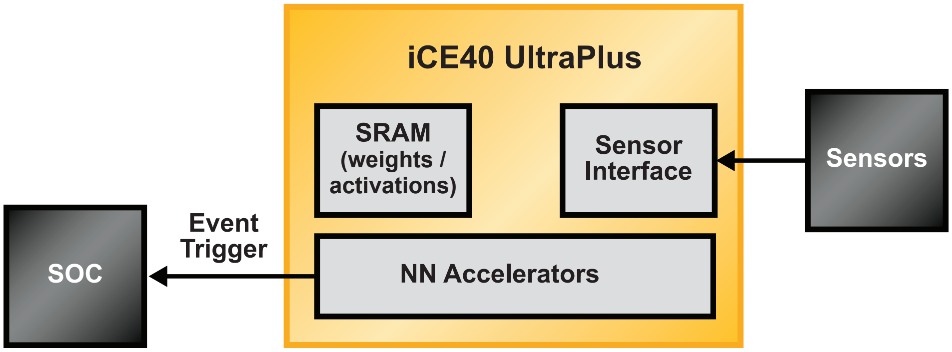
On their own in an application like this, with no assistance from an SoC, Lattice FPGAs provide higher performance with lower power consumption than a standalone CPU could provide because the CPU has to execute its tasks as software, while the FPGA uses a far more efficient, hardware-based implementation. For example, a CPU controlling a smart doorbell or security camera might process 1-2 frames per second while burning 100 mW; an iCE40 UltraPlus FPGA from Lattice can handle 5 frames per second at 7 mW – 3-5 times the performance at one-fourteenth the power.

If they can drive a smart doorbell or security camera, then Lattice sensAI solutions can also be used in a laptop to help:

- Detect when the user is looking at the screen. When the user looks away, the laptop can save power by dimming the screen, and then brighten it when the user refocuses on the screen.
- Adjust security according to the laptop's location.
- Detect where the user's gaze is directed. This can help with tasks that would ordinarily require a mouse; instead, eye-tracking could provide hands-free operation of some frequent tasks.
- Optimize how energy is spent on the graphics. That energy can be used for rendering the part of the screen where the user is looking. The rest of the screen can remain fuzzier or more poorly rendered, saving energy, until the user shifts their gaze to a different part of the screen.

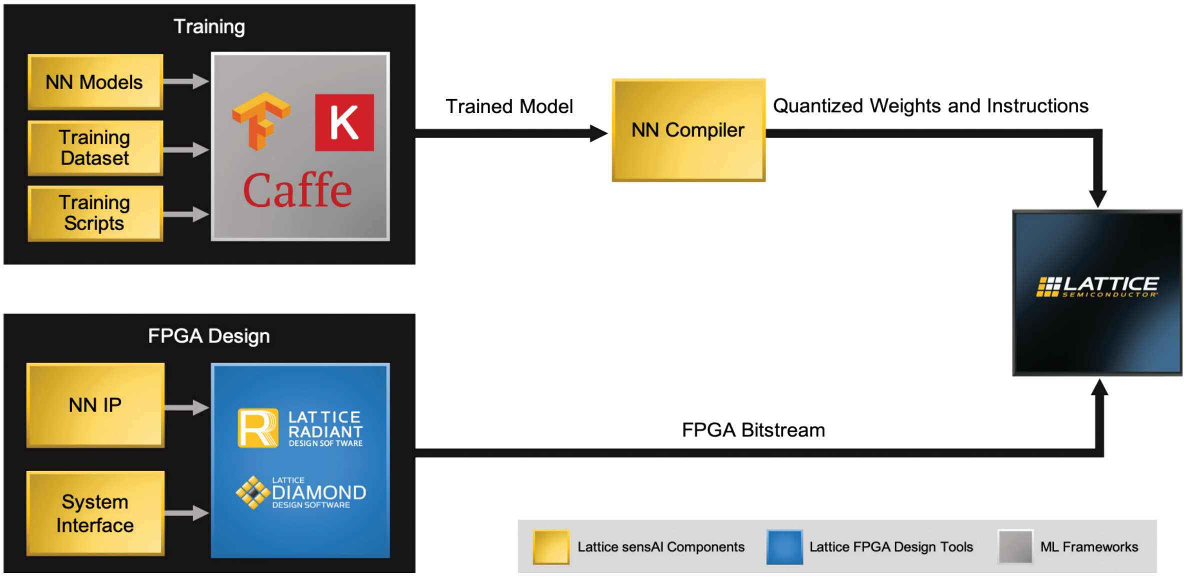
- Influence the narrative trajectory of a game, directed by the movement of the player's eyes.
- Detect someone looking over a laptop user's shoulder
- Dim the laptop screen if no one is using it to save battery life

Here's a simple diagram illustrating how a Lattice iCE40 UltraPlus FPGA can help offload some of the AI processing from a laptop's SoC.



In this implementation, the sensor interface collects the inputs from the individual sensors, processing them in neural-network (NN) accelerators within the FPGA, assisted by on-chip SRAM that stores the weights and activations required for processing the neural nets. Decisions made by the accelerators can then wake the SoC if necessary for further processing.

The AI layer is built using the many resources that Lattice's sensAI solutions stack brings to the iCE40 UltraPlus and CrossLink-NX FPGAs. Designers have access to a full software stack and a complete set of design tools for adapting networks trained on the major frameworks like Caffe, Keras, MobileNet, ResNet, SSD, and TensorFlow. The stack includes reference designs, demo boards, IP cores, and hardware platforms that can be used to develop various common AI applications (like presence detection, object counting, facial recognition, and others). Lattice even offers custom design services for developers that simply want the AI functionality without having to immerse themselves in how to develop and implement an AI application.



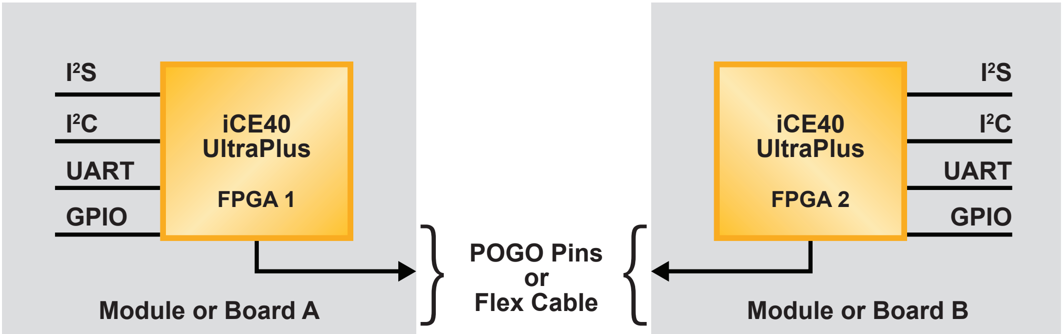
Reducing Signals in New Form Factors

The second challenge for modern laptops will be figuring out how to move beyond the traditional form factors that we're all used to. Part of that move is likely to involve flexibility – even if that means simply bending the screen in the middle to close the unit. Laptop engineering today is challenged by the difficulty in routing numerous signals – which run a variety protocols – all around the laptop.

A simple way to handle this is to reduce the number of signals through signal aggregation. Multiple low-bandwidth interfaces can be multiplexed onto a single higher bandwidth signal for de-multiplexing elsewhere, dramatically lowering the wiring footprint in the laptop. It makes board-to-board connections easier; it makes for easier on-board routing; it means fewer wires traversing a hinge or other flexible element; and it can improve reliability by reducing the number of connectors needed.

Signal aggregation can be implemented on single wires or LVDS pairs. Lattice FPGAs can implement these signals at a variety of performance points, providing options for the most efficient implementation. For example, an iCE40 UltraPlus can drive 7 Mbps onto a wire; higher bandwidth aggregation speeds are possible using higher-performing Lattice FPGAs.

The challenge, however, comes from the fact that the different signals may represent different protocols. That challenge can be met by implementing an I/O hub, similar to a sensor hub. That hub terminates local I/O signals of different flavors and multiplexes them onto fewer high-speed wires. Those wires travel to an I/O hub at the other end, where the signals are de-multiplexed and reacquire their original protocol nature.



Lattice FPGAs provide the physical hardware for receiving the I/O signals and transmitting the multiplexed versions. Lattice also provides the IP for building the I/O hub. Signal aggregation is sensor agnostic, so data stream from different sensor types (RGB, IR, Lidar, radar, etc.) or signals travelling over different bus types (I2C, I2S, UART, GPIO) can be aggregated over the same pin or cable. Lattice has longstanding expertise in enabling signal aggregation in mobile phones, and that expertise is applicable to sensor aggregation in laptops.

Lattice Enables the Future Laptop

Engineers are hard at work developing laptop computers that will provide users with the kinds of experiences that they've already come to expect from smartphones and tablets. The future laptop will be easier to use, have a longer battery life, and be more secure than today's models.

Some of the most noticeable improvements will be in energy consumption and form factor. Laptops will use the power-reduction techniques that allow batteries to last an entire day or more. And they will be more flexible and easier to carry.

Lattice FPGAs will be key to enabling these new capabilities and features in laptops. Doing more work outside the SoC allows the SoC to sleep more, waking only when its computing power is truly required. A sensor hub with an AI layer, implemented in pure hardware, will connect multiple cameras, microphones, and other sensors, meaning more downtime for the SoC. An I/O hub driving multiplexed signals will reduce signal count, making laptops easier to build and providing a richer user experience by enabling AI-based sensor fusion.

Lattice FPGAs provide the physical platform for these hubs, and Lattice's sensAI solutions stack makes the AI layers simple to implement. Together, they can help developers create lighter, lower-power laptops that will power business and personal users through the 2020s.

Reference

[1] https://www.gartner.com/en/newsroom/press-releases/2020-01-13-gartner-says-worldwide-pc-shipments-grew-2-point-3-percent-in-4q19-and-point-6-percent-for-the-year

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