The State of Stateless Linux OSes (and the future of Solar Computing)

December 16, 2025

The title is more of a gag on the other parodied State of the Union addresses, like State of the Onion by Perl Developer Larry Wall: https://www.perl.com/pub/2006/09/21/onion.html/

Stateless applications, or even machines, may involve some amount of storage, even if it is not local. The purpose of stateless systems may have diverged with increasing options/capabilities, but its adoption in embedded systems can still have a lot of utility.

https://www.redhat.com/en/topics/cloud-native-apps/stateful-vs-stateless

A stateless application may comprise only one part of a lightweight system, whereas the rest of the kernel and OS might have stateful applications.

What about Stateless OSes?

Depending on the need, such as a LiveCD/USB, a stateless OS isn't going to save info on ROM, but it can serve a useful purpose even in a persistent-intended system such as PuppyLinux, which allows a persistant storage option, One theory is that developing a new, lightweight system might be easier to select off-the-shelf stateless applications/modules, and interfaces, then integrate them into a single OS that limits where storage must take place.

Rather than starting from scratch, like Gentoo (which itself isn't technically from scratch), building an OS that can have predefined and pretested, benchmarked applications can produce a list of memory requirements, and then the applications can be loaded as separate, single application OSes. This might allow bypassing higher memory needs, at the expense of a "truly" userspace OS.

Stateful Userspace, just not all at once

"The sum of the parts is less than the whole" can alternately be written as "The whole is greater than the sum of the parts." Unless multitasking and time is of essence. The tradeoff of serial applications (RISC analogy and CISC comparisons are somewhat congruent) is at the expense of time and processing needs.

Deliberately limiting IPC bandwith/memory cache and clockrate is only to meet energy constraints, not to artificially limit processing for less reasons. While there are certainly efficiency cases where clock rate improves throughput, there are many edge/niche cases where that may not apply.

The purpose of solar femtoTX motherboard is to explore those edge cases.

Another Four Core A53... in 2025?

Just 2 months ago, Qualcomm, one of the wealthiest chipmakers in the world, just behind Apple, Nvidia, and Intel (historically), with a market capitalization of $188 Billion, decided to release yet another Quad Core Single Board Computer, to win perhaps a 10-15% share of the Single Board Computer Market.

https://www.jeffgeerling.com/blog/2025/arduino-uno-q-weird-hybrid-sbc

My guess is that someone in the product development meeting at Qualcomm had this idea:

Developer Jerry: "Hey, let's take on Raspberry Pi!"

Developer Tom: That's a great idea! We've got the cash! SEO assistant, let's get on the first page of Google Search results

Developer Berry (SEO Whiz): Sure thing! On it.

Developer Jerry: We'll have the Raspberry Pi cornered in time for our 2nd quarterly results!

What's needed?

More 16MB-128MB SoCs with Display Interfaces & GUIS and *Boring* Bootloaders - Towboot, Coreboot (for 386 and 486, etc).

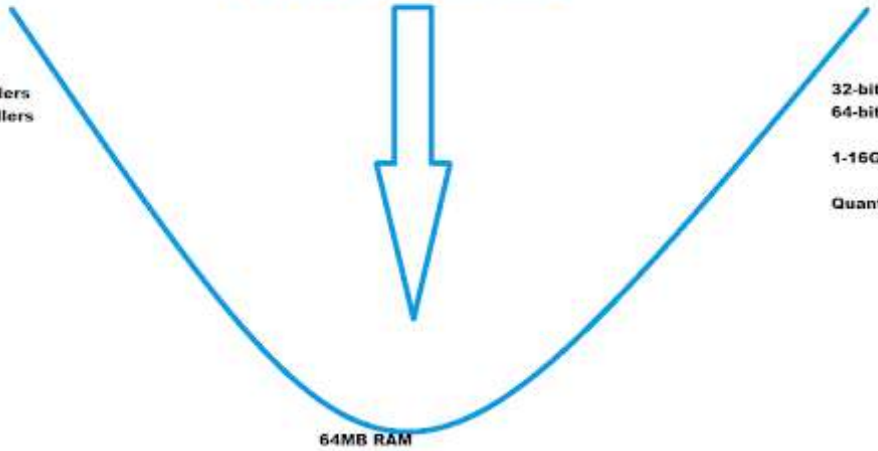
https://github.com/EI2030/Low-power-E-Paper-OS/blob/master/Hyperlinks.md#arm9-armv5-socs

Memory in Pixel display controllers (present on the Ambiq Micro Apollo 510): https://contentportal.ambiq.com/documents/20123/387733/Apollo-SoC-Selector-Guide.pdf

SAM9X60
https://ww1.microchip.com/downloads/aemDocuments/documents/MPU32/ProductDocuments/DataSheets/SAM9X60-SIP-Data-Sheet-DS60001580.pdf

https://direct.nuvoton.com/en/numaker-rtu-nuc980-chili-board

The Uncanny Valley of Low-RAM Single Board Computers



8-bit Microcontrollers
32-bit Microcontollers

KB to <8MB RAM

Quantity: Many

32-bit Application Processors
64-bit Application Processors

1-16GB RAM

Quantity: Many

64MB RAM

Examples: Microchip SAM9X60,
Nuvoton NuMaker-RTU-NUC980

Quantity (of Boardmakers): Few

Display Controllers: HDMI, DSI, if any. Need: E-ink, MiP

Apollo510B
96 MHz 250 MHz turboSPOT
32-bit Arm Cortex-M55 with Helium technology, DMA, Network coprocessor
120
4MB
3.75MB
1.71-2.2V
12-bit, 11-channel, up to 2.8 MS/s Sampling Rate
4
I²C/SPI Master (7x) 1x full-duplex/1x half-duplex I²C/SPI Slave USB 2.0 FS/HS SDIO v3.0/eMMC (2x)
1/2/4/8-bit wide (1x) up to 96 MT/s (SDR/DDR) 1/2/4/8/16-bit wide (1x) up to 250 MT/s (SDR/DDR)
I²S Master/Slave (2x) full-duplex, with ASRC (1x)
PDM stereo DMIC interface (1x) Low Power Audio ADC (1x) PLL for Precision Audio
SPI 3-wire/4-wire Dual/QuadSPI MIPI DSI at 1.5 Gbps (2 lanes) 4-layer Display Controller Memory in Pixel (MiP) Interface
2D/2.5D GPU with anti-aliasing, dithering, and HW vector graphics acceleration

Why 16-128MB? Because the era of Solar is upon us.

Today you can solar power 4MB without much of a sweat. 5 years ago you could solar power around 384KB or RAM. The Apollo 3 was released in 2020. The Apollo 510 in 2025. I'm referring to portable solar panels that can fit inside a pocket, or maybe a briefcase, not a foldout panel that is as large as a newspaper.

The purpose of portable solar mobile devices is just that, as most commuters aren't setting up a camping spot in the middle of rush hour on 5th Avenue.

That's only when paired with a lightweight processor no larger than a Pentium. At 32nm or less, and at 60MHz or less. That was in 2011, but Intel never released it and that didn't include RAM. The Quark was released and even partnered with the Arduino to create the Galileo Board. But very little RAM, and it was a microcontroller for all intents and purposes. Has anyone soldered RAM to it and installed Windows 3.1? Maybe. Available to Intel partners for development only, and today Intel Foundry advertises its services but the Quark is not on the menu (I've tried to reach out to them multiple times but never got a response).

By comparison, a Cortex M4 uses around the same number or slight more than and ARM1 processor (25,000 transistors).

The 386 had 275,000. The 486 had 1.2 million. The Pentium 3.3m. When RAM is 90% of your SBC's energy consumption, the motivation to create a low RAM board (w/ ultra low voltage and power - 0.6V-0.8V) increases.

Because then you don't need a USB port in your bill of materials to recharge/power it (unless you want to).

Millions of computer users worldwide could type on a solar powered laptop, with a solar powered keyboard by ONiO, and a board that uses a 10mW of power. Set the ceiling, and the applications will follow.

A microcontroller such as the Arduino or a Single Board computer requires access to either another PC/laptop, or a power supply. One can plug in a microcontroller to a USB or a Serial TTL interface. Boards should be standalone and require just a lightweight (low power) monitor and keyboard to run.

Remember when these could run on their own? (Some had a backup battery, but still)

Low Power Memory makers typically sell just a few MB, at most: . https://www.sure-core.com/memory-products/ (SRAM) https://www.weebit-nano.com/ (ReRAM) I am not really sure which memory suppliers are developing for the high end (many MB, but I imagine if it's really leading edge, their partners aren't publically advertising it, esp if they are using it internally to confer or research some further competitive advantage)

When I was a kid, my uncle took me strawberry picking. The farm charged by the basket. Whatever you could fit in the basket was yours. Software development should follow that principle.

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If I spell my name backwards, it's "innavoig." Phonetically, it's closest to "in a voyage." Hence the naming of this blog.

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An interesting article was posted on LWN.net on linux support for 32-bit systems. https://lwn.net/SubscriberLink/1035727/4837b0d3dccf1cbb/ " Arnd Bergmann started his Open Source Summit Europe 2025 talk with a clear statement of position: 32-bit systems are obsolete when it com...

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