20 years later - it’s real-time, really!

The work done on real-time Linux has benefitted the open-source OS for years, but it was only this week that Linus Torvalds admitted its last piece into the mainline kernel.

With the release of version 6.12 on 18 or 25 November 2024, Linux will become a real-time operating system. As a unixoid operating system, Linux was originally designed as a General Purpose Operating System (GPOS). On the other hand, there were a large number of real-time operating systems (RTOS) that were specially designed for industrial applications and the hardware used there. Examples here were OS-9, VRTX, VxWORKS, pSOS, QNX etc. These RTOSes were generally highly specialized, had low memory size requirements and short or very short response times to interrupts, but supported only very few CPU types and even fewer computer peripherals.

In order to fulfill real-time requirements, Linux previously had to be patched. The Preempt-RT patch, which has been developed since 2005, was intended for this purpose. On 20 September 2024, the patch became an official part of the kernel.

The patch will be available for ARM64-, RISC-V or x86 platforms. Depending on the hardware used, the achievable response times will be well below 100 microseconds; on average, around 10 or slightly less microseconds should be achievable.

Thomas Gleixner [tglx], our CTO, handed over the pull request in paper form, as a ball in gold foil and with a bow. Just as Linus had wished years ago.

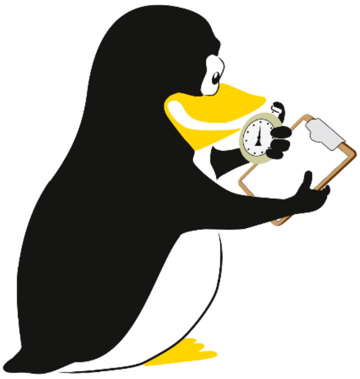
The PR is usually sent in electronic form. This happened in the morning hours of September 21, without the fuss shown here.

A short excursion into history

The KURT project (Kansas University Real Time under the direction of Prof Dr Douglas Niehaus) can be regarded as the nucleus for the patch set. Here, an attempt was made to upgrade Linux itself so that it is real-time capable. Among other things, high resolution timers were introduced for this purpose. This approach was made available in December 1999 as Kurt 2.0 for Linux 2.2.5, and the port to Linux 2.4 were completed in November 2001.

Based on this work, further patches were provided to convert Linux into an RTOS. This led to a lengthy debate on the Linux Kernel Mailing List (LKML) in 2004 as to whether Linux could become a real-time system or not. KURT was further developed in the LibeRTOS(Linux Based Enhanced Real-Time Operating System) project, in which the founder of Linutronix, Thomas Gleixner, was involved.

The Preempt-RT approach developed from this work. The company Red Hat backed this idea and one of their employees, Ingo Molnar, significantly advanced the approach. When Red Hat's support was withdrawn in 2014 and Thomas wanted to turn the project into a "hobby project", the Real-Time Linux Workgroup was founded within the Linux Foundation in 2015. And since then, this workgroup (and Linutronix GmbH) has been driving the integration of Preempt-RT into the Linux kernel.



However, the RT project has not reached the end of its work with its inclusion in the kernel. There are still many more optimizations that need to be done and, not to be forgotten, new topics will come up as Linux continues to evolve.

While Linux with Preempt-RT could already be found everywhere in industry - just think of all the PLC controllers that run under Linux, the lasers, sensors or robots etc. - the fact that real-time is now an official part of mainline Linux will certainly open up further fields of application for Linux and thus contribute to its further spread.

However, nobody should expect that the inclusion of Preempt-RT now that the kernel has been compiled will solve all problems relating to real-time. The **blog post** by our colleague John Ogness provides a good overview of the potential pitfalls.

25 years after the first Real-Time Linux conference and 20 years after the start of the debate on LKML, we celebrated the launch of Preempt-RT. Again in Vienna, with many companions and guests.

We invite you to take some time and have a view at our 20th anniversary publication.