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**Stretch-ing is great exercise – it gets you in shape to win**

Project stretch (1955-1961) was one of the first transistorized computer systems. Because of the new approach in circuit design (transistors) many innovations were made in usage, architecture, and reliability of the system.

The first crucial design decision to make in developing the stretch architecture was the technology and packaging. Ralph Palmer (lab manager for IBM’s computer division) chose to use junction transistors over surface-barrier transistors (as used in the Univac LARC) in order develop fast, and low-noise circuits for stretch. A design specification of 20 ns gate delay times was used in developing said circuits. For packaging of transistor circuits, another IBM team had been developing a new manufacturing system dubbed the Standard Modular System (SMS) which was adopted by stretch to pack in four times as many transistors for twice the space.

Next, memory was considered. The standard memory at the time had a 12 µs cycle time and the goal was set for the stretch to achieve a 2 µs memory cycle. This was accomplished by the team at the expense of current and cooling. The cooling issue was solved by using transformer oil to achieve a final memory cycle time of 2.18 µs. Previous reliability of memory was very low (about 5-10 minutes between failures (mean time)). For the stretch system data parity was added in order to do 1 bit correction and 2 bit detection of errors. Because of the error checking/correcting system during the contract’s acceptance check the stretch was able to achieve >90% reliability (desired contract spec) even though one of the bit line drivers failed. This was a great innovation in memory and was used on many future systems even to this day.

Stretch was the first system to include instruction level parallelism by the use of a pipeline. Up to 11 instructions could be pipelined simultaneously and instead of the programmer having to worry about data dependencies it was all handled by the stretch architecture. Another design innovation used to speed up program execution was the optimization of multiply instructions and at the same time, conversion of division by constants to multiplication during compilation of the program. I/O innovations included the invention of “channels” in which a single set of hardware was able to multiplex memory access.

Architectural innovations included the switch from a 6-bit byte to an 8-bit byte, addition of interrupts, a real-time clock, and memory protection. The change in byte size required a complete overhaul of I/O device design but was worth it in the end because it allowed more I/O support and options (lower case letters).

Software included with the stretch included a Fortran compiler and assembler. Later, Ted Codd built the first multiprogramming operating system for the stretch which has turned into one of the most fundamental concepts of every modern operating system.

Even though only nine copies of stretch were ever sold and the development costs were never recovered, project stretch laid a crucial foundation for later computer systems developed not just by IBM, but every major player in the computer architecture industry.

The most interesting parts of this paper to me was the interesting solution used in memory cooling, the invention of a pipeline which did not rely on proper code to execute correctly, and the foundation laid for every modern operating system today.