AccuVote-OS Precinct Count (AVOS)

The AccuVote-OS voting machine is very old technology. This machine was originally developed in 1986 and first introduced to the market in 1989. It is believed to have been used for the first time in U.S. general elections in Minnesota in 1990. This system has been marketed and maintained under many brand names over the years, but it has very little technology in common with other systems sold and marketed under those brands. The steps NH has taken to operate the system further decrease the commonalities with other jurisdictions who have or still use this device.

The CPU of the system is an NEC V25, the microcontroller version of the NEC V20 processor. A microcontroller (MCU for microcontroller unit) is a small computer on a single integrated circuit chip. In modern terminology, a microcontroller is similar to, but less sophisticated than, a system on a chip (SoC). Microcontrollers allow simplification of motherboard design while reducing size by integrating into a single package functions that otherwise would had required additional physical chips.

The V20 was a processor made by NEC that was a reverse-engineered, pin-compatible version of the Intel 8088 with an instruction set compatible with the Intel 80186. Intel 8088 was the processor of the original IBM Personal Computer model 5150, the first generation of PC computers introduced 1981. The V25 has a 16-bit internal architecture and 8-bit external data bus with 20-bit address bus, making the theoretical maximum addressable memory merely 1 Megabyte. However, the AVOS motherboard has two RAM chips with 128Kbytes each. The V20 was introduced in 1982 and launched in 1984. The V25 was officially phased out in early 2003.

This device does not have a hard drive or any other internal persistent storage. It does not have a filesystem and it does not have a general-purpose operating system. The design predates modern network technologies. It has no ability to communicate via Internet Protocol, Ethernet, or wireless networking. Many electronic identifiers of physical devices like MAC addresses that are common today are not present in this machine, because it was designed before those technologies were widely adopted. AVOS has a copper-wire telephone system modem and RS-232 serial ports, but those ports have been physically disabled in New Hampshire voting machines.

In this device, the software is installed on a socketed 128 Kbytes EPROM microchip. EPROM stands for Erasable Programmable Read-Only Memory. It is a type of programmable read-only memory (programmable ROM) that can be erased and reused. This type of chip has to be physically removed from the circuit board, placed into a separate erasing device and completely erased before it can be reprogrammed using a separate programmer device. Erasing the chip is done by shining an intense ultraviolet light through a window on the chip, through which the silicon chip is visible. The erasing window must be kept covered with an opaque label to prevent accidental partial or erratic erasure by the UV by sunlight or camera flashes. Therefore, the window is always covered by a sticker as seen in the picture. The voting machine is physically incapable of altering the programming on the chip on its own: reprogramming can only be done with a separate device.

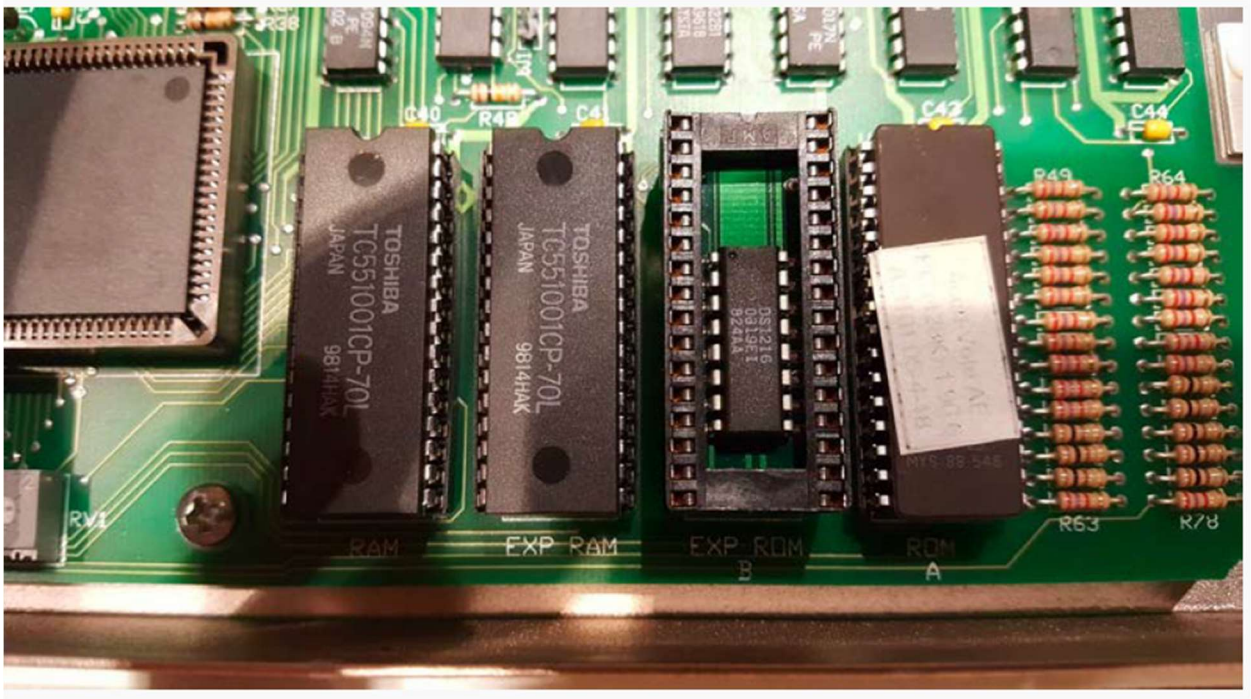
The only storage device the system has is an Epson-manufactured battery-refreshed SRAM card. Like everything else in the device, the memory card does not have a filesystem in a traditional sense. The memory card can hold up to 128Kbytes and connects to the voting machine with 40-pin card-edge connector. The original manufacturer stopped making this card in 1998. The memory card capacities are 32 Kbytes, 64 Kbytes, or 128 Kbytes.

The source code of this device has been part of at least three independent studies. The code, which comprises a little more than 20,200 lines of code, is written in C and Assembler. One module of the software that has received particular scrutiny and led to the discovery of vulnerabilities is the AccuBasic interpreter. It was originally created in 1996 to facilitate flexible election night reporting.

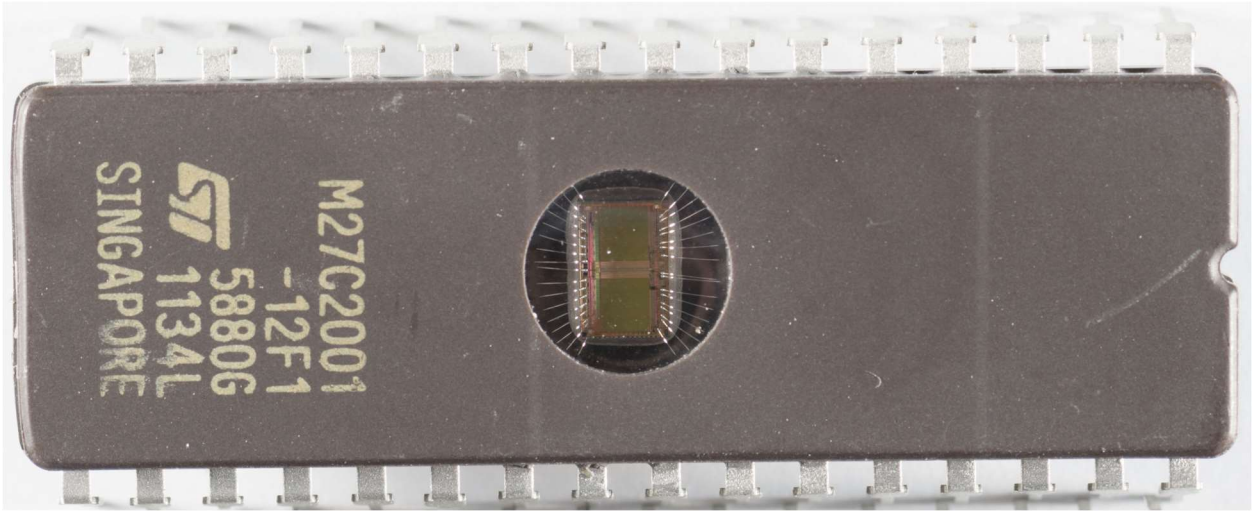
With only 256 Kbytes of RAM, the device cannot store or process digital images of ballots. Scanners of this type are called Optical Mark Recognition (OMR) Scanners. The main CPU is primarily used to control the peripheral devices, analyze ballot data, update memory card totals, and print reports. Information gathered by the ballot reader is transferred to the CPU by means of a high-speed serial input connection. The scanner head controllers do not understand (“parse”) the ballot; they transfer eight bits at a time for a total of ten bytes of data per scan line of both sides combined. From that very limited amount of data, the election software identifies which vote targets on the ballot contain voter marks. In this design, the voting targets are located as cross-sections of the timing marks on the sides of the paper ballot. If the timing marks are off, the voting machine will identify an incorrect location on the paper as the voting target.

This type of voting machine does not use white light to illuminate the paper. The scanning of each timing mark and voting mark position is done using red-orange light-emitting diodes and silicon photodiodes in a special configuration which monitors the diffuse reflectance of the ballot surface. The red-orange emitters are Aluminum Indium Gallium Phosphide (AlInGaP) and have a peak wavelength of 621 nanometers. In a sense this design is intentionally color-blind. Red-orange is invisible and black is black, and all other colors are seen as shades of gray on a red-black scale. This is very similar to looking at objects under sodium-vapor fog light, all you can see is shades of gray in yellow.

Many vulnerabilities involving Diebold legacy voting systems, including the AccuVote-OS, are related to Election Management software called GEMS. New Hampshire does not use GEMS for election results reporting. Election programming for New Hampshire is done by a third-party service company, LHS Associates, located in Salem, NH.



Picture: AVOS circuit board with socketed EPROM chip containing election software. Software upgrades to this machine are installed by physically replacing the chip; the chip is socketed to facilitate that. The chip inside a socket is a SmartWatch CMOS real time clock with an NVRAM controller circuit and an embedded lithium energy source – placing the chip inside of a socket was a common design at the time this board was designed. RAM chips are on the left and the square chip in far left is the MCU.



Picture: EPROM type memory chip without sticker protecting the data on the chip from UV radiation.