What is the 8051 doing in the year 2008 ?

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Introduction:

In 1986, a rather young Reinhard Keil met with an Intel application engineer from America at a trade show in Germany. They spoke and Reinhard offered that he was working on a C compiler for the 8051. In fact, this was to become the world's first C compiler for the 8051. The Intel guy asked him "why are you wasting your time ? The 8051 will soon be dead…we have much better products coming soon. Spend your time on something worthwhile". At that time, Intel had plans to replace the 8051 with the new 16 bit 8096. You might know the 8096 as the "80C196" or as simply the "196".

How incredibly wrong this fellow was. The 196 was a fairly successful family – but is now gone and certainly never managed to replace the 8051. Fortunately, Reinhard ignored his advice and continued on with his work which eventually culminated with the famous Keil C51™ compiler.

Many others have predicted or even proclaimed the demise of the 8051, but this legendary product line continues, even as it is pushing 30 years old. Today, new devices are still being added to the marketplace and Reinhard continues his work on the C51 and his IDE, µVision®3.

The 8051 Industry Reaction:

Depending on who you talk with – the 8051 is either gone, drifting down, steady or mildly increasing. This is a classic case of a multi-sided coin and all the 8051 players have their own perspective of events. There is the issue of what is growing ? Number of chips sold ? Number of new chips introduced ? How many new design wins and where ? US, Asia, Europe ? How many developers currently work with the 8051 ?

These many different views can be explained as a shift in the 8051 market creating new players and marginalizing some of the old ones to the sidelines. The newer 8051 chips are designed from a different perspective. This perspective tends to focus more on the peripherals and the 8051 is used to "drive" or "control" these peripherals. More on this later from Hal Barbour.

The reality is the 8051 performs superbly and economically in many applications. It is the near-perfect part – coupled with plenty of tools, experienced developers and a plethora of existing code to perform the most surprising digital feats…and all from a mere 8 bit architecture.

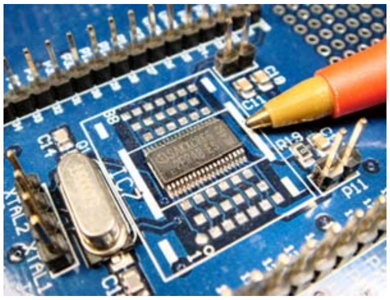


Figure 1: The Infineon C868 and the newer, smaller and more powerful XC866.

Why has the 8051 continued all these years especially now that new powerful 32 bit ARM Cortex™-M3 devices are available for a mere $1? It makes sense that the 8051 would be replaced by these types of devices. 8051 devices would then be found in only a few legacy products. But, 8051s are everywhere !

The 8051 of today is not the same one from the past. It is faster, smaller, has more ROM and RAM (with banking), more data pointers (up to 8) and far fewer cycles per instruction (from 12 to 1 or 2) plus many new peripherals. It can be a chip or gates programmed into a FPGA. The 8051 continues to evolve.

The 8051 is a component of many modern products being manufactured today. That on-off button on your vacuum cleaner might be merely providing an input to an 8051 which in turn is turning on a triac. This allows a cheap on-off switch plus motor control. Or the display lights on your new Cisco router might be controlled by an 8051. This type of list is very long. Your PC keyboard is probably powered by an 8051.

The Development Tools:

Problems in long term support of a given architecture usually happen when development tools become stale or are lost entirely. This happens when active support for devices dies away and is no longer kept up to date. Interest is lacking since many of the players have started in newer, more profitable and more exciting ventures. Engineers and tech support have often moved on to new jobs and their skills and knowledge move with them. Some firms rely on residual sales and do very little or no new development and few activities other than maintaining a website and a series of reps who sell other complementing products.

But the 8051 market is still interesting and profitable for many players. For one, Keil continues with on-going support and product development. This is not likely to end soon. There are other companies that operate in the same fashion. Certainly, there are enough of them to sustain the 8051 tools industry.

It can also be argued that there are more, better and cheaper development tools available today for the 8051 than in the first few years after its birth.

Compilers:

Compilers are the key focus of any microcontroller tools chain. Compilers are first on the purchase list once the chip is selected and everything else follows. Nearly everybody has to buy a compiler. A few might purchase only an assembler and it is doubtful anyone hand codes assembly anymore. Other components such as in-circuit emulators and RTOSs are nice options, but not an absolute necessity.

A premium compiler is important because of the limited resources of the 8051. Code size in particular is important because of the small amount of ROM available. Atmel has a few parts with only 2Kbytes and this can be a tight fit for any project. Banking schemes to increase memory size need to be fast, easy to implement and robust. A good compiler can help you get the appropriate code size and speed balance in your project. RTOS support is tricky because of the limited stack. Keil C51 excels in these aspects and is why it has become the *de facto* standard around the world.

Many compiler companies see the 8051 as steady or very slowly increasing. Keil's 8051 business is substantial and active development work is still being done. There are few (maybe no) bugs in the compiler but Keil engineers are kept busy installing new devices in their Device Database®. At the time of this writing, it is estimated to take a Keil engineer 3 to 4 days to enter all the new 8051 devices and companies from the last few months into the database !

Plus there are always a few companies changing 8051 components such as interrupts, data pointers and the way the stack is implemented. These changes must be accommodated for by the compiler.

Other compiler companies claim to have great and increasing 8051 business but this is difficult to confirm accurately because of competitive secrecy. It is rather easy to make spurious marketing and sales claims.

Figure 2: Keil Development Tools for the 8051. The easiest and most powerful available today.

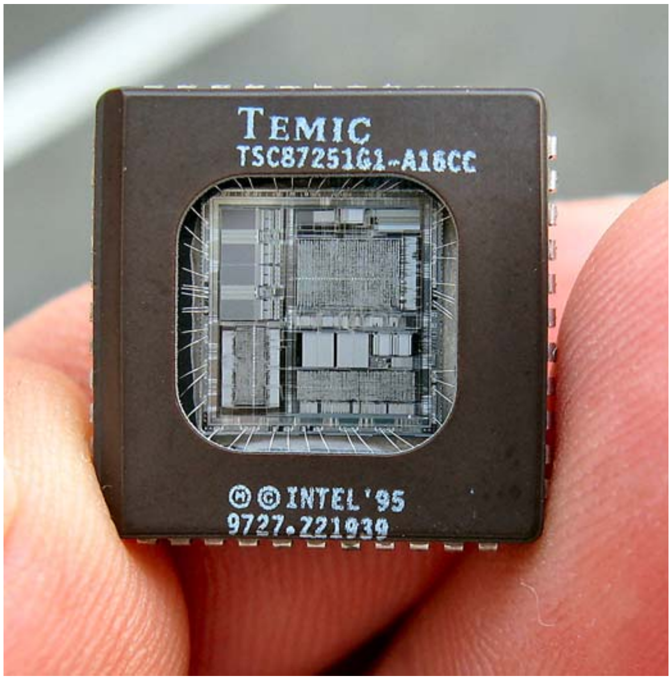


Figure 3: Temic 251. Special development chip with a window to allow erasing the OTP (One Time Programmable) EPROM memory. This chip is exceedingly rare and was tough to procure at the best of times.

In-Circuit Emulators (ICE):

About 10 years ago, emulators were as much a necessary acquisition as the compiler. Since then, In-Circuit Emulator (ICE) companies have seen a drastic decline in sales. ICEs for the 8051 had became very sophisticated and offered advanced features. Today's JTAG based debuggers are generally not able to match their power. ICEs suffered greatly from technology changes in chips. Mainly because of fewer cycles per instruction, increased core speeds and 8051 firms reluctant to supply expensive bond-out chips.

JTAG to USB adapters such as the Keil ULINK®2 are not strictly emulators. They provide the connection between the debugging module inside the production chip with the debugger software running on a PC. You can think of the debugging technology being moved from an external ICE to inside the 8051 chip. Of course, it is impossible to move all the ICE features onto the chip – this would take up too much real estate.

Emulators are sold into two main camps: 1) external address/data bus and 2) single chip applications.

External bus designs are much simpler for emulators to handle. The emulator has access and can manipulate the address, data and control busses using secretive tricks to start, stop and query the processor. Hardware breakpoints are easy to implement and can be unlimited number since emulators use RAM comparators. Software breakpoints are difficult to add to read only memory such as Flash or EPROM.

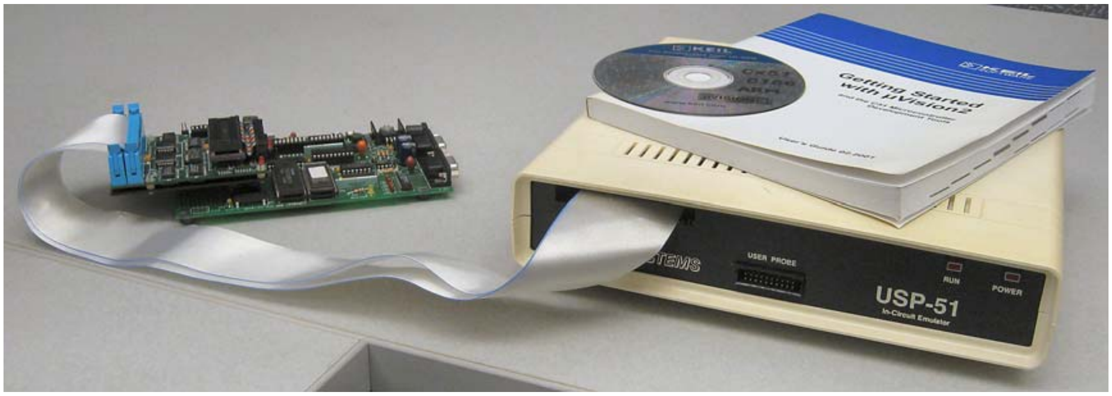


Figure 4: Signum Systems In-Circuit Emulator with OKI probe debugging the Keil 8051 board. Few people work with these anymore: but this technology was vital for the development of the 8051 market.

You can still buy these products but both Keil and Signum (and others) also offer solutions for today's 8051.

Stopping the processor without skidding and reconstructing certain ports and control lines was particularly challenging and took some years to be adequately solved. Skidding refers to not being able to stop the execution of the instruction on which the hardware breakpoint is placed.

Single-chip applications are much harder for Ice's to support. The address and data bus are not visible to the emulator. Hardware breakpoints without special features on the chip are impossible. Software breakpoints are difficult to add to read only memory such as Flash. Access to the inside of the chip must be provided by either special chips called bond-outs or have special debugging modules integrated into every production chip such as "Hooks", OCDS or IP products from FS2 and Signum Systems.

Emulators replace the MCU on the target board with either a bond-out or regular production chip installed on the pod. Bond-outs are notoriously expensive specially designed chips with extra pins connected to internal nodes to provide debugging access. Keeping bond-outs up to date with the latest silicon versions is quite challenging. Getting replacement bond-outs for emulators is becoming a serious problem.

The most common debugging modules used in the 8051 are Hooks and Enhanced Hooks. Their integrated modules use up valuable chip real estate on production chips. These modules are not used in regular operation: only during debugging sessions.

Premium 8051 emulator manufacturers include Signum Systems and Hitex. Nohau was one of the better sellers but not quite as technologically advanced. Good 8051 ICEs cost between $3,500 and $5,500 ten years ago at the height of their popularity…and are still in this price range today ! There are also cheaper and less capable models that some found suitable for their needs.

Probably the biggest problem for ICEs is the introduction of the single or double clock 8051. Original debugging technologies such as Hooks and Enhanced Hooks (licensed by MetaLink) used a debugging module in the MCU that relied on empty cycles on the address/data busses to transfer commands and data in and out to the outside world. That was when the 8051 used 12 cycles per instruction. Modern 8051 designs are now 1 or 2 cycles per instruction with the result there is no space left !

The other serious problem was the increasing speed of the 8051 cores. Emulators started having a difficult time keeping up. This problem occurred in other architectures as well.

Figure 5: Dallas Semiconductor was one of the first companies to offer reduced cycle per instruction parts. We can assume this part was made in the 30th week in 1997. (9730)

ICEs have essentially been replaced by simulators, JTAG based debuggers and monitor programs. Simulators run models of the target part in software and give excellent visibility to the internal registers. JTAG based debuggers access on-chip modules inside a regular production MCU usually via a JTAG port.

These modules sometimes include tracing to various complexity levels. Monitors are small programs residing in the MCUs memory that give access through a port, usually a UART. Some versions use a CAN port. See "Current Advanced Debugging Technology" below.

FS^2 and Signum Systems have modern emulator solutions with on-chip debugging modules. They offer start, stop, hardware breakpoints, PC trace and other options and are quite sophisticated and useful. These modules are designed into the 8051 device by the manufacturer. Keil supports the FS^2 debugging technology with its µVision3 IDE.

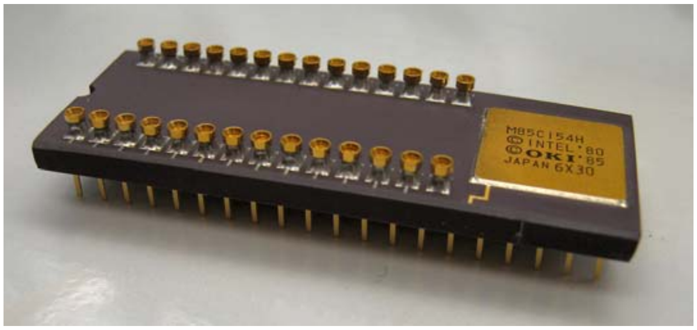


Figure 6: An interesting chip. 8051 from OKI with an EPROM socket on top. This gave access to the address and data busses and some control lines (i.e. CE, PGM & OE). This unusual "feature" was used to full advantage to make in-circuit emulators for many single-chip parts that were otherwise impossible to emulate. OKI inadvertently saved the 8051 emulator industry for a time.

ICE Monopolies:

A further problem is that sometimes an ICE manufacturer would negotiate an exclusive license for a debugging technology from the semiconductor vendor. This encouraged expensive emulators which rarely possessed the latest in debugging technology due to a general lack of competition. There does not appear to be any instances of this anymore. Many OEMs, but not all, publish complete technical descriptions of their debugging solutions. ARM publishes details of its Embedded-ICE™ and CoreSight™ technologies.

Board Manufacturers:

Most of these have seen a dramatic decline in business. Their business opportunities have drastically changed. Since many newer 8051 designs are single-chip and require a new board anyhow: designers merely have their own developed. They do not need to worry about hardware aspects such as connecting memories and peripheral chips and tricky timing issues. Costs working with single-chip designs are dramatically lower than external bus designs. Single chip designs are much easier to implement.

Many board manufacturers have found a better market in 16 and 32 bit architectures where they can better use their advanced skills for these more complicated and value added designs.

One well-known company in the late 1990s had the 8051 represent about 75% of its business with the rest mostly 16 bit and none in 32 bit. Today, the 8051 represents less than 5% of its business (and most of this to a single customer !) with much of the rest going to 32 bit products such as ARM and the PowerPC.

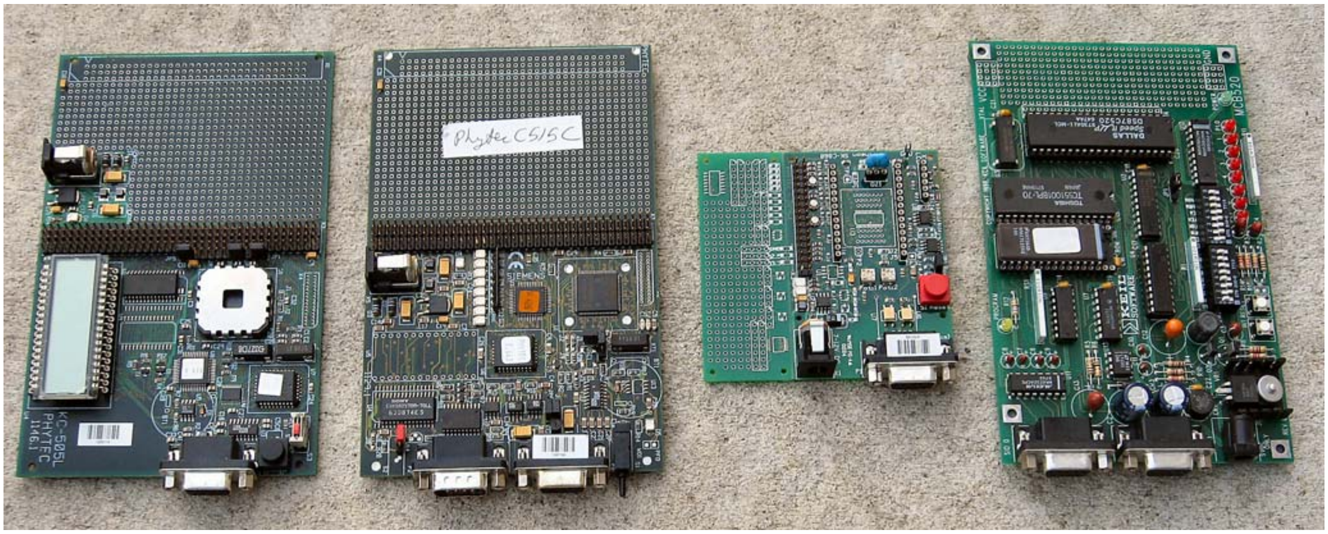


Figure 7: 8051 evaluation boards: – Phytec C505L, C515C, C868 (all Infineon) and Keil 8051

8051 Block diagram

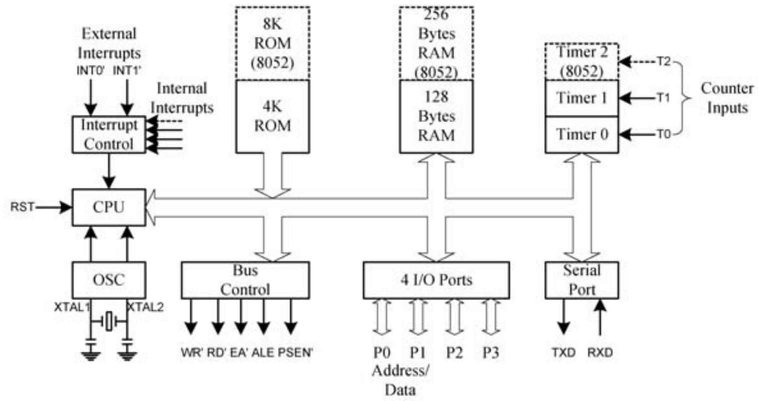


Figure 8: Original 8051 diagram. How many people have studied this diagram since its inception ?

Open Bus Architectures:

The lesson learned in the personal computer is that an open architecture is necessary for success. Competitors will create new accessories and features that will greatly improve the product and ensure a long life. This was true for the Apple II and the IBM PC. This is true for the MCU business as well. Modern 8051 suppliers have created peripherals and improvements never dreamed of in the early days.

Most processors do not have an open architecture and are proprietary. Many of the older patents are expiring with the result more processors are becoming available without royalty payments. The Motorola MC68000 is an example. You can now buy a 68000 soft core from an independent supplier.

Another lesson is that not always will the original architecture designer reap the most benefit. While Intel made a great deal of money on the 8051 and its derivatives, so have others such as Philips and Infineon. Intel could never make the 251, their 16 bit 8051, a success. Temic, however, was much more successful with the 251 and reportedly returned large royalty payments to Intel. Temic is now owned by Atmel and apparently still supplies the 251. Intel no longer sells any 8051 or 251 parts and maintains web pages only for “historical reference purposes”. www.intel.com/design/mcs51.

ARM is trying to duplicate these successes by licensing the common core to many semiconductor manufacturers. The Cortex-M3 and Cortex-M1 processors in particular are aimed at the MCU embedded market. The differential competitive advantages are in the peripherals and a few other things. The CPU core is essentially the same. This makes it easier to switch from one chip to the next. The same skills and the same tools can be used across various silicon vendors. Sound familiar ? Yes, just like the 8051 market.

What about the others ?

What happened to some of the other early chips like the 6502 ? 6800 ? 68000 ? Z80 ? 8080 and so on ?

Many of these chips were actually microprocessors rather than microcontrollers. They required external memory and peripheral chips while microcontrollers (aka MCUs) contained these on-chip in one package. External peripherals and memory could still be used those parts with an external addressing option and most have this capability. Many of these chips are still with us today but in different guises. This is one reason today’s MCU marketplace is so fragmented into so many architectures: none hold more than a 5% share.

The 6502, once the most widely used microprocessor (it powered the Apple II and Commodore PET) has disappeared. However, the 6502, like many of its peers, might still be available disguised as something else. The 8080 grew up to be the powerful Intel Pentium x86 series of microprocessors which are also provided by AMD. The original MC6800 microprocessor from Motorola (now Freescale) has evolved into the MCUs such as the HC11 and the HCS12 series which are still sold today in huge quantities. The original 16/32 bit Motorola MC68000 is still available as the Coldfire.

More importantly, each of these chips had only a single source, or maybe two. The 8051 preceded each of these in the MCU form. It was first. The 8051 had several sources once Intel licensed it and has dramatically grown since to number dozens of firms offering the 8051 in various forms and flavors.

Figure 9: Original MC68000 8 MHz (current M68K chips are the same size as the original die of this part)
ST10R201 bond-out from STMicroelectronics (16 bit), 44 pin S87C51FB from Philips (now NXP)
40 pin Philips 8051, 44 pin 80251 - 16 bit 8051. Chips today are much smaller than these.
The big 8051 is 2 inches long, small chips are almost ¾ inch and the 68000 is 3 ¼ inches and has 64 pins.

Current markets for the 8051:

Hal Barbour, President of CAST, Inc., offers this description of the two types of markets the 8051 is being designed into. These are two interesting categories and there is evidence his descriptions are fairly accurate.

The old 8051 market, with external ROM and RAM and the standard run-of-the-mill peripherals is essentially dead. Single-chip applications are more the norm and can be used with great cost efficiency to run various applications, even for very simple devices with only general purpose I/O.

Dashboard Control for Chips: The 8051 is embedded in a "big" chip with a variety of customizable features. The 8051 core controls these features and passes data in and out of the chip. In these applications Hal says the 8051 is "reliable and low cost". This is good for designs with a few million gates or sophisticated mixed signal designs.

Analog sensing and control chips: On the chip with the 8051 are specialized peripherals designed to accept some analog values. The 8051 decides what to do with this data, such as converting it to a digital value, and where to send it. The 8051 can scale the sensor output to the proper values and make other decisions. Two good examples are a tire pressure indicator and a temperature sensor.

Current Advanced Debugging Technology:

Simulators:

Many current 8051 silicon vendors offer very little or no debugging capabilities. Write, Compile, FLASH, RESET and Run is not the best workable option. This includes connecting LEDs to port pins coupled with software code stubs for instrumentation of the system. Very slow going this way, but is not an unknown method of debugging. It can take an enormous amount of time to develop and debug a project in this manner.

It is cumbersome, error-prone, and slower than accurate simulation or with real silicon containing a debugging solution. Sometimes, this is all you have and is what you must use. This is not recommended by anyone. Developers need to be much more productive than this.

One solution is to develop sophisticated simulators and this is exactly what Keil did with their µVision IDE. This gave the added benefit of high visibility into the chip not possible even with advanced emulators. Code Coverage and Performance Analysis are standard. Program code can be debugged with a simulator and the confidence is very high that the developed code will run properly in the production hardware.

External input signals are readily simulated with C type scripts. Code Coverage and Performance Analysis is available which is normally possible only with advanced hardware ICEs. These are easy tasks for µVision's simulator. Keil simulators are very successful and today are the major design tool for many 8051 "boutique" designs as well as standard projects.

Debugging Modules:

Newer technology moves the debugging technology from inside the emulators to either a software simulator or to a module inside the production chip itself which is usually accessed via the JTAG port.

FS²: First Silicon Solutions provides a two wire debug solution to chip makers. Breakpoints, triggers and device programming are provided. FS2 is now owned by MIPS Technologies.

Triggers can be set-up for a specific address, bank, or data. Code Read, Code Write, Xdata Read, Xdata Write, Idata Read, Idata Write, SFR Read, and SFR Write are all different events that can be triggered individually or in combination. They do not appear to have PC trace (program counter).

NXP utilizes FS2 technology on their LPC952/954 parts. Answers to some frequently asked questions at: www.standardics.nxp.com/support/faq/microcontrollers/lpc900/lpc952/#k

Keil supports the FS2 debugger with µVision3 with the ULINK2 or ULINK-ME for certain NXP LPC900 parts. Please see www.keil.com/pr/article/1142.htm. Also see www.keil.com and search for "LPC952".

Signum Systems: Signum provides a similar solution to chip makers. Two pins are for debug only (no trace) and five more for trace capability. Signum can collect all transactions on IDATA and the SFR space plus PC and XDATA trace...all in real-time. No CPU cycles are stolen. This is very important.

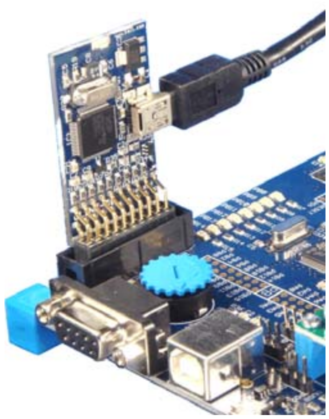
Signum sells the ADM-51 ICE for this technology and it sells for about US$900 and US$1,200 with trace.

For more information visit www.signum.com and search for the ADM-51. The ADM-51 supports Teridian Semiconductor parts. Keil also supports Teridian Semiconductor 8051 parts. A development suite consisting of Keil C51 and Signum Systems ADM-51 is a very powerful and easy to use set of tools.

OCDS: On Chip Debugging Systems: On Chip Debug Support (Infineon)

Originally designed by Infineon (then Siemens) to add a debugging module to their 32 bit TriCore devices. Infineon use this same technology in their 8051 derivatives such as the new XC800 series.

This acronym, or one similar, has become a generic term used by other firms to describe such debugging modules inside a microcontroller to provide various debugging features. Access to this module is usually through the existing JTAG port. Sometimes you will see the terms OCDS Level 1 and Level 2. This refers to standard JTAG debugging and trace respectively.



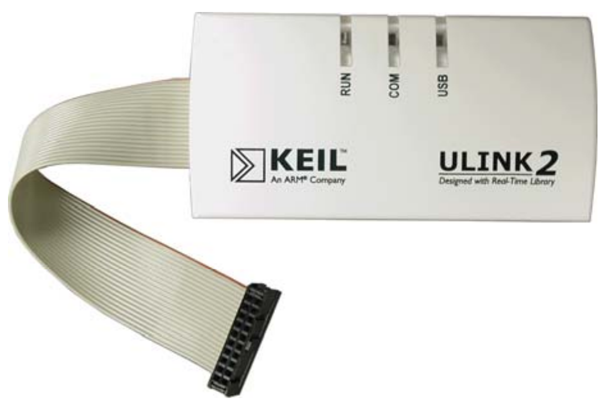


Figure 10: USB to JTAG Adapters: ULINK-ME (left) and ULINK2 (right).
They work with JTAG, Infineon OCDS and FS² as found in NXP processors and are quite flexible.
The ULINK2 can connect to various target connector standards.

Recent 8051 New Device Highlights:

Many companies are currently involved with releasing new 8051 products. Some are not announced yet and as they are released they will be listed on the Keil website www.keil.com. Keil is already working on supporting these types of devices. Some devices are permanently confidential and Keil supports these by special agreements. Here is a small sample of recent announcements.

For the complete list of 8051 devices supported, please go to www.keil.com/c51/chips.asp. This list contains the names of many interesting players in the 8051 market…big and small. You can also find information such as 8051 datasheets, MCU descriptions and various third party suppliers.

Analog Devices: The ADE7000 series of AC power metering devices. These devices all contain a single-cycle 4 MIPS 8052 core to control the various peripherals. See www.analog.com and click on Power Measurements.

The ADuC83x/84x devices feature 1 MIPS 8052 cores with precision (up to 24 bit) ADCs and 12 bit DACs.. They use a single-wire debugger via the UART and this is supported by Keil. For technical information on how this works see www.keil.com/support/man/docs/monadi/

Atmel: Atmel make an impressive line-up of low cost yet powerful 8051 devices to complement their 16 and 32 bit lines. Simulation is a good way to develop with many of these parts. www.atmel.com

Cypress Semiconductor: Keil supports existing and new 8051 products from Cypress. www.cypress.com.

California Eastern Laboratories (CEL): CEL has an interesting ZigBee transceiver chip that is driven with a 8051. ZigBee is a medium range wireless network using DSSS spread spectrum techniques. The ZIC2410 has 96K of internal FLASH and 8K RAM. The Flash uses 8051 banking techniques which is an integral feature of Keil µVision. See www.cel.com and follow CEL ZigBee Solutions for ZIC2410. An eval kit is listed under Technical Information.

Infineon XC878: The XC800 series contains a two cycle 8051 core running up to 26.7 MHz. To add processing power to the 8051, these devices contain a MDU for 16/32 bit multiplication and division and a CORDIC coprocessor for computation of trigonometric, hyperbolic and linear functions.

With 2 Capture/Compare modules, the XC878 series is targeted to the motor control market. CAN controller(s) are standard peripherals. Keil offers full simulation for these parts as well as hardware debugging with the OCDS (On Chip Debugging Support) using the Keil ULINK2. Keil has evaluation boards available. See www.keil.com/pr/article/1125.htm for information on the USCALE kit.

SiLABS C8051F900 Series: These ultra low voltage MCUs run on a 0.9 to 3.6 volt power supply. They contain a 1 or 2 cycle per instruction 8051 with 25 MPIS @ 25 MHz. These parts use OCDS that is supported by the Keil ULINK2. See www.silabs.com.

Evatronix RT8051XC: These cores are mentioned in the section "8051 Cores for purchase" below. Keil supports these with simulation and On-Chip Debug Support with the µVision Debugger. See www.evatronix.pl and click on *Quick Search for Cores.*

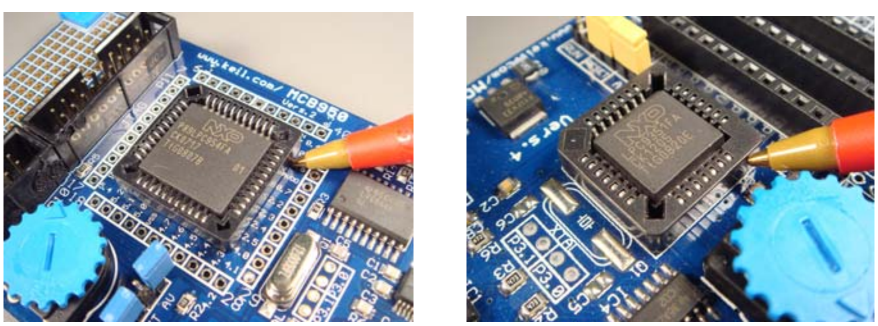


Figure 11: NXP LPC954 and the new LPC9351 in a Keil evaluation board.

NXP LPC900 series: The LPC952/954 use the FS^2 debugging technology as described above. These devices are supported with the Keil ULINK2 or ULINK-ME USB to JTAG adapter and µVision3. See www.keil.com/pr/article/1142.htm. The LPC9351 is a drop-in pin compatible upgraded LPC935.

Teridian Semiconductor: 8051 devices with peripherals and features to make power meters (71M65xx), smart-card devices (73S12xx), circuit breakers (71M640x) and scale controllers (71M8100). www.teridian.com. Teridian uses the Signum Systems ADM51 emulator with real-time trace and debug.

FPGA Soft Cores:

What do you do with these ? Instead of buying an 8051 chip, just get a FPGA and program into it the 8051 core along with the peripherals you need plus other logic your project requires and you now have your own "8051-on-a-chip".

What happens if the supplier of that 8051 chip with the special unique peripheral that you absolutely have to have is discontinued ? Well, this is not a problem. Just get an 8051 soft core plus a model of your special peripheral and program these into a FPGA. Now you have a copy of your discontinued 8051 in a chip ready to go. Here are two companies that do this and there are more:

Actel: Actel has several free 8051 core implementations for use in their FPGA products. They execute most instructions in a single clock cycle. Actel's Core8051 is a standard implementation with two clocks, four ports and a serial interface. Their Core8051s is a stripped down version that enables users to add their own peripherals (such as clocks, ports, serial interfaces, etc) as needed for their specific design.

The Actel OCI debug and trace module is supplied by FS2 and delivered with the cores. See www.actel.com and search for 8051. Actel is moving towards newer designs using the 32 bit ARM Cortex-M1 processor. It is possible to have both 8051 and Cortex-M1 cores in one Actel FPGA and communicating with each other.

Xilinx: Roman-Jones Consulting (www.roman-jones.com/PB8051Microcontroller.htm) offer an inexpensive soft core for Xilinx FPGAs. Software development for this core uses a special version of Keil C51 that operates directly on the 8051 core loaded in the FPGA.

Hitex: Hitex has a development system for the Mentor Graphics M8051EW, Quickchip QUIC_8051 and the Synopsys DW8051 cores. This system comprises of an evaluation board with an Altera Cyclone EP1C12F256C7 FPGA and an emulator. See www.hitex.com and search for SoC51.

You can use the Keil C51 compiler with µVision3 IDE to write your code and the Hitex DProbeHS emulator to load this code into the FPGA and then debug it. The Keil 8051 simulator can also be used in conjunction with the emulator for complete debugging flexibility.

8051 Cores for Purchase: "Roll Your Own"

It is possible to purchase an 8051 core and design your own chip incorporating that new revolutionary peripheral you have invented. This is exactly what many of the companies in the Keil Device Database have done. It can cost about US$25K to $75K to accomplish this if you have a team with the correct engineering skills. More for more complex designs or if you need to contract some of the work out.

These prices are actually quite inexpensive when compared to designing your own CPU core and peripherals. Plus this saves a huge amount of time. To get a mainstream semiconductor manufacturer to build a custom part normally requires sales in the millions of pieces. This is how automotive companies and other large consumers of chips get the exact chips they want.

Here are some sources for IP cores (Intellectual Property). Look above at the section "FPGA Soft Cores".

Evatronix: Evatronix create the RX8051XC soft core in VHDL or Verilog for use in your own chip. It is configurable and it can support either Intel or Siemens peripherals. www.evatronix.pl

For information of Keil support for Evatronix cores see www.keil.com/pr/article/1109.htm

CAST: CAST is a supplier of the Evatronix R8051XC core plus a great deal more. They offer many other cores and functions such as USB, PCIe and JPEG. CAST works with this core closely with developers and has done so for at least ten years. www.cast-inc.com

Mentor Graphics: Mentor Graphics make a two clocks per instruction 8051 core called M8051EW. It can use the FS2 debug module or another if you prefer. See www.mentor.com and search for 8051. Hitex has a development system available for this core. See www.hitex.com and search for SoC51.

Dalton Project: The University of California computer science department has a free 8051 core in VHDL. It has no peripherals yet. Search for "Dalton 8051".

Verilog files: www.opencores.org has a similar free offering but in Verilog. Search for 8051. This project has some peripherals available.

Real life case: Architecture Migration:

This real-life example illustrates some of the troubles with older architectures that are not supported as they were in the past.

An automotive company manufactured a product using the Intel 80C196CA. This is a diagnostic reader for use on heavy duty trucks. It was a success with 10s of thousands sold.

First, the bond-out chip in the emulator died and no replacement was available. They were suddenly unable to debug problems or to add new features. This was required as the vehicles' messages were often modified by the OEMs of truck platforms. Bond-out availability is increasingly becoming a problem for emulators.

They decided to switch to a Motorola Coldfire device. This meant all new tools at great expense. Both a new compiler and a new emulator were needed. This was not to mention the learning curve and porting expense for the new architecture. This too, became a successful product.

About three years later, added required functionality and increased bus loading on the vehicle networks was causing this product to lose a significant number of CAN messages with dire consequences. Then, Freescale announced end-of-life on this particular part. The company decided to switch to a more powerful ARM7™ from NXP. Once again, an entire new tool chain was required with the attendant learning curve and porting expense. They were able to ship once again and healthy sales continue today.

Had they used an 8051 chip, the same tool set, code reuse and learning curve reduction would have saved much time and money as various parts were withdrawn from the market. A fast 8051 has enough processing power available for this product, albeit barely.

The good news is that now that they are in the ARM processor family, the same tool chain will function for years to come as new ARM devices are released. Additionally since the ARM processors have power to spare: new features and modifications to the software are relatively easy to add. ARM processors will be available for many decades since there are a large number of sources.

A second example:

Another company used a 196 in their specialty or boutique product. They sold only a few dozen a year in residual mode after an initial sales quantity of several thousand per year for about 4 years. This 196 derivative was discontinued and they either must get them from the gray market (can be dangerous for reliability) or redesign for another part.

They do not sell enough product to justify a major redesign. The original software developer has moved on to other things and is not interested in this assignment. They are not sure what they are going to ultimately do once their supply of 196 parts run out.

If they had used an 8051, they would not be facing such problems today. Interestingly, when they originally designed this product many years ago, they deemed the 8051 too short-lived and with insufficient power to allow for future upgrades to their product. A contemporary 8051, with its increased power would have no trouble running this product. But back then, they could not have known this.

8051 and ARM: Will history repeat itself ?

The continued success of the 8051 is largely the result of four significant factors:

1. The number of companies licensing the core with new peripherals.
2. The number of tools companies still maintaining and updating their products.
3. The large number of 8051 aware engineers, both hardware and software.
4. The large amount of existing 8051 software that can be reused. Some is in the public domain.

Semiconductor companies, of all sizes, provide this common, familiar 8051 core that customers feel comfortable with. Therefore, the 8051 will be around for many years to come.

ARM, with its ARM7™, ARM9™, ARM11™ and now with the new Cortex-M3 which plugs directly into the embedded MCU market, is poised to repeat what the 8051 did. The Cortex-M1 is available for FPGA designs and there are a few more yet-to-be-announced devices. Semiconductor companies, of all sizes, provide this common, familiar ARM core that customers feel comfortable with…but with an improved architecture, much faster 32 bit operation and lower power consumption. Luminary Micro has at least one Cortex-M3 for under $1.

Essential to this is the existence of a large number of development tools for ARM devices available that have active engineering resources dedicated. Dead, out-of-date and obsolete tools are deadly to maturing microprocessor architectures. Serious developers are usually unable to choose a architecture if it does not have a viable tool chain.

Other architectures abound, each with a small portion of the fragmented MCU market. This makes them vulnerable to many of the problems discussed in this paper. It is harder for developers to switch to another to gain new technology or the best fit peripheral set. At one time, this could be used by a silicon vendor to "handcuff" developers to a particular chip family – but today's marketplace expects more flexibility than this. This is why they migrate towards a common architecture such as the 8051.

Conclusions

The last item is developers must have confidence that an architecture will be available for many years in order to commit their designs. Many of those I have spoken with are somewhat surprised the 8051 has lasted so long but are glad for this and expect the 8051 to have a healthy life for many more years.

However, the 8051 standard product line-up may diminish as the years pass. The total number of 8051 parts may diminish. The famous Intel 8051RA, RB and RC microcontrollers from 1995 are long gone. Others have taken their place. Specialty products such as the ones described in this paper are bound to stay indefinitely as are the tools for them. As mentioned before, at the time of this writing Keil is adding even more new 8051 devices to their database.

Some projects might get upgraded to bigger 32 bit MCUs to allow for new features in a product or faster operation, but there will always be a market for many 8051 derivatives.

Check back to www.keil.com periodically for the latest developments in the 8051 world and an updated version of this document.

Robert Boys

ARM
Autumn, 2008

Who helped with this document ?

Here are the main players who helped me: Reinhard Keil, Jon Ward (ARM), Jerry Lewandowski (Signum Systems), Hal Barbour (CAST, Inc.), Mike Copeland (Infineon) and Axel Wolf (NXP).

I have not forgotten all the other engineers who over the years have taught me quite interesting things about this embedded market…including their 8051 secrets !