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Implementing Embedded Systems with a MicroBlaze processor using Low-Cost Spartan-3 FPGAs

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Agenda

- Low Cost Embedded Solution

- 1 FPGA-based Processing Solutions solve Critical Embedded Challenges
- 2 Getting Started with Low Cost Embedded Solutions is Easy
- 3 Hardware Design Flow
- 4 Software Development Flow
- 5 Linux eases Embedded Software Development
- 6 Powerful Techniques for Optimizing Embedded System Performance

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1

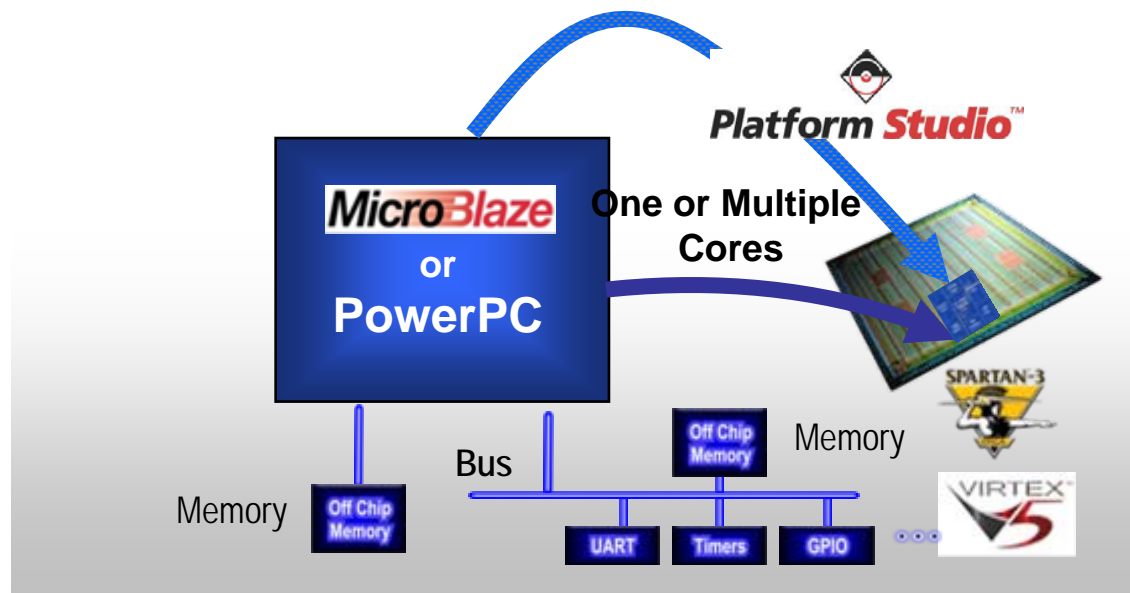
FPGA-Based Processing Solutions Solve Critical Embedded Challenges

Embedded System Challenges

	Critical Embedded System Needs	Solution Requirement
✓	Want a tightly integrated system that reduces overall System Cost	Low cost platform that can integrate the processor, peripherals & glue logic
✓	Want processor system that's a fit to the target application	Flexible processing solution with mix of standard or custom peripherals
✓	Want a solution that can be changed rapidly during the product life cycle	Configurable platform that can be modified even while in the field
✓	Want to minimize inventory of off-the-shelf (OTS) parts for each project	One type of device (e.g. FPGA) that can be used across many projects
✓	Want a solution that will not become obsolete necessitating software rewrite	Common processor system architecture for software re-use

Configurable Embedded Processing

Flexibility-Differentiation-Price/Performance




Choose Processor (Flexibility)

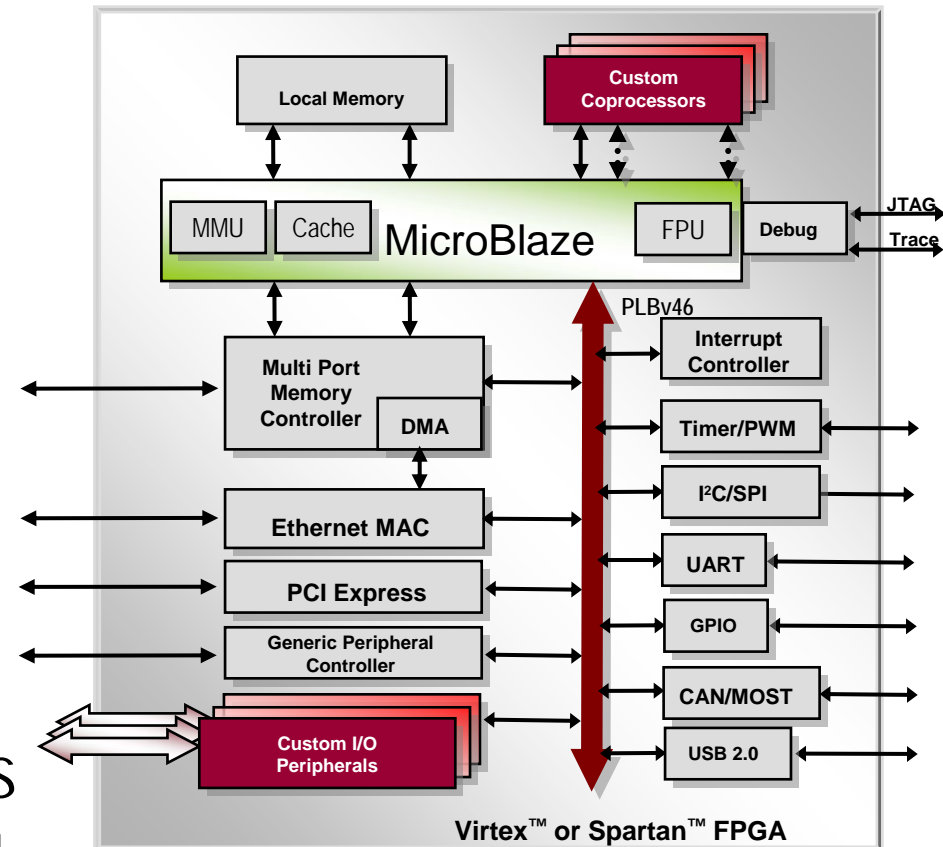
Customize System (Differentiation)

Choose Silicon (Price/Performance)

Processing System Tailored for Target Applications

Flexible System Architecture

- Customizable Processor Architecture
 - Pipeline, Instructions
 - Caches, Floating Point Unit
 - Memory Management Unit 
 - **User-defined Coprocessors**
- Selectable I/O Interfaces
 - Ethernet, PCI
 - Uart, SPI, I2C, GPIO
 - **User-defined Peripherals**
- Adaptable Memory Interfaces
 - DDR, DDR2, SDRAM, Flash, SRAM



Flexible Device Selection for Lowest System Cost

Spartan-3 Platforms	3	3E	3A	3AN	3A DSP
	<i>High Density</i>	<i>Logic</i>	<i>I/Os</i>	<i>Non-Volatile</i>	<i>DSP</i>
Logic					
I/Os					
Security					
Power Management					
Embedded Processor					
DSP Capabilities					
On-chip RAM					
Flash Memory					
<i>Production</i>	<i>NOW!</i>	<i>NOW!</i>	<i>NOW!</i>	<i>NOW!</i>	<i>NOW!</i>
Starter Kit Available	<i>YES</i>	<i>YES</i>	<i>YES</i>	<i>YES</i>	<i>YES</i>

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2

Getting Started with Low Cost Embedded Solutions is Easy

As easy as... 1).... 2).... 3)....

Getting Started with MicroBlaze

MicroBlaze Embedded Development Kit

Spartan-3AD 1800A Edition

- Spartan-3AD 1800A Development Board
- EDK and ISE software tool suites
- MicroBlaze v7 Reference Design
- BlueCat Linux Image
- JTAG Probe (USB/PC4), Power Supply
- FLASH device, Ethernet & Serial Cables
- Documentation
- Available Now
- Promotional Price - \$395
 - Regular price - \$595

MicroBlaze Embedded Development Kit
Spartan-3AD 1800A Edition

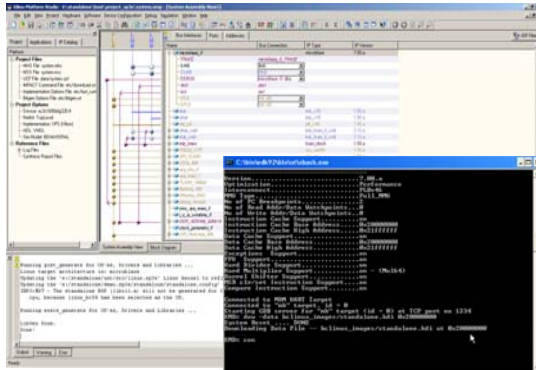


http://www.xilinx.com/products/devboards/emb_devkits.htm

Getting Started...

1

Setup the Tools



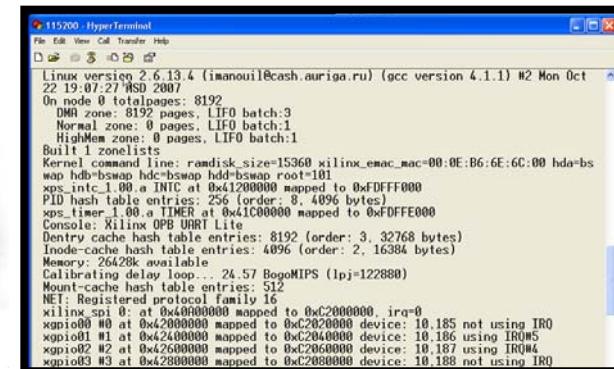
2

Connect the Board



3

Download & Run Software



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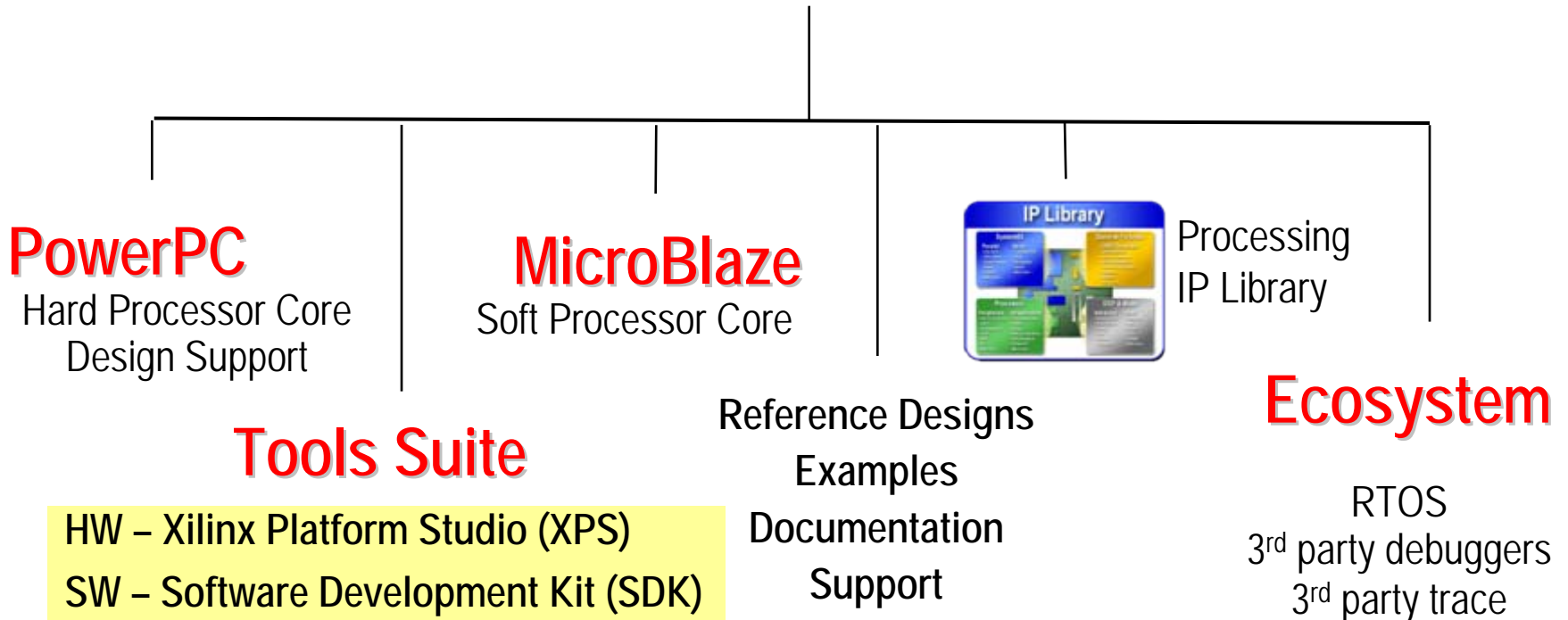


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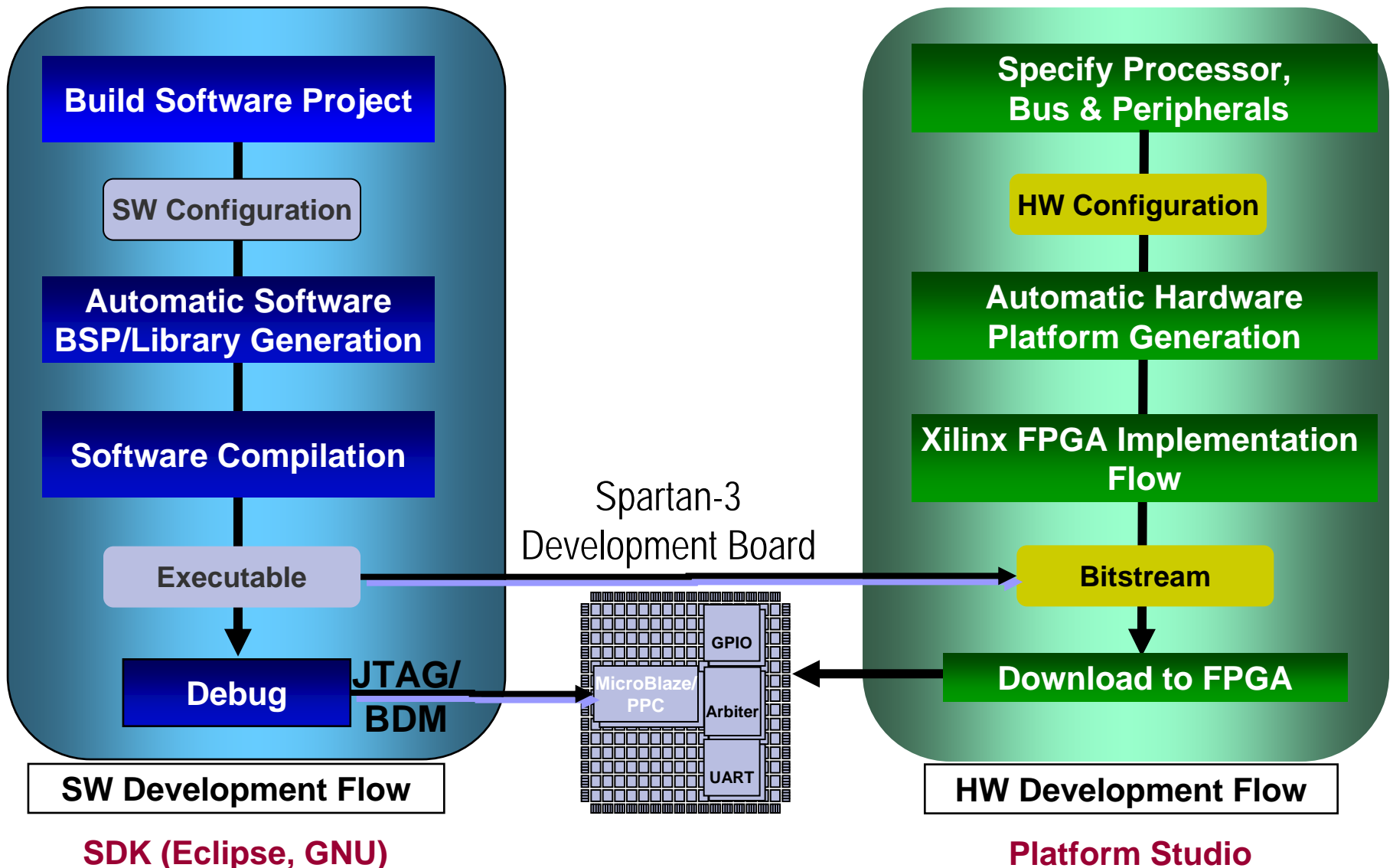
Creating & Configuring a Custom Embedded System *Hardware Design Flow*

Embedded Design Solution

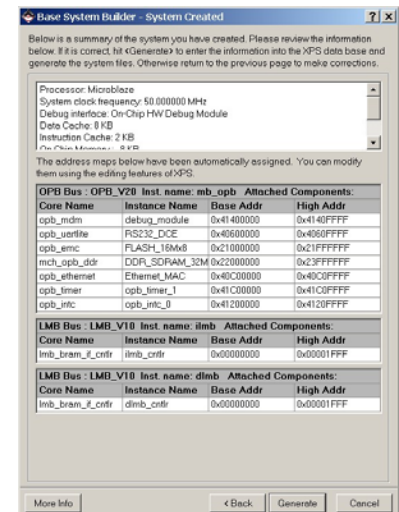
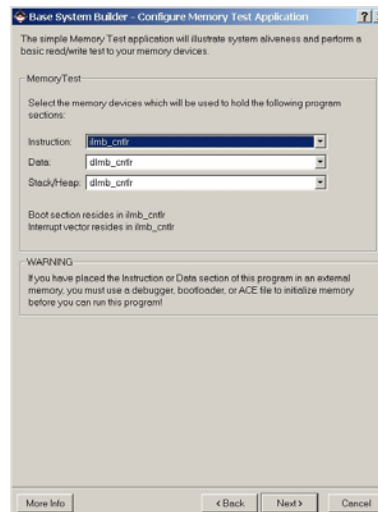
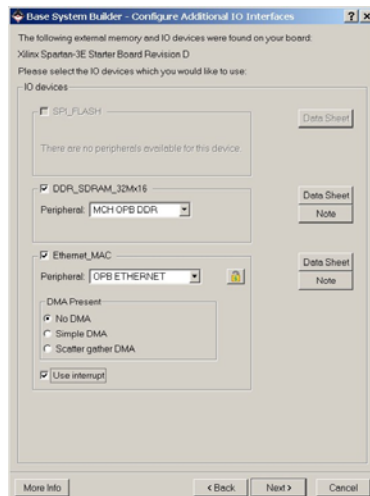
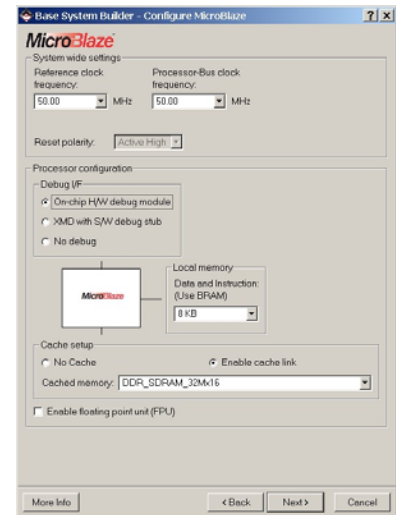
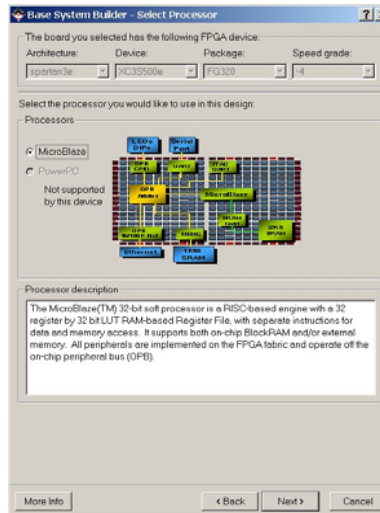
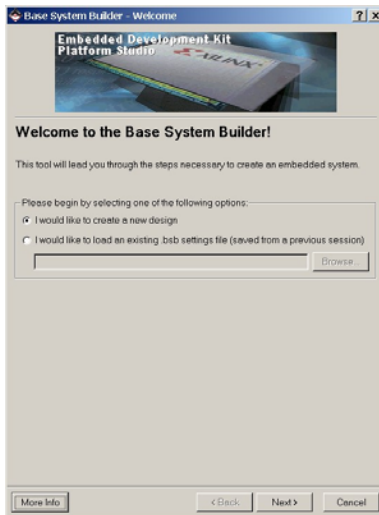
Embedded Development Kit (EDK)



Hardware/Software Design Flow



Wizard-based System Creation



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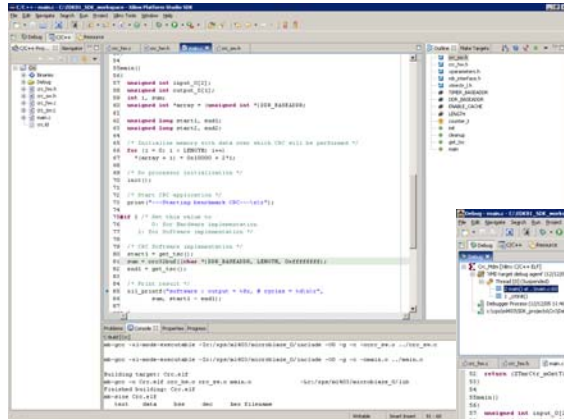
4

Creating and Debugging Software Applications with Eclipse IDE ***Software Development Flow***

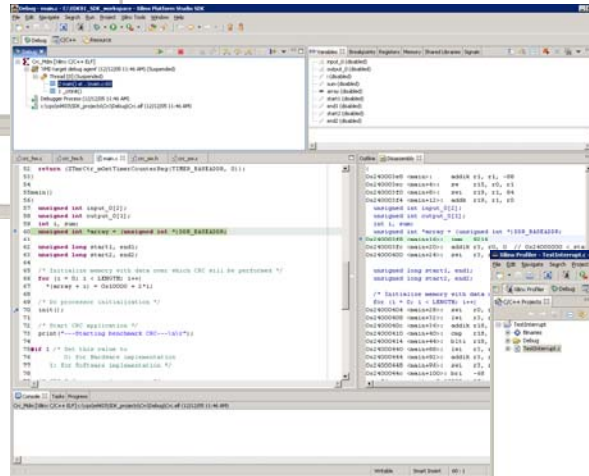
Xilinx Platform Studio SDK

Eclipse IDE with GNU tools

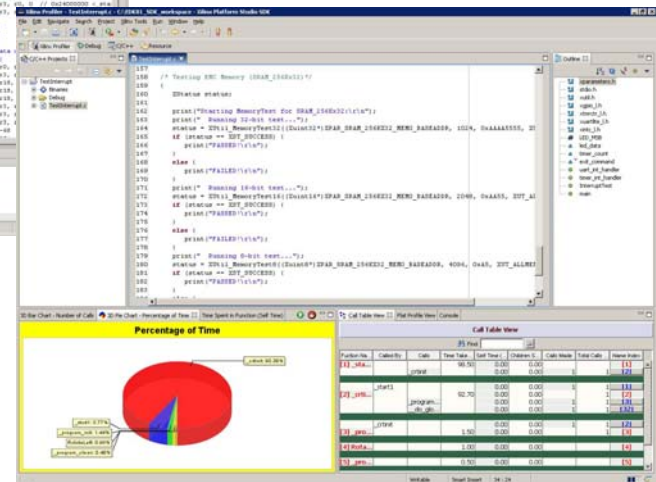
Compiling 'C' code with GCC



Debugging with GDB



Profiling with Gprof



- Supports MicroBlaze & PowerPC 405/440 processors
- Supports JTAG-based On-Chip Debugging (*BDM*)

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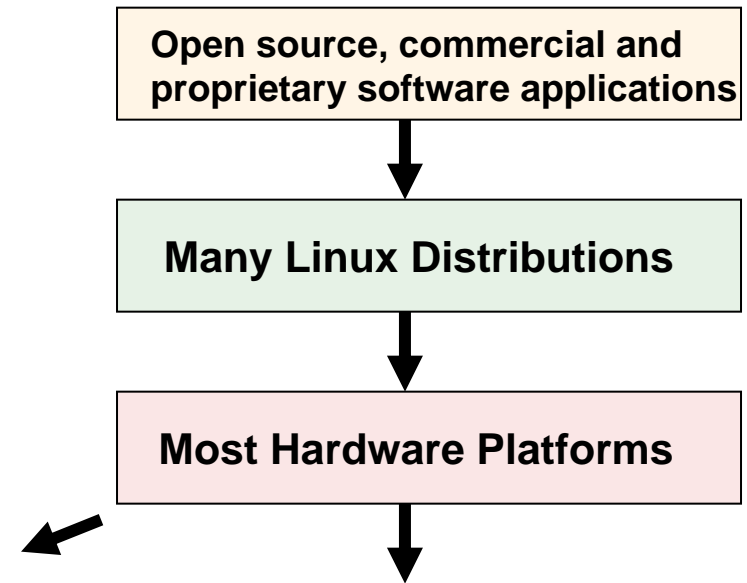


5

Linux eases Embedded Software Development

Embedded Linux

- Ubiquitous Software Platform
 - Wide range of applications
 - Easily portable and reusable
- Runs on a wide range of Hardware platforms
- State of the Art networking
- Open Interfaces
 - POSIX, SysV, BSD
- Very Reliable
 - Protected address spaces
- FREE!!!!



Linux and Real-Time

- Linux is a general purpose, not real-time OS (RTOS)
- Embedded vendors offered real-time enhancements, often in mutually incompatible ways
- Linux 2.6 provides significant real-time performance enhancement
 - A single real-time solution, minimizes forking, maintain interoperability

Linux 2.6 Key Features

- More “real-time” performance
 - More Kernel Pre-emption Points
 - New Scheduler
 - Synchronization
 - NUMA (Non-Uniform Memory Access)
- More embedded infrastructure
 - Subarchitecture (makes porting easier)
 - Headless configuration
 - Virtual memory not required (demand paging)
 - POSIX threads, signals, timers
 - uClinux (MMU-less processors)
 - Device Support (goodies for consumer electronics)

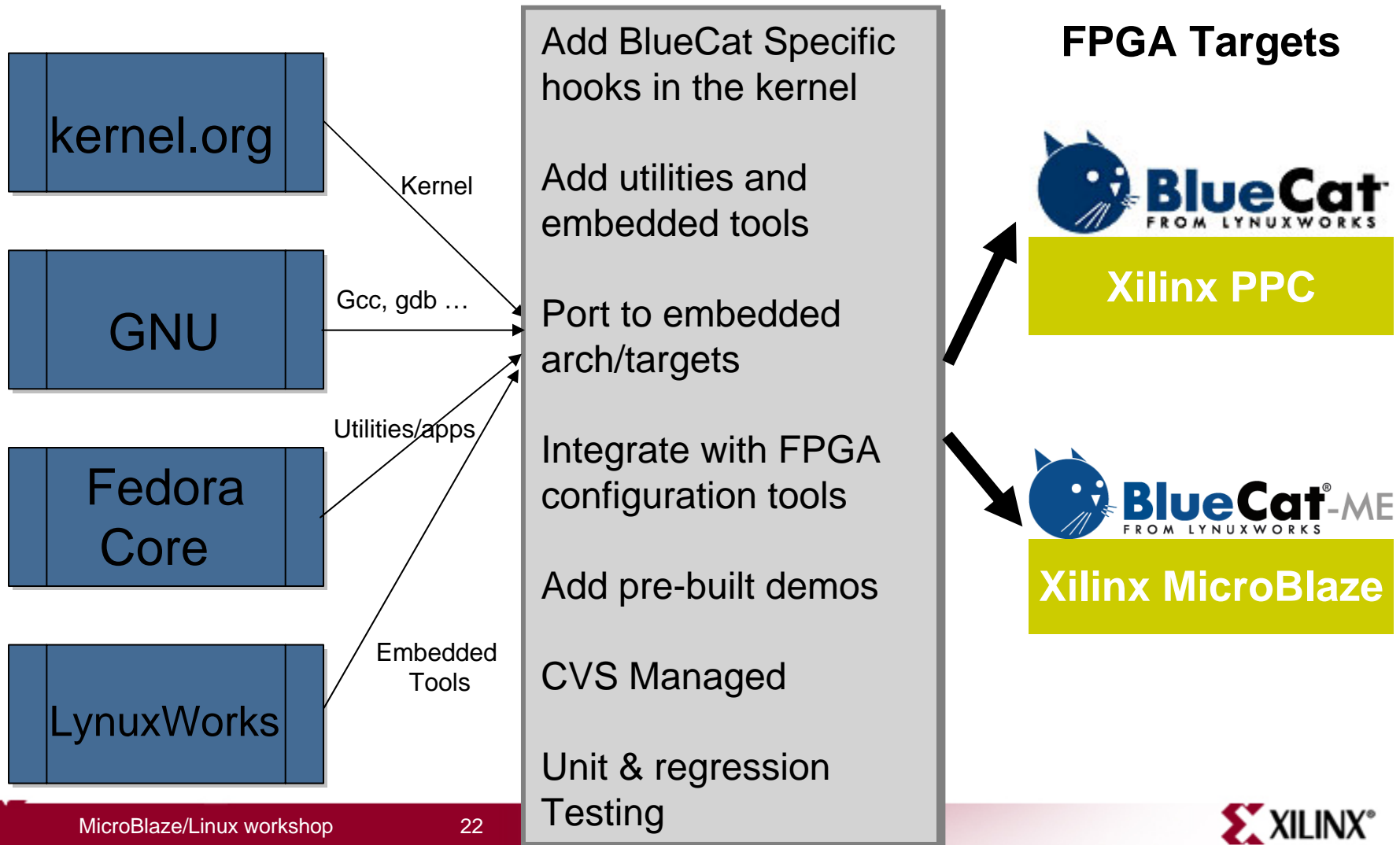
Linux 2.6: A Breakthrough for Embedded Systems
<http://www.linuxdevices.com/articles/AT7751365763.html>

Migration of Software Applications

- Migration from traditional CPU based systems to processor based FPGAs is becoming easier for software developers
 - Linux programming API is the same
 - Linux kernel is the same
 - MMU is now available on both Xilinx processors
 - Industry standard GNU tools
 - Eclipse based development environment
 - Easy configuration of Linux from Xilinx EDK

BlueCat Linux

for FPGA-based Embedded Processors



Linux BSP Generation

The screenshot shows the Xilinx Platform Studio interface with the 'Software Platform Settings' dialog box open. The 'Processor Instance' is set to 'microblaze_0'. Under 'Processor Settings', the 'CPU Driver' is 'cpu' and the 'CPU Driver Version' is '1.11.a'. A table lists processor parameters for 'microblaze_0':

Name	Current Value	Default Value	Type	Description
CORE_CLOCK_FREQ_HZ	100000000	100000000	int	Core Clock Frequency in Hz
xmdstub_peripheral	none	none	peripheral_instance	Debug peripheral to be used with xmdstub
extra_compiler_flags	-g	-g	string	Extra compiler flags used in BSP and library generation
archiver	mb-ar	mb-ar	string	Archiver used to archive libraries for both BSP generation and library generation
compiler	mb-gcc	mb-gcc	string	Compiler used to compile both BSP/Libraries and user applications

Under 'OS & Library Settings', the 'OS' is set to 'linux_bc54' and the 'Version' is '1.00.a'. A button labeled 'Generate Linux BSP for BlueCat Linux 5.4.x' is visible. A callout box with an arrow pointing to the OS dropdown contains the text: 'BlueCat Linux Specified as OS In Xilinx EDK'. The dialog also includes 'Use', 'Library', 'Version', and 'Description' columns for a table, and 'OK', 'Cancel', and 'Help' buttons at the bottom.

Linux BSP Generation (contd)

The screenshot shows the Xilinx Platform Studio interface. The 'Software Platform Settings' dialog box is open, showing the configuration for the 'linux_bc54' OS. The 'OS and Libraries' tab is selected, and the 'Drivers' section is expanded to show the configuration for 'linux_bc54'. A callout box with an arrow points to the configuration table, stating 'Configuration for BlueCat Linux specified in Xilinx EDK'.

Name	Current Value	Default Value	Type	Description
BLUECAT_PREFIX	/usr/eLinux/build/standalone		string	Path to the BlueC
KERNEL_CONFIG	/usr/eLinux/build/standalone/demo/standalone/developer.config		string	BlueCat Linux 5.4

Linux BSP Generation (contd)

The screenshot displays the Xilinx Platform Studio interface. The top window shows the 'System Assembly View' with a table of components and their bus connections. The bottom window shows the 'Output' console with the following text:

```
Running post_generate for OS'es, Drivers and Libraries ...  
Linux target architecture is: microblaze  
Updating the 'e:/standalone/usr/src/linux.sp3e' Linux kernel to reflect the design  
Updating the 'e:/standalone/demo.sp3e/standalone/standalone.config' kernel configuration file to reflect the design  
INFO:MDT - The standalone BSP (libxil.a) will not be generated for the processor  
cpu, because linux_bc54 has been selected as the OS.  
  
Running execs_generate for OS'es, Drivers and Libraries ...  
  
LibGen Done.  
Done!
```

An arrow points from the text 'Libraries for Linux Generated in the Xilinx EDK' to the 'Done!' message in the output console.

Name	Bus Connection	IP Type	IP Version
microblaze_0		microblaze	7.00.a
TRACE	microblaze_0_TRACE		
ILMB	ilmb		
DLMB	dilmb		
DEBUG	microblaze_0_dbq		
dxcl	dxcl		
ixcl	ixcl		
IPLB	mb_plb		
DPLB	mb_plb		
ilmb	lmb_v10	lmb_v10	1.00.a
dilmb	lmb_v10	lmb_v10	1.00.a
mb_plb	plb_v46	plb_v46	1.00.a
dilmb_cntrl	lmb_bram_if_cntrl	lmb_bram_if_cntrl	2.10.a
ilmb_cntrl	lmb_bram_if_cntrl	lmb_bram_if_cntrl	2.10.a
lmb_bram	bram_block	bram_block	1.00.a
RS232_DTE	xps_uartlite	xps_uartlite	1.00.a
SPI_FLASH	xps_spi	xps_spi	1.00.a
LEDs_8Bit	xps_gpio	xps_gpio	1.00.a
xps_intc_0	xps_intc	xps_intc	1.00.a
xps_timer_1	xps_timer	xps_timer	1.00.a
FLASH_16Mx8	xps_mch_emc	xps_mch_emc	1.00.a
Buttons_3Bit	xps_gpio	xps_gpio	1.00.a
Ethernet_MAC	xps_ethernetlite	xps_ethernetlite	1.00.a
debug_module	mdm	mdm	1.00.a
proc_sys_reset_0	proc_sys_reset	proc_sys_reset	2.00.a
l_o_io_combine_0	l_o_io_combine	l_o_io_combine	1.00.a
DDR_SDRAM_32Mx16	mPMC	mPMC	3.00.a
clock_generator_0	clock_generator	clock_generator	1.00.a
DIP_Switches_4Bit	xps_gpio	xps_gpio	1.00.a

**Libraries for Linux
Generated in the Xilinx EDK**

BlueCat-ME Linux IP Cores Support

- BlueCat Supports Following Devices
 - UARTLite
 - 16550 UART
 - Linear Flash
 - Ethernet-Lite
 - SPI Flash and Parallel Flash
 - Timer
 - INTC
 - MPMC
 - GPIO Devices
- BlueCat Linux for MB7 Features
 - MMU Support
 - Shared Libraries
 - Separated memory space for each user process
 - Dynamic page swapping

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Powerful Techniques for Optimizing Embedded System Performance

When more software performance is required

- Option 1: Optimize the software
 - Limited return for time spent if good coding practices were used originally
- Option 2: Optimize the compiler
 - Open source GNU compilers
- Option 3: Configure the OS
 - Allocate more time to processes that require them
 - Still limited to determinism of Linux Kernel

25% to 50% Performance Increase

When more software performance is required

- Option 4: Customize MicroBlaze processor
 - Add Floating Point, Barrel Shifter
 - Modify Caches
- Option 5: Customize System Architecture
 - Free processors and configurable hardware make this an appealing option
- Option 6: Move S/W algorithms into hardware fabric
 - Easily programmable hardware makes this a feasible option that is not usually available
 - Performance gains are huge

2X to 40X Performance Increase

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How do I get Started ?

Getting Started with MicroBlaze & Linux

MicroBlaze Embedded Development Kit Spartan-3AD 1800A Edition

- Spartan-3AD 1800A Development Board
- EDK and ISE software tool suites
- MicroBlaze v7 Reference Design
- BlueCat Linux Image
- JTAG Probe (USB/PC4), Power Supply
- FLASH device, Ethernet & Serial Cables
- Documentation
- Available Now
- Promotional Price - \$395
 - Regular price - \$595

*MicroBlaze Embedded Development Kit
Spartan-3AD 1800A Edition*



LYNXWORKS™

Open. Reliable. Safe. Secure.

BlueCat-ME Linux for Xilinx MicroBlaze

http://www.xilinx.com/products/devboards/emb_devkits.htm

BlueCat Linux for MicroBlaze

Availability

- Demo version
- Evaluation version
- Fully Supported version
- GPL version

The screenshot shows the LynxWorks website page for BlueCat Linux and LynxOS RTOS for Xilinx Reference Platforms. The page includes the LynxWorks logo, a navigation menu with 'CORPORATE' and 'ALLIANCES', and a main heading: 'MicroBlaze 6, MicroBlaze 7 and PowerPC: BlueCat Embedded Linux and LynxOS RTOS for Xilinx Reference Platforms'. The text describes the availability of BlueCat Linux and LynxOS RTOS for Xilinx EDKs, highlighting support for real-time systems and the Xilinx Virtex-4 FPGA. It also mentions the Xilinx MicroBlaze and PowerPC EDKs, the Eclipse-based Luminosity IDE, and training on developing embedded systems. A table at the bottom provides a summary of supported platforms and versions.

POWERPC	BlueCat	LynxOS	LynxOS-178
PowerPC 405			
Xilinx Virtex-4 ML403 Embedded Platform	5.4	4.2 (coming soon)	
Xilinx Virtex-4 ML405 Embedded Platform	5.4		
Xilinx Virtex-4 ML410 Embedded Platform	5.4		
MICROBLAZE	BlueCat	LynxOS	LynxOS-178
MicroBlaze 6			
Xilinx Spartan-3E 1600E MicroBlaze Development Kit	ME 5.4.1		
Xilinx Virtex-4 ML401 Evaluation Platform	ME 5.4.1		
MicroBlaze 7			

<http://www.lynuxworks.com/board-support/xilinx.php>

Summary

- Configurable Embedded Processing Solutions
 - Integration, Flexibility & Non-obsolescence
 - Optimal System Performance
- FPGA-based Embedded System Design
 - Hardware Design Flow
 - Quick Wizard-based System Creation
 - Standard FPGA design flow
 - Software Development Flow
 - Industry-standard Eclipse IDE for 'C' programming
 - Comprehensive Driver support and automatic-BSP generation
- Embedded Linux
 - Ubiquitous Open Software Platform
 - Wide range of Applications, Libraries and Drivers
- Getting Started Quickly
 - Low Cost MicroBlaze-Linux Development Kit

References

- Processor Central
 - <http://www.xilinx.com/processor>
- Newsletters, Appnotes, Whitepapers and other resources
 - http://www.xilinx.com/products/design_resources/proc_central/resource/proc_central_resources.htm
- Forums
 - <http://forums.xilinx.com/>
- Embedded Magazine
 - <http://www.xilinx.com/publications/magazines/index.htm>
- Embedded Ecosystem Partners
 - <http://www.xilinx.com/ise/embedded/epartners/listing.htm>
- LynuxWorks BlueCat Linux
 - <http://www.lynuxworks.com/board-support/xilinx.php>

Xilinx Services

Finish Faster

Xilinx Productivity Advantage (XPA)

Bundled starter solutions

Includes: SW, IP, Boards
& Education Credits

3 Special Offers



Xilinx Education

Targeted courses and tracks

Delivered by experts

Knowledge on demand

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References

Integrated ISE Design Suite 10.1

