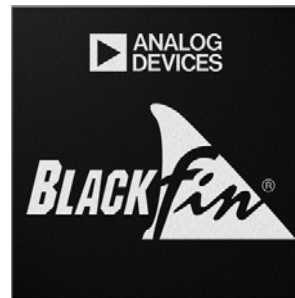


The World Leader in High Performance Signal Processing Solutions



DSP Primer & Considerations

Фoрyм DEDF'2009 Minsk

Johannes Horvath
TBDM EU,EEU,RUSSIA



Example DSP Applications....

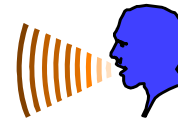
COMMUNICATIONS

- Echo Cancellation
- Digital PBXs
- Line Repeaters
- Modems
- Global Positioning
- Sound/Modem/Fax Cards
- Cellular Phones
- Speaker Phones
- Video Conferencing
- ATMs
- Wireless Local Loop
- Private Data Comms Systems

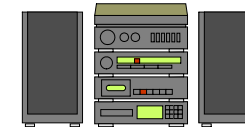


VOICE/SPEECH

- Speech Recognition
- Speech Processing/Vocoding
- Speech Enhancement
- Text-to-Speech
- Voice Mail



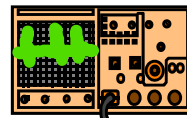
PRO-AUDIO



- AV Editing
- Digital Mixers
- Home Theater
- Pro Audio

INSTRUMENTATION

- Spectrum Analyzers
- Seismic Processors
- Digital Oscilloscopes
- Mass Spectrometers



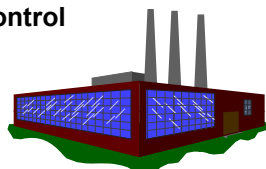
CONSUMER

- Radar Detectors
- Power Tools
- Digital Audio / TV
- Music Synthesizers
- Toys / Games
- Answering Machines
- Digital Speakers



INDUSTRIAL/CONTROL

- Robotics
- Numeric Control
- Power Line Monitors
- Motor/Servo Control



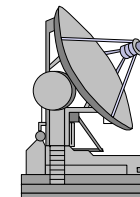
MEDICAL

- Patient Monitoring
- Ultrasound Equipment
- Diagnostic Tools
- Fetal Monitors
- Life Support Systems
- Image Enhancement

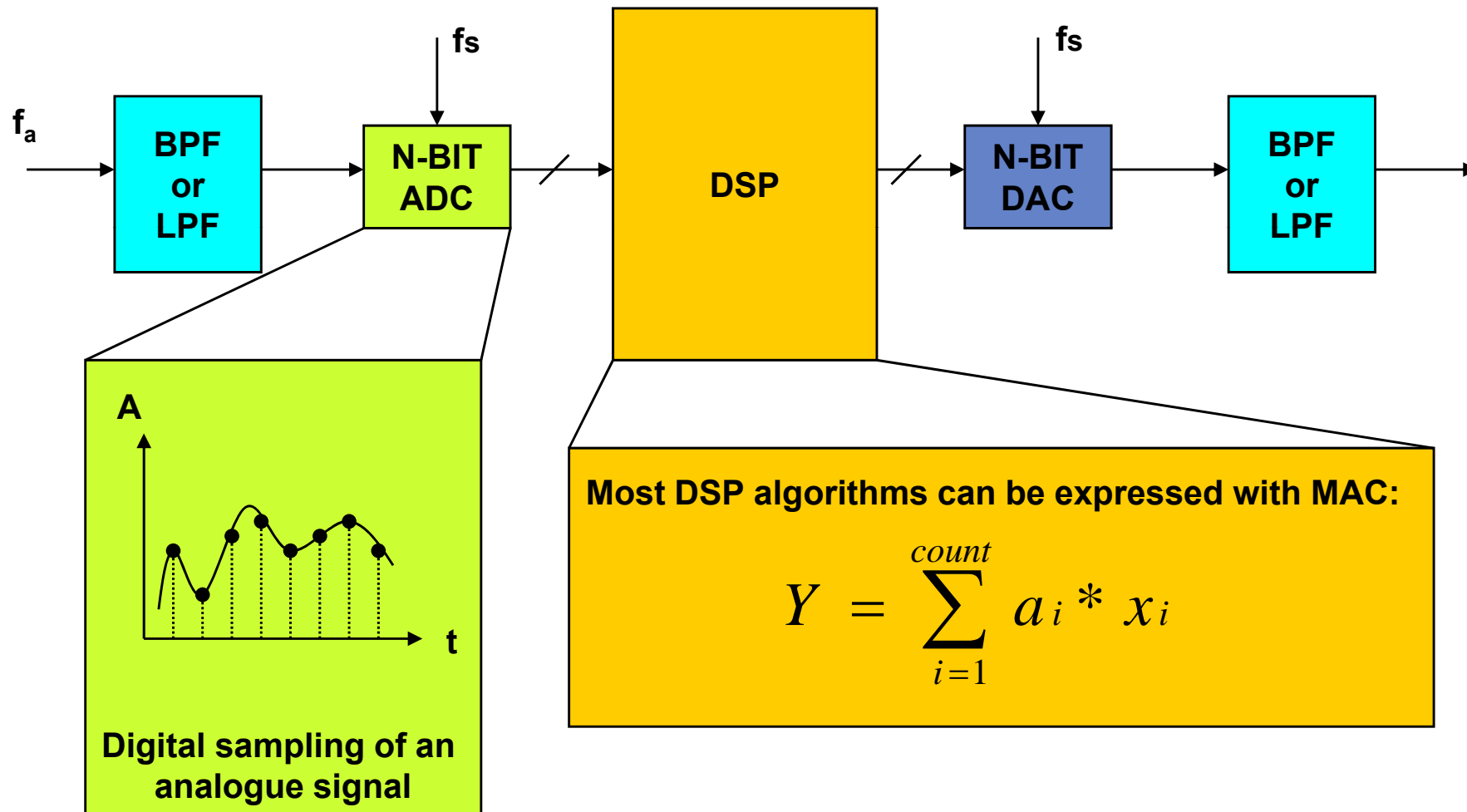


MILITARY

- Secure Communications
- Sonar Processing
- Image Processing
- Radar Processing
- Navigation, Guidance



Traditional DSP Signal Chain





Anatomy of a DSP

- ◆ **Fixed point and/or floating point math and computes in a single cycle**
 - Multipliers, ALUs, shifters
 - Optional special instructions for tasks related to communications, video, etc.
- ◆ **Multiple core resources to access data**
 - Many data and address registers
 - Large accumulator registers to hold the results
- ◆ **High frequency operation is important but these features also are typical**
 - Multiple operations can be done each core cycle
 - ◆ Computes, data accesses, and address updates
 - Deeper pipeline good for higher speed but unfriendly to change of flow
 - Zero overhead looping
 - DSP addressing for circular buffers and FFT bit reversal
- ◆ **Fast and deterministic interrupt service routines**
 - High speed peripherals, timers and real-time budget drive requirements
- ◆ **DMA controller to move data while the processor does other work**
- ◆ **Memory**
 - Single cycle internal memory with banking to allow simultaneous DMA and core access



System Development with a DSP

- ◆ **Almost all development occurs in C/C++ but many developers still program their most frequently executed code in assembly**
 - **Interlocked pipeline and algebraic assembly are important**
 - ◆ Interlocked pipeline means that programmer doesn't have to mentally schedule cycles; much easier to maintain as well
- ◆ **Compiler friendly but ...**
 - **The more compute units that exist, the harder it is for a compiler to take advantage of all the units**
- ◆ **Even if developers have DSP-specific assembly, today's developers almost always have Matlab and C functional models**
 - **Makes porting to a new processor easier**
- ◆ **System bandwidth is just as important a consideration (and in many cases it is more important) than other development items**
 - **Time needs to be spent up front planning this out**



Anatomy of a controller

- ◆ **Branching and change of flow**
 - ◆ Occurs often in a control application
 - ◆ Shorter pipelines and branch prediction help
- ◆ **High performance caching**
 - **Instruction and data cache widely used to manage accesses from larger, slower external memories**
- ◆ **Byte addressability is friendly to networking apps**
- ◆ **Memory protection and translation**
- ◆ **Most frequently used instructions encoded as the smallest size possible to improve code density**
- ◆ **Stack and Frame pointer support**
- ◆ **User and Supervisor modes for operating systems support**

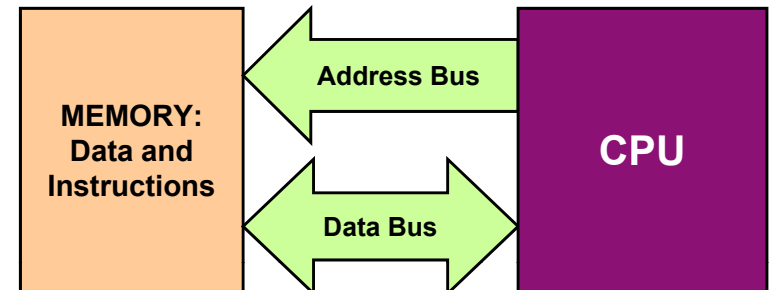
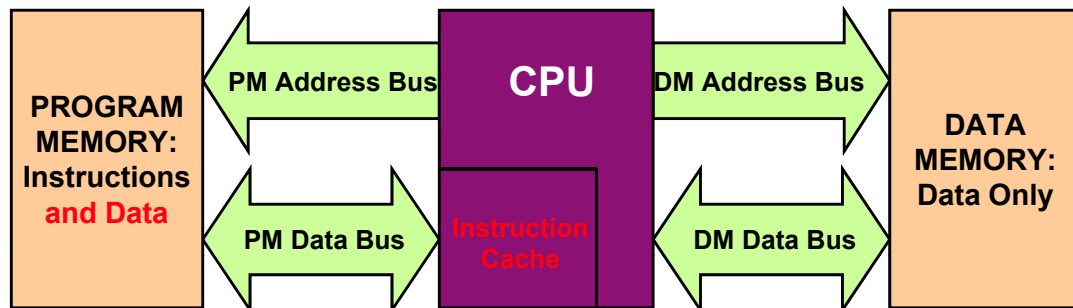
DSP vs. Microcontrollers

◆ DSP Architecture

- **Harvard Architecture**
 - ◆ Separate Program & Data Memory Space
- **Dedicated Hardware Multiplier**
- **Single Cycle MAC**
- **Efficient Computation**
- **Less Memory Required**
- **Algebraic Assembly Language**
- **Can Combine Many Advanced Control Features**

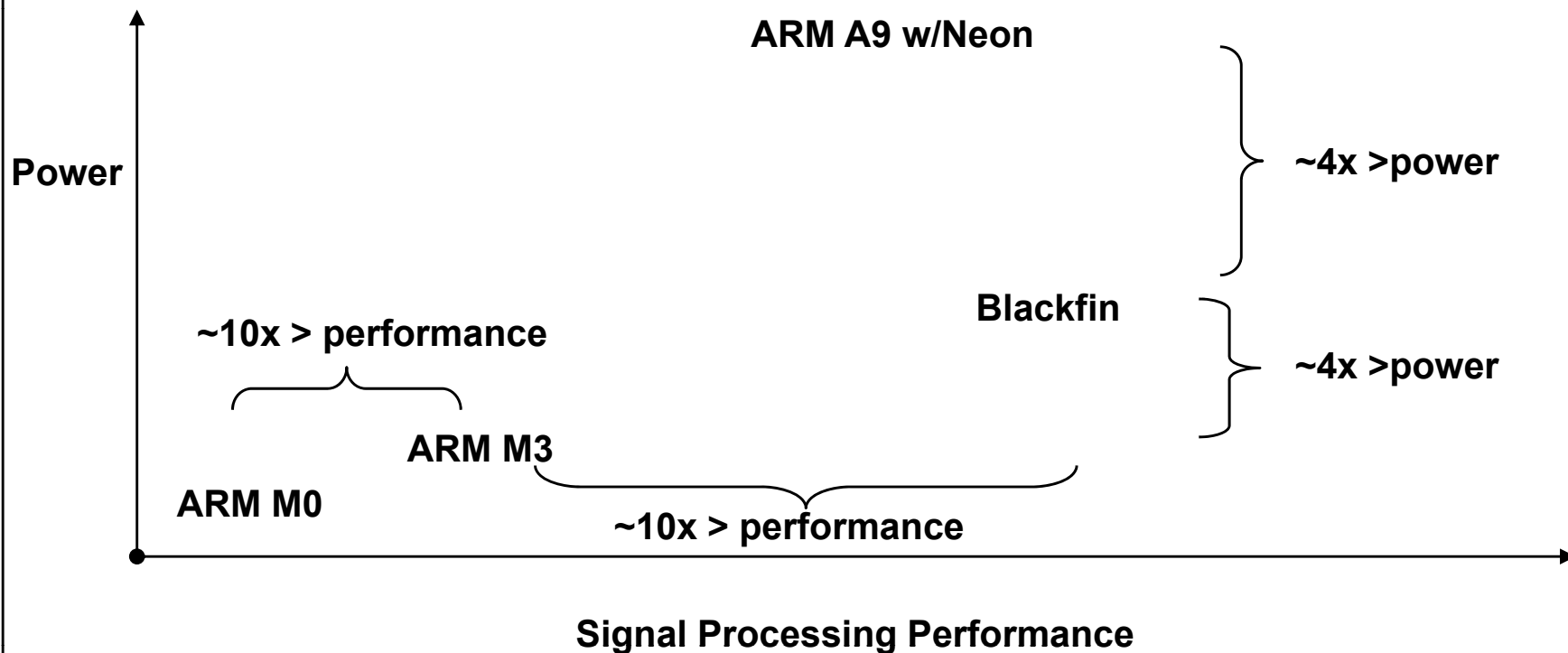
◆ Microprocessor Architecture

- **Von Neumann Architecture**
 - ◆ Common Program & Data Memory Space
- **Multiplication in Software (multiple cycles)**
- **Large Amount of Memory Needed**
- **Mnemonic based Assembly Language**

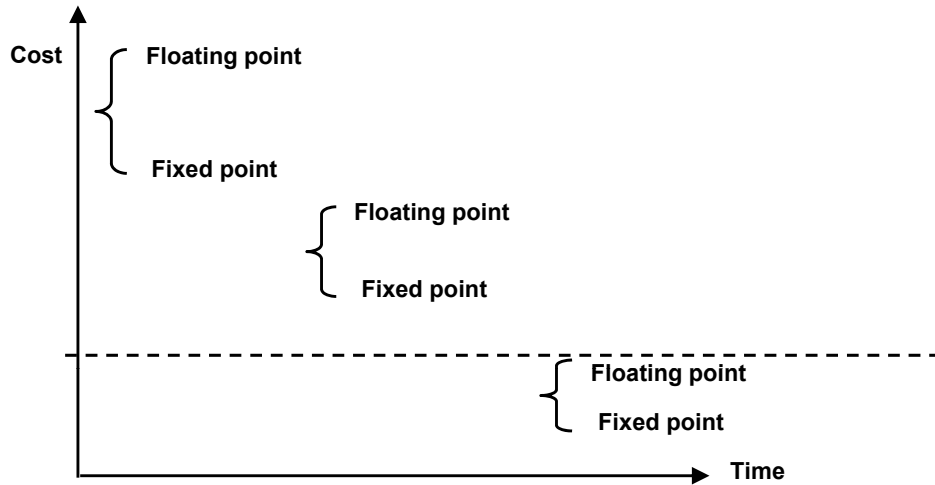


The Industry landscape

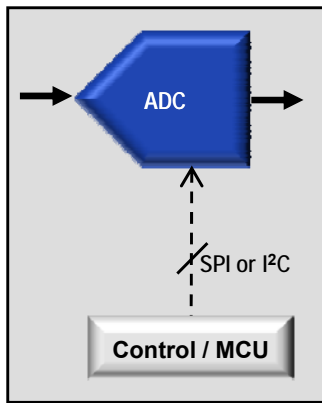
- ◆ DSP's have continued to add integrated controller features
- ◆ Microcontrollers have continued to add DSP features
- ◆ FPGAs have added support for embedded cores



Trends in the applications domain



Floating point is becoming more common in traditional fixed point applications as cost drops

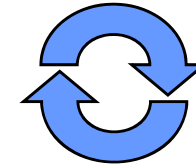


More modes and complexity on the digital side our analog components increases the need for integrated processors

Biometric Security

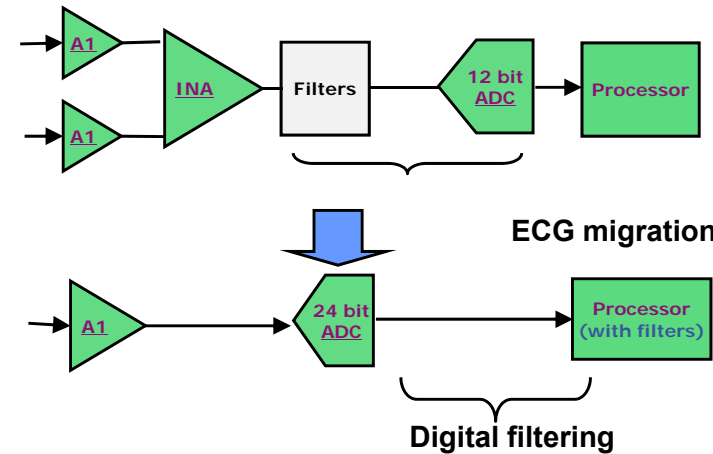


Surveillance Systems



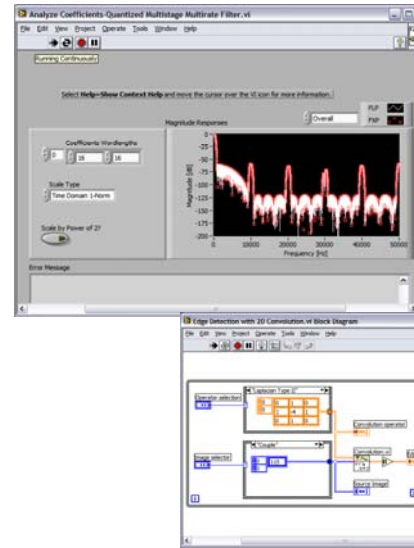
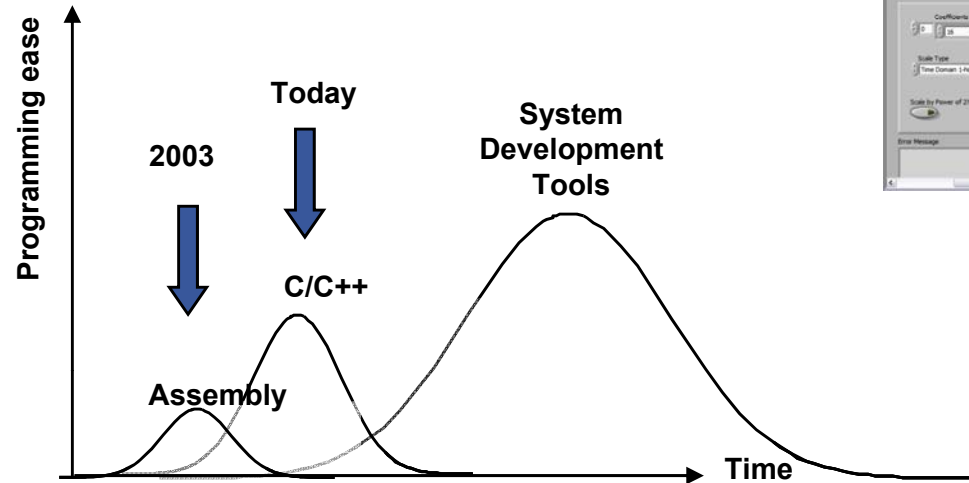
Industrial Control

Decisions, actions, data reduction moving to front-end of systems

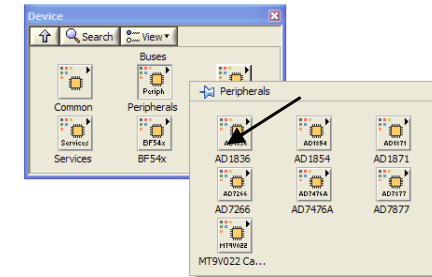


Digital content moving "upstream" in the signal chain

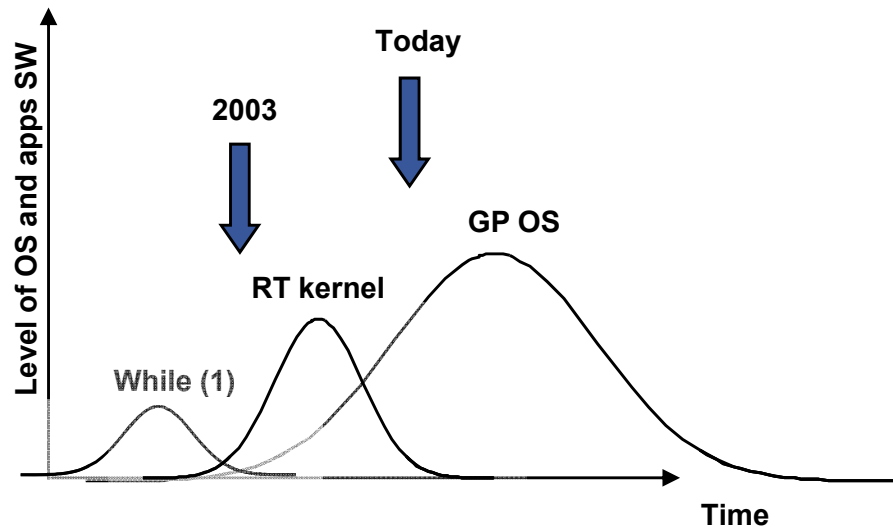
Software development trends



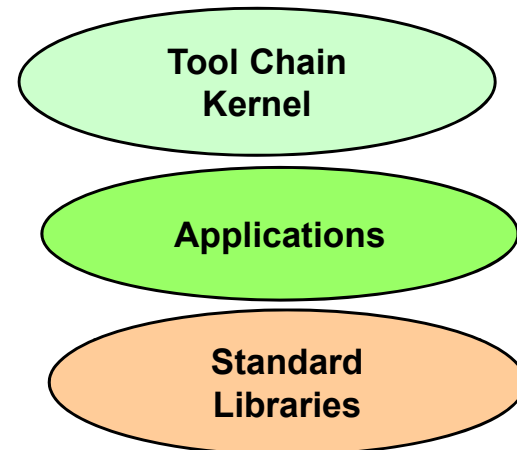
Sigma Studio is a fine example of how the programming model is evolving



Move from to assembly to higher level language to abstracted programming language



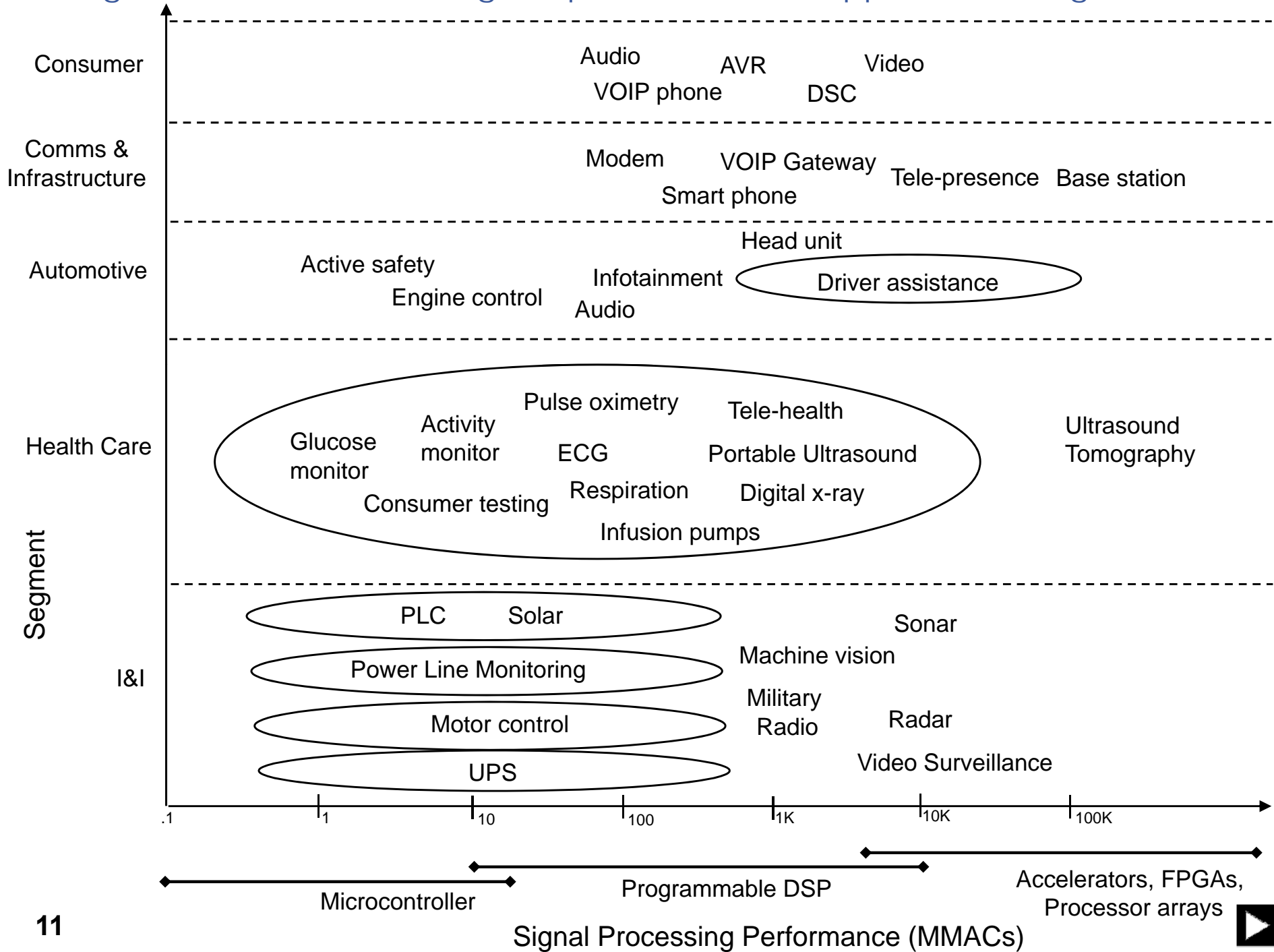
Open Source Community



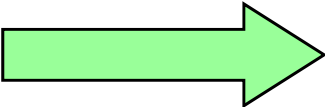
More developers moving to linux and open source



Programmable Processing Requirements for Application Segments



Project Progress

6  **24 Months**

◆ **Average time for the project:**

- **65% took less than 12 months**
- **17% took between 12 and 18 months**
- **18% were greater than 18 months**

} Longer development window
Requires long term support

What does performance mean?

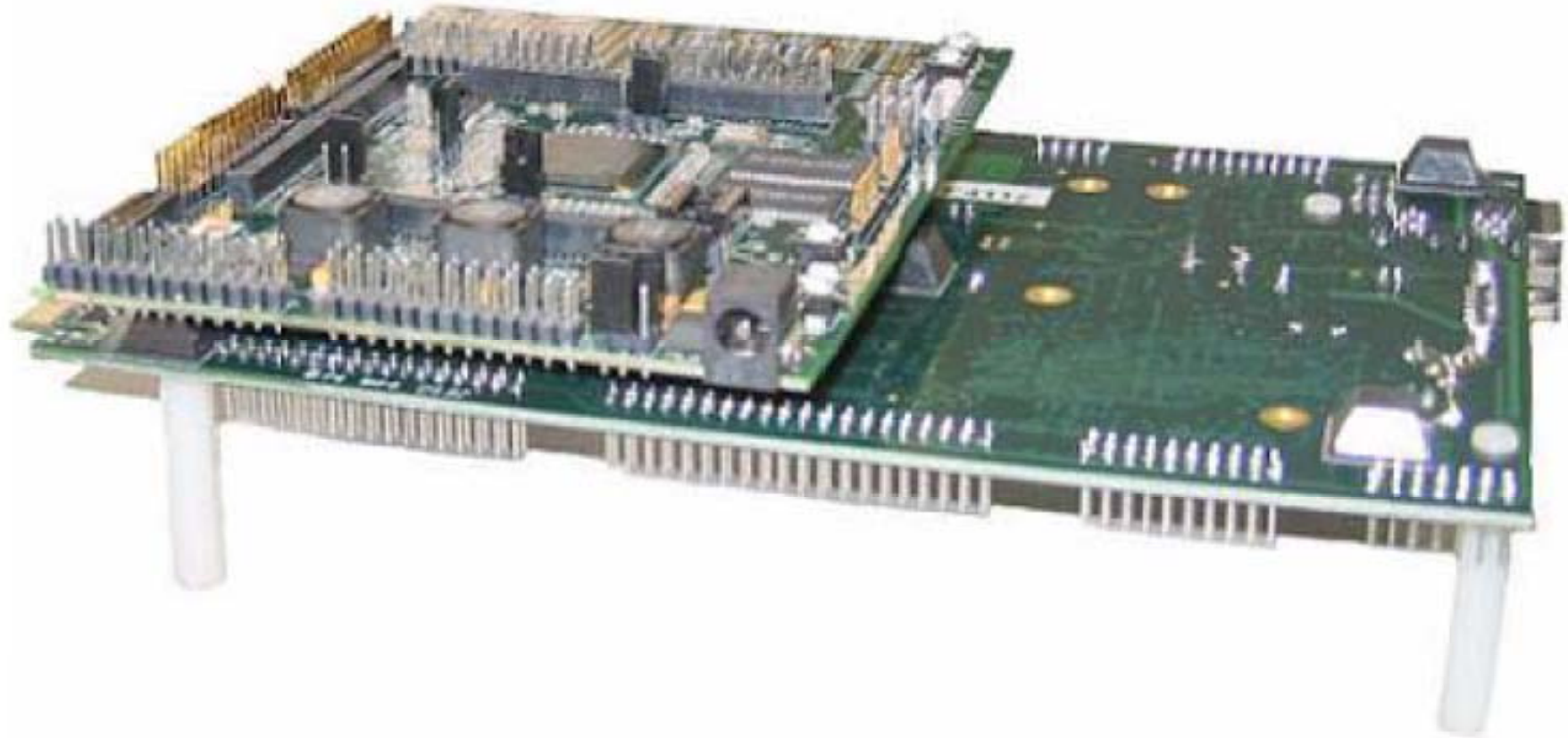
Attribute	% Ranked 1 or 2 in importance when selecting Blackfin
Performance	42%
Ability to Perform both DSP & MCU Functions	37%
Cost	36%
Development Tools	31%
Peripherals (specific peripherals and/or overall peripheral mix)	28%
Power	24%

From an ADI 2009 survey of customers that designed in a Blackfin processor

FPGA Usage

- ◆ **50% of developer in CY2009 developers**
 - would use an FPGA and/or programmable logic in their next design
- ◆ **The other half**
 - Do not need the function
 - Too Expensive
 - Too much power
 - Too hard to use
- ◆ **Our processors do co-exist with FPGAs.**
 - In development phase to simulate a larger system
 - In the final system to add peripherals or IO
 - In the final system to co-process

ADI Evaluation solutions with an FPGA



**FPGA Expander card for our EZKITs
Verilog for connections to peripherals**

Extensive network of partners



- ◆ Mathworks
- ◆ ZP engineering
- ◆ Danville
- ◆ Schmid Engineering
- ◆ BlueTechnix
- ◆ Promwad
- ◆ Phytec
- ◆ Mega-F
- ◆ Kaztek
- ◆ Boston Engineering
- ◆ TechEN
- ◆ Impact Engineering
- ◆ PMDi



What is new with our Eval Platforms?

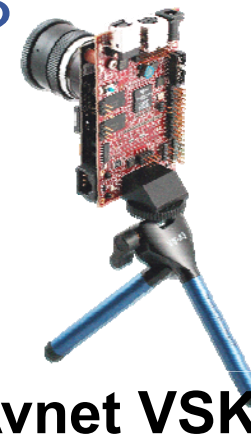
SHARC EZKIT



BF518 EZKIT



Low-cost ICE



Avnet VSK



Bluetooth Extender



BF52x EZKIT

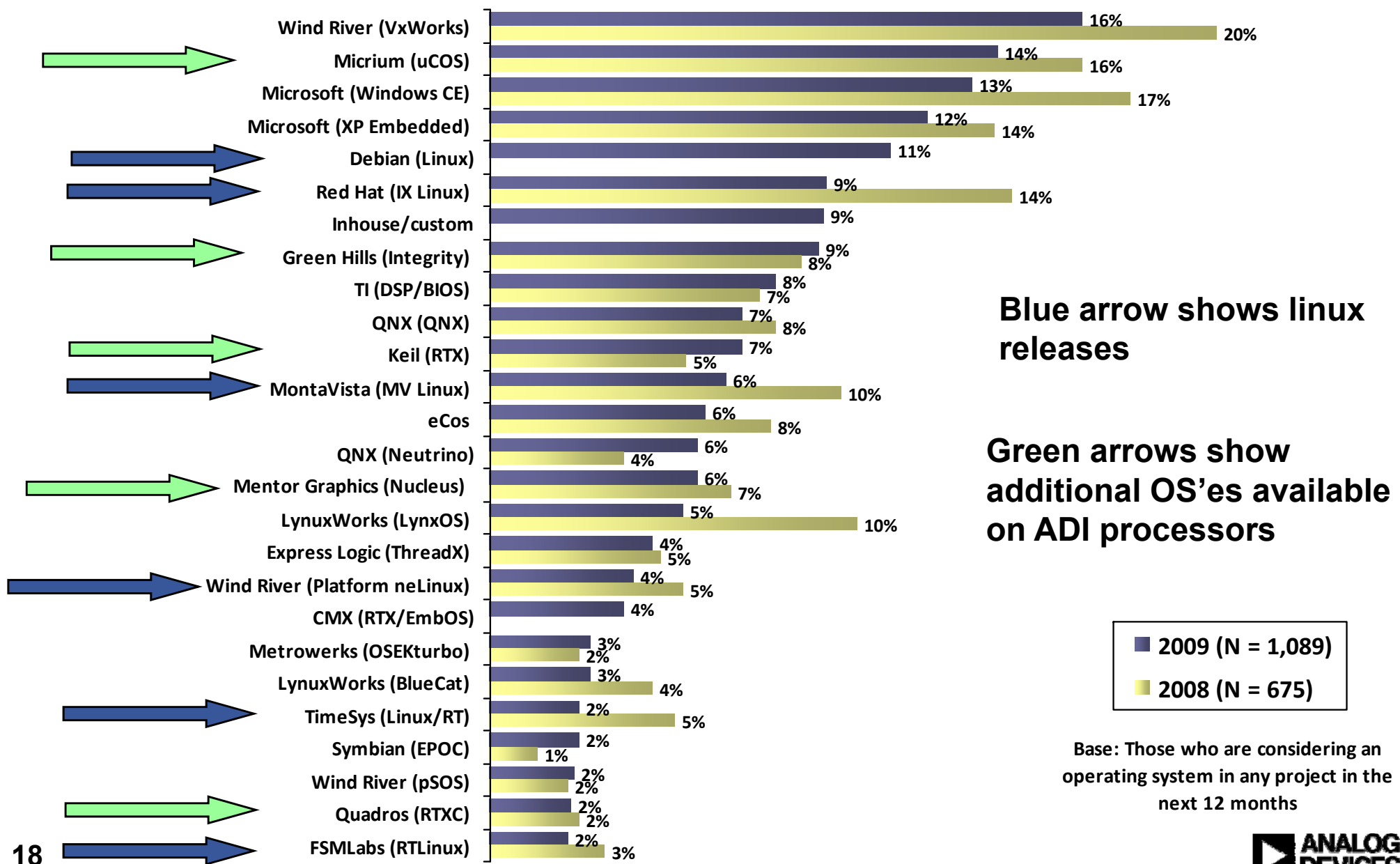


BF54x EZKIT

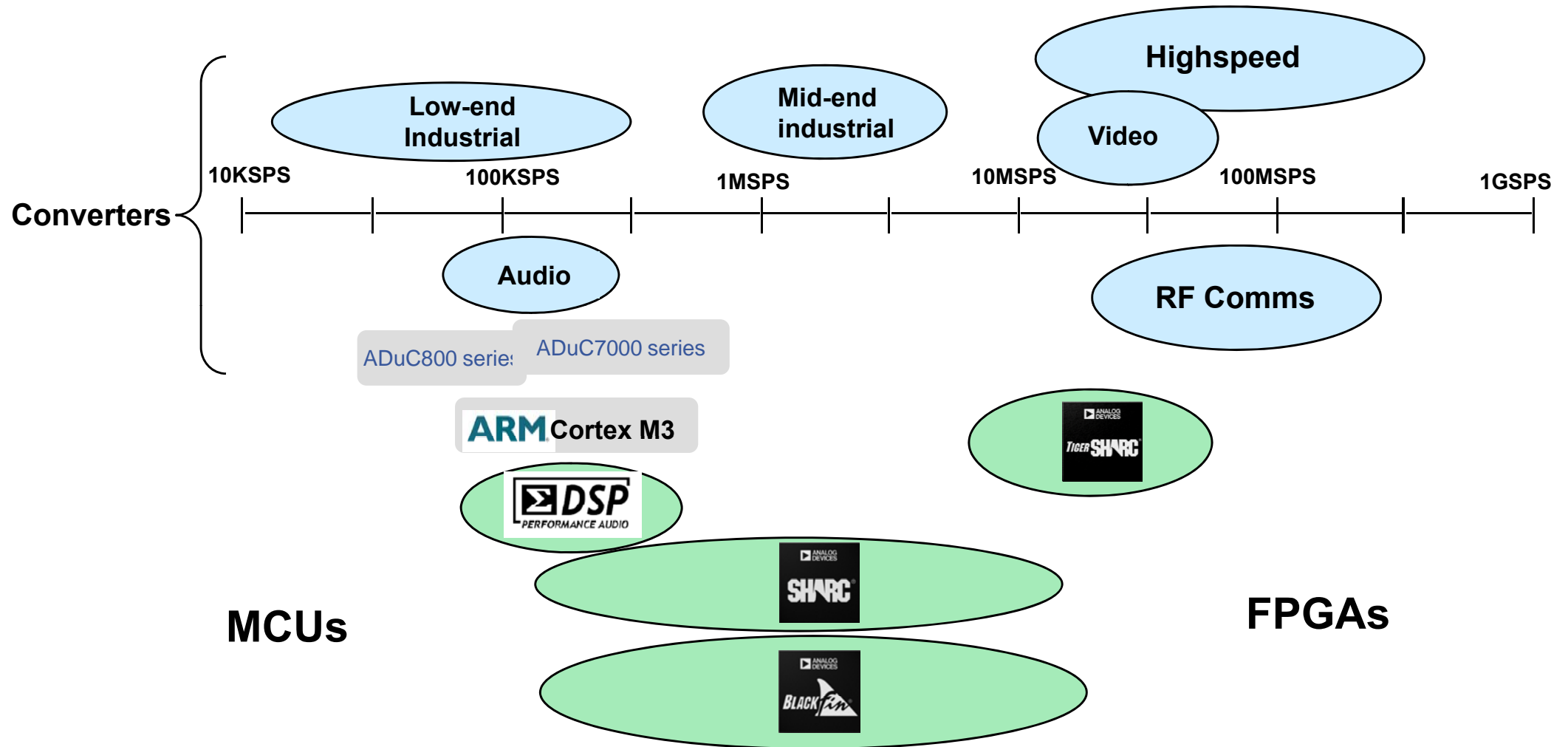


BF508 EZKIT

Please select ALL of the operating systems you considering using in the next 12 months.



The Converter-Processor Spectrum





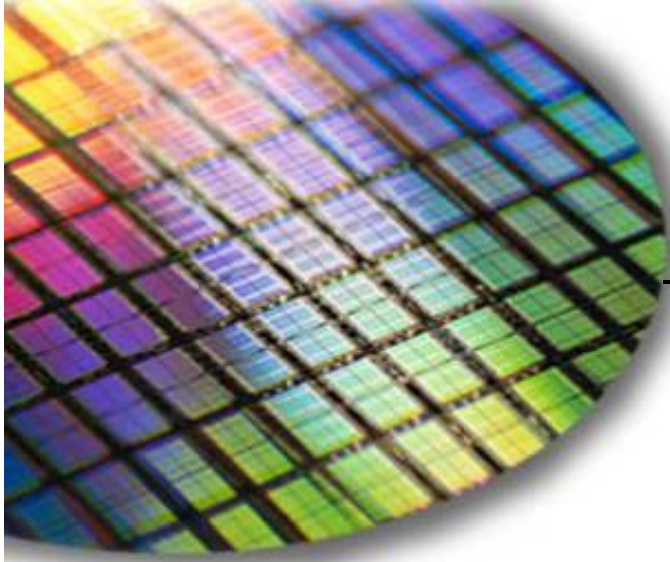
Important Questions/Thoughts you should ask

- ◆ **Does the C or C++ code exist for the customer's current processor application?**
 - It is straight forward to port this code to our processors

- ◆ **Fixed point or floating point?**
 - If the application requires floating point more than 5% of the time, SHARC is the answer
 - Blackfin does support software-based floating point

- ◆ **Which operating system is used?**
 - If it is one of the following, we have it available on our processors:
 - ◆ uCLinux, uC-OS II from Micrium, VDK Green Hills Integrity and Velocity, Quadros, Nucleus, Express Logic

- ◆ **Is networking and connectivity required?**
 - We have Ethernet, USB (device and host), Storage (NAND, SDIO, etc.), and the ability to add the 4 most popular wireless standards (wifi, Zigbee, Bluetooth, and proprietary wireless)



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Important Question
to ask yourself

Discovery Questions/Thoughts

- ◆ **In the portable health care space, many customers use a 3rd party design house**
 - We have multiple options in this area with success stories to show
- ◆ **Many customer use 3rd parties to order development**
 - Bluetechnix
 - Promwad
- ◆ **Processor roadmaps are important to customers**
 - We have fixed and floating point roadmap products on both ends of the performance and power spectrum
- ◆ **Design references are very important**
 - We have a wide variety available (future Distance learning session?)
- ◆ **Power and energy management**
 - We have collateral to help the customer understand our processors
 - Blackfin and SHARC options
- ◆ **In the I&I:**
 - IEEE1588, Signal Condition, Oscilloscope, Signal Generator, Real time, FFT, DFT, Capture, Flexibility, Screen controller, Analysis, Vector Control, Bandwidth, Integration, Flexibility, DC Brushless, AC Induction, Permanent Magnet

Discovery Questions/Thoughts

- ◆ **What do you need in terms of performance?**
 - What do you mean by performance?
- ◆ **Do you need a connectivity processor or a high performing processor that can be connected?**
 - Blackfin can be either
- ◆ **75% of the developers that use Blackfin describe their use as either MCU or MCU and DSP**
 - Only 25% describe it as DSP only

Help

- ◆ **ADI Processor communities via EngineerZone and uClinux are very active**
 - **Check them out at:**
 - ◆ <http://ez.analog.com/index.jspa>
 - ◆ <http://blackfin.uclinux.org/gf/>

